LIFE SCIENCES

Grade 11 Teacher's Guide

basic education
Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

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Life Sciences Teachers' Guide: An Introduction

The purpose of this textbook and teachers' guide series is to equip you, the teacher, with the necessary tools to effectively teach life sciences within the FET phase. All the materials have been designed with the aim of *covering all the content required for CAPS* but at the same time *effectively communicating the broader value of Life Sciences to your students and classes* in a way that is *easy to read*. We hope that you find this book to be a helpful resource as you teach and engage with your students, and may it facilitate an even greater appreciation within you of the subject. Since January 2012 the teaching in all schools was adapted to meet the standards laid out in the National Curriculum and Assessment Policy Statements (CAPS) document. It is highly recommended that you be familiar with this document.

Overview of the National Curriculum

(a) The *knowledge, skills and values* deemed most important for South African learners is clearly set out in the National Curriculum and Assessment Policy Statement for Life Sciences. The content is adapted to the unique environment and context of South Africa, but at the same time provides an awareness of important global trends.

(b) The National Curriculum Statement Grades R - 12 undertakes to:

- equip all learners, irrespective of their backgrounds, race, gender or ability, with the *knowledge, skills and values* necessary to reach their goals and be functioning members of society.
- facilitate access to higher education.
- smooth the transition of learners into to the workplace.
- provide employers with a profile of a learner's competencies.

(c) The key principles of the National Curriculum Statement for Grades R - 12 are:

- *social transformation*: working to alleviate the educational differences of the past and providing *equal educational opportunities* to all.
- *active and critical learning*: encouraging learners to think about and understand what they are learning and not merely emphasising the rote-memory of facts.
- *high knowledge and high skills*: specified minimum standards of knowledge and skills are set to be achieved at each grade.
- *progression*: both the content and the context of subjects will be expanded as one progresses through the grades.
- *Social awareness*: being sensitive to issues such as poverty, inequality, race, gender, language, age, disability and other factors.
- Valuing *human rights, inclusivity and environmental and social justice*.

- *Valuing indigenous knowledge systems*: acknowledging the rich history and heritage of this country.
- *Credibility, quality and efficiency*: providing an education that is comparable in quality, breadth and depth to those of other countries.

(d) The aims as listed in the National Curriculum Statement Grades R - 12 interpret the kind of citizen the education systems tries to develop. It aims to produce learners that are able to:
- identify and solve problems and make decisions using *critical and creative thinking.*
- *work effectively as individuals and with others* as members of a team.
- organise and *manage themselve*s and their activities responsibly and effectively.
- collect, analyse, organise and *critically evaluate information*.
- *communicate effectively* both visually, symbolically and with language.
- *use science and technology effectively* and critically, showing responsibility towards the environment and the health of others.
- demonstrate an *understanding of the world as a set of related systems* by recognising that problem solving contexts do not exist in isolation.

(e) Inclusivity is one of the key principles of the National Curriculum Statement Grades R - 12 and should be a central part of the organisation, planning and teaching at each school. Educators need to:
- have a sound understanding of how to *recognise* barriers to learning and address them in the classroom.
- know how to *plan for diversity* .
- use various curriculum differentiation strategies (Consult the Department of Basic Education's Guidelines for Inclusive Teaching and Learning, 2010)
- address barriers to learning using the support structures within the community, District-Based Support Teams, Institutional-Level Support Teams, parents and Special Schools as Resource Centres.

What is Life Science?

The term 'Life Sciences' indicates clearly the two ideas held together in this subject. Life refers to all living things- from the most basic of molecules through to the interactions of organisms with one another and their environments. Science indicates it is necessary to use certain methods in our study of the subject. The two broad aims of any science are to *increase existing knowledge* and *discover new things*. We approach this using a careful method that can be copied by others. The methods include proposing hypotheses and carrying out investigations and experiments to test these hypotheses. Scientific knowledge changes over time as more is

discovered and understood about our world; as such, Life Sciences is a constantly growing subject.

Life Sciences Strands for Grade 11 and 12

Everything within grade 11 and 12 will fit under one of these four broad strands. These knowledge pathways grow over the three years of FET. Within each knowledge strand, ideas should not be studied separately; you goal as a teacher should be to encourage the students to rather seek to discover the links between related topics so that they grow in their understanding of the inter- connectedness of life. As you teach each section or chapter, highlight to them the broad strokes that place it under one of these strands:

- Knowledge Strand 1: Life at the Molecular, Cellular and Tissue Level
- Knowledge Strand 2: Life Processes in Plants and Animals
- Knowledge Strand 3: Environmental Studies
- Knowledge Strand 4: Diversity, Change and Continuity.

Although there is some flexibility in the order in which the knowledge strands are covered, it is important to remember that Knowledge Strand 1 must be taught before Knowledge Strand 2, and that Knowledge Strand 3 must come before Knowledge Strand 4. It is up to you to decide whether to start the school year with Knowledge Strand 1 or Knowledge Strand 3.

The purpose of studying Life Sciences

There are three broad purposes, which will be expanded upon as we continue:

- Aim 1 – acquiring the knowledge of Life Sciences
- Aim 2 – doing practical work and investigations
- Aim 3 – understanding the applications of Life Sciences in society- both present society (indigenous and western) and within the context of history.

Specific Aim 1: Acquiring knowledge of Life Sciences

Learners are expected to develop an understanding of Life Science concepts, processes, phenomena, mechanisms, principles, theories and models. The specific skills you are wanting to equip them with, is to be able to:

1. *Acquire and recall knowledge*
    - Access information
    - Select key ideas
    - Recall facts
    - Describe concepts, processes and theories

Verbs that can be used in testing this skill: **State, name, label, list, define, describe.**

2. *Understand, comprehend and make connections between ideas and concepts*
   - Write summaries
   - Develop flow charts, diagrams and mind maps
   - Recognise patterns and trends

   Verbs that can be used in testing this skill: **explain, compare, rearrange, give an example, illustrate, calculate, interpret, suggest, make a generalisation, predict, select, differentiate.**

3. *Apply knowledge in new and unfamiliar contexts*
   - Use information in a new way
   - Construct meaning from new data using pre-acquired knowledge

   Verbs that can be used when testing this skill: **demonstrate, interpret, predict, compare, differentiate, illustrate, solve, select.**

4. *Analyse, evaluate, and synthesise scientific knowledge, concepts and ideas*
   - Analyse information and data
   - Recognise relationships between existing knowledge and new ideas
   - Critically evaluate scientific information
   - Identify assumptions
   - Categorise information

   Verbs that can be used when testing this skill: **Appraise, argue, judge, select, evaluate, defend, compare, contrast, criticise, differentiate, distinguish.**

Specific Aim 2: Investigating phenomena in Life Sciences

Practical investigations involve a specific range of skills, which can be summarised as follows:

1. *Follow Instructions*
   - Students must be able to adhere to instructions that they are given
   - Adhering to safety rules

2. *Handle Equipment/apparatus*
   - Knowledge of apparatus (naming, handling and what it is used for)
   - How to use chemicals and taking necessary precautions when handling them
   - Using equipment appropriately and safely

3. *Make Observations*
    - Drawings
    - Descriptions
    - Grouping of materials (similarities and/or differences)
    - Measurements
    - Comparing materials before and after treatment
    - Observing results of an experimental investigation and recording information in the appropriate manner
    - Counting

4. *Record Information or data*
    - Simple tables
    - Drawings
    - Descriptions
    - Constructing a pie chart
    - Line graph
    - Histogram or bar chart as suited to the data and choosing suitable axes and scales

5. *Measure*
    - Reading linear and two-dimensional scales
    - Scaling and choosing headings for axes
    - Measuring quantities
    - Making valid measurements of variables, repeating measurements to obtain an average where necessary in all quantitative work
    - Recognising, or supplying the correct units for common measurements
    - Counting systematically

6. *Interpret*
    - Convert information into an appropriate graph, table etc. and extract data
    - Apply knowledge
    - Analyse and recognise patterns or trends
    - Acknowledge limitations of experimental procedures
    - Make deductions based on evidence to reach a conclusion

7. *Design/plan investigations or experiments*
    - Identifying a problem and formulate a question that will guide the investigation
    - The aim of the investigation
    - The Hypothesis
    - Selecting the correct apparatus or equipment and/or materials and chemicals
    - Identifying variables

- Adhere to laboratory safety procedures

Specific Aim 3: Appreciating and understanding the importance of Life Sciences in society (present and past)

- Understanding the history and relevance of discoveries
- The history of scientific discoveries is the context of our learning.

- Being aware of the value indigenous knowledge systems give to Life Sciences
- Understand the different cultures in which indigenous knowledge systems developed
- Link specific cultures directly to the areas in Life Science that they have influenced

- Know the value and application of Life Sciences knowledge in industry, careers and everyday life
- Analyse the applications of biotechnology
- Summarise and understand the positive and negative effects of biotechnology on the environment
- Have a knowledge of the different career paths in Life Sciences

- Develop language skills
- Improve writing skills
- Grown in the ability to read and understand scientific text and produce essays, summaries etc.

Time Allocation

The time allocation for Life Sciences in Grade 11 and 12 is 4 hours per week.
The curriculum for Grade 11 has been designed to be completed within 32 weeks out of 40 weeks in the school year. The Grade 12 curriculum is designed to be completed within 27 ½ weeks out of the 40 weeks. The extra weeks are designed to allow for school-based activities that may disrupt teaching.

Syllabus

For the detailed syllabus descriptions applicable to Life Sciences for grade 11 and 12 please consult your CAPS document or access it online here (insert link)

Assessment

Assessment can be defined as the *planned process of gathering and interpreting data on the performance of students* in your class.

Assessment serves a purpose to both students and teachers. It allows students to gauge their own progress and test their understanding and skills. For you as a teacher, it will help you identify weak areas and intervene where needed to reinforce concepts.
The four steps of assessment would be to *generate and collect the evidence* of progress, *evaluate* it, *record* the results and *use your findings* to adjust (in teaching and learning) where needed.

Using your findings entails

- Making judgements about a specific student's progress
- Informing the students about their strengths, weaknesses and progress
- Using your findings to assist other teachers and the parents, in making the best decisions possible for the student.

In both formal and informal assessments, always consider the content, concepts and skills and the aims specified for Life Sciences. It is important to ensure that over the year, *all the subject content is covered*, the *full range of skills is included,* and *different forms of assessment* are used.

Types of assessments

Assessments should be both *on* learning (formal) and *for* learning (informal).
Informal or daily assessments
The aim of informal assessments is to provide consistent feedback to the learner of their progress that can be used to improve their learning. Informal assessment occurs daily. This is done through observations, discussions, practical demonstrations, learner-teacher conferences and informal classroom interactions. It should be seen as a part of the learning activities taking place in the classroom.

- There should be a minimum of three informal assessments done per week. These can be marked by you or the students.
- There should be a consolidation task at the end of each topic.
- Practical skills should be taught in a way that integrates them into the theory being taught.
- The assessments should vary in their difficulty and cognitive levels so that collectively all the degrees are covered.

Formal Assessments

The aim of these assessments is to provide you a systematic way to evaluate how your students are progressing. Examples of formal assessments include tests, exams, tasks, projects, assignments, demonstrations and orals.

These are the assessments that are marked by you, and those results recorded formally for progression and certification purposes. For grade 11 and 12, these assessments are broken up in the following way:

- 25 % school-based formal assessments (incudes June exam, as well as trials for grade 12)
- 75% end of year examination

Degrees of difficulty for test/exam questions

Each question set will fall into one of the following levels:

Level 1: **easy** for the average student to answer

Level 2: **moderately** challenging for the average learner to answer

Level 3: **difficult** for the average learner to answer

Level 4: **very difficult**. The skills and knowledge required to answer these questions allows for the level 7/high-achieving students to be discriminated from the other high-ability learners.

Factors that influence the cognitive demand of questions

Content difficulty: A question that asks a student to recall an **abstract theory** or fact, or complex content, is harder than once that asks for recall of a **simple fact**.
Writing difficulty: It is generally easier to recall a sequence of events in a **few sentences** or point form, compared to being asked to answer in an **essay form**.

Reading difficulty: Different sources may be more **complicated to comprehend** and interpret. For example, a magazine article is in a **simpler format** than a classical work like an excerpt from a textbook. The difference in content, vocabulary and structure, and the way abstract ideas are presented will influence the student's ability to extract information.

It is important as an examiner to make sure that you can identify the *type of cognitive demand* that a question will place on the learner, as well as *the degree of difficulty of the question* or task. Combining these two features together we can consider the question against a framework for question difficulty. It is important to do this so that a paper is neither too difficult nor too easy. These are the other factors that influence the difficulty level of a question

Content/concept difficulty: This refers to the difficulty of the subject matter, topic or knowledge assessed and required. In this judgement, difficulty is present in the academic and conceptual demands a question makes, as well as the grade level limits of the specific element being questioned.

Stimulus difficulty: This refers to the difficulty of the language (linguistic complexity) and the challenge presented to the learner when they try to read and understand the language of both the question and any source material provided as part of it.

Task difficulty: This refers to the challenge the learner faces when trying to formulate or produce an answer.

Expected response difficulty: This refers to the difficulty imposed by examiners in the mark scheme and memorandum. This is largely applicable to constructed response questions and less to selected response questions (multiple choice, true/false, matching columns)

Weighting of cognitive levels for Grade 11 and 12

Knowing Science 40%

- State or name
- List
- Label
- Define
- Describe

Understanding Science 25%

- Communicate understanding
- Interpret
- Exemplify and classify
- Summarise
- Classify
- Infer
- Compare
- Explain

Applying scientific knowledge 20%

- Perform a basic or routine procedure or rule or method
- Apply an understanding of learned concepts or facts from a known to an unfamiliar context.
- Demonstrate
- Solve

Evaluating, analysing and synthesising scientific knowledge 15%

- Analyse complex information and adapt *appropriate strategies to solve non-routine*/complex/open ended questions.
- *Evaluate or make a critical judgement*, for example on the quality of results, the probability or desirability of an outcome.

- To create a new product by *integrating concepts*/ ideas/ information and *make connections* between different ideas or the overall purpose or structure of a system.
- To *differentiate or suggest a reason*.

School based assessments for Grade 12

TERM	Task	Weighting (% of SBA)	% of reporting mark per term
1	Practical Minimum 30 marks	10	25
	Test Minimum 50 marks	10	75
2	Practical Minimum 30 marks	10	25
	Mid-year Exam One paper - 150 marks Duration: 2½ hours	20	75
3	Assignment (50 marks) Duration: 1 - 1½ hours	15	25
	Trial Exam Two papers - 150 marks each Duration: 2½ hours each	35	75
	Total	**100**	

The different tasks of the Formal Assessment Programme

Tests and Examinations

- Minimum 50 marks
- It must cover the work taught in that specific term
- The mid-year exam must cover Term 1 and Term 2
- For grade 12, the trial exams must cover Terms 1-3
- The degree of difficulty must be considered, and the assessment must be balanced in terms of cognitive levels and topics.
- They must follow the NSC exam in design, rigor and format
- One minute must be allocated per mark
- Each test/exam must cover all three specific aims with at least 20% of the weighting going to specific aim two.
- Remedial and intervention strategies must be in place where needed

Practical Tasks

- One task must involve manipulation of apparatus or data collection
- All seven skills must be covered over the practicals for the year
- Each practical must assess at least 3 of the 7 skills
- Minimum 30 marks

Research Project

- All three specific aims must be covered
- The marks for this must be recorded in the third term, no matter when the project was completed
- It must be 50 marks
- The task is long-term (more than three weeks non-contact time)
- It must be investigative
- Sub-skills to be included are *formulating questions and hypotheses*, *gathering information* and being able to *manipulate and process* it. *Patterns must be identified* and the *data evaluated*. Valid *conclusions must be drawn,* and the *findings communicated* effectively.

Assignment

- It must be skills based and not heavily weighted towards content recall
- All three specific aims must be covered
- The mark for the assignment must be recorded in the third term, no matter when the assignment was completed.
- It must be 50 marks
- Short term task (1-1 ½ hours)
- Completed individually, at school, under controlled conditions.
- No resources may be used while completing the task
- It must include a short source-based essay (10-15 marks)
- As many of the following as possible must be covered: *analysing and interpreting data*, *making drawings* and *plotting graphs*, drawing *tables*, *performing calculations* and *justifying conclusions*.

Assessment Tools

The purpose of these tools is to assist you to record information gathered during assessments. They allow your marking to be systematic, and they enable you to check the quality and content of your assessments. It makes any analysis of a student's achievements more objective.

Types of assessment tools: These can be checklists, rubrics, an observation notebook, recordings, written descriptions, portfolios and more.

Before assessment it is important for the students to know: How and when they will be assessed, the format for the response and the consequences of the assessment.

Questions to be answered after the assessment

Were the criteria used appropriate?
Has feedback been given to the learners?
Have any learning disabilities been identified?
What follow-up action is needed?
How will the assessment further the purpose of teaching and learning?

Rubrics for assessment (rubrics from Siyavula, Life Sciences Grade 10)

Assessment Rubric 1: Practical activity

- To be used for any practical task where learners are required to follow instructions to complete the task.

Assessment criteria	0	1	2	Comments
Following instructions	Unable to follow instructions	Instructions followed with guidance	Able to work independently	
Observing safety precautions	Unable to observe safety precautions	Sometimes does not follow safety precautions	Able to follow safety precautions completely	
Ability to work tidily	Cannot work tidily	Can work tidily		
Cleans up afterwards	Does so once reminded	Does so without reminding		
Organisation	Disorganised	Fairly organised	Organised and efficient	
Use of apparatus, equipment and materials	Always used incorrectly and materials wasted	Sometimes used correctly and aware of material usage	Apparatus and materials used correctly and efficiently	
Results or final product	No result or final product	Partially correct results or product	Results or product correct	
Answers to questions based on activity	No answers provided or most are incorrect	Can answer questions and at least 60% are correct	Can answer application and questions correctly	

Assessment Rubric 2: Investigation

- To be used for an investigation, especially where learners must write their own experimental report or design the investigation themselves.

Assessment criteria	0	1	2	3	Comments
Aim	Not stated or incorrect	Not clearly stated	Clearly stated		
Hypothesis or prediction	Not able to hypothesize	Able to hypothesize, but not clearly	Clearly hypothesizes		
Materials and apparatus	Not listed or incorrect	Partially correct	Correct		
Method	None	Confused, not in order or incorrect	Partially correct	Clearly and correctly stated	
Results and observations (recorded either as a graph, table or observations)	No results recorded or incorrectly recorded	Partially correctly recorded	accurately recorded but not in the most appropriate or specified way	Correctly and accurately recorded in the most appropriate or specified way	
Analysis or discussion	No under-standing of the investigation	Some under-standing of the investigation	Understands the investigation	Insightful understanding of the investigation	
Evaluation	No attempt	Partially correct	Correct, but superficial	Critical evaluation with suggestions	
Neatness of report	Untidy	Tidy			
Logical presentation of report	Not logical	Some of report is logically presented	Report is logically presented		

Assessment Rubric 3: Graph

- To be used for any graph or translation task you would like to assess, either on its own or within another activity.

Assessment criteria	0	1	2	Comments
Correct type of graph	Not correct	Correct		
Appropriate heading, describing both variables	Not present	Present, but incomplete	Complete	
Independent variable on x-axis	Not present or incorrect	Present		
Dependent variable on y-axis	Not present or incorrect	Present		
Appropriate scale on x-axis	Incorrect	Correct		
Appropriate scale on y-axis	Incorrect	Correct		
Appropriate heading for x-axis	Not present or incorrect	Correct		
Appropriate heading for y-axis	Not present or incorrect	Correct		
Units for independent variable on x-axis	Not present or incorrect	Correct		
Units for dependent variable on y-axis	Not present or incorrect	Correct		
Plotting points	All incorrect	Mostly or partially correct	All correct	
Neatness	Untidy	Tidy		
Graph size	Too small	Large		

Assessment Rubric 4: Table

- To be used when learners must draw their own table and you would like to assess it.

Assessment criteria	0	1	2	Comments
Appropriate heading, describing both variables	Not present	Present, but incomplete	Complete	
Appropriate column headings	Not present or incorrect	Mostly correct	Correct and descriptive	
Appropriate row headings	Not present or incorrect	At least half correct	All correct	
Units in headings and not in body of table	None present	Present but in the body	Present and in the headings	
Layout of table	No horizontal or vertical lines	Some lines drawn	All vertical and horizontal lines drawn	
Data entered in table	Not correct	Partially correct	All correct	

Assessment Rubric 5: Scientific drawing

- To be used when learners must do a drawing, particularly in Life and Living.

Assessment criteria	0	1	2	Comments
Appropriate, descriptive heading	Not present	Present, but incomplete	Complete	
Appropriate size of drawing (sufficiently large on page)	Incorrect (too small)	Correct		
Accuracy of drawing (correct shape and proportion of parts)	Incorrect	Somewhat correct	Correct	
Structures or parts placed correctly in relation to each other	Mostly incorrect	Mostly correct, but some misplaced	All correct	
Diagram lines are neat, straight and done with a sharp pencil	Not clear or neat or blunt pencil	Clear and neat		
Label lines do not cross over each other	Incorrect	Correct	All correct	
Parts are labelled	Mostly incorrect	Mostly correct with some missing or incorrectly labelled	All correct and labelled	

Assessment Rubric 6: Research assignment or project

- To be used when learners must do a research assignment or project, either outside of class or in class time, and either individually or in groups.

Assessment criteria	0	1	2	Comments
Group work (if applicable)	Conflict between members or some did not participate	Some conflict and some members did not always participate	Worked efficiently as a group	
Project layout	No clear or logical organisation	Some parts are clear and logical, while others are not	Clear and logical layout and organisation	
Accuracy	Many errors in content	A few errors in content	Content is accurate	
Resources used (material or media)	No resources used	Some or limited resources used	A range of resources used	
Standard	Poor standard	Satisfactory	Of a high standard	
Use of time	Did not work efficiently and ran out of time	Worked fairly efficiently	Worked efficiently and finished in time	

Assessment Rubric 7: Model

- To be used when learners must design and build their own scientific models.

Assessment criteria	0	1	2	Comments
Scientifically accurate	Model inaccurate or incomplete	Mostly accurate, but with some parts missing or incorrect	Accurate, complete and correct.	
Size and scale	Too big or too small, parts not in proportion to each other	Correct size, but some parts too big or too small	Correct size and proportional scale	
Use of colour or contrast	Dull, with little use of contrast	Somewhat colourful	Creative and good use of colour and contrast	
Use of materials	Inappropriate use or only expensive materials used	Satisfactory use of appropriate materials and recyclables where possible	Excellent use of materials and recyclables where appropriate	
Use of a key or explanation	Not present	Present but incomplete or vague	Clear and accurate	

Assessment Rubric 8: Poster

- To be used when learners must make a poster, either individually or in a group.

Assessment criteria	0	1	2	Comments
Title	Absent	Present, but not sufficiently descriptive	Complete title	
Main points	Not relevant	Some points relevant	All points relevant	
Accuracy of facts	Many incorrect	Mostly correct, but some errors	All correct	
Language and spelling	Many errors	Some errors	No errors	
Organisation and layout	Disorganised and no logic	Organisation partially clear and logical	Excellent, logical layout	
Use of colour	No colour or only one colour	Some use of colour	Effective colour	
Size of text	Text very small	Some text too small	Text appropriate size	
Use of diagrams and pictures	Absent or irrelevant	Present but sometimes irrelevant	Present, relevant and appealing	
Accuracy of diagrams or pictures	Inaccurate	Mostly accurate	Completely accurate	
Impact of poster	Does not make an impact	Makes somewhat of an impact	Eye catching and makes a lasting impact	
Creativeness	Nothing new or original	Some signs of creativity and independent thought	Original and very creative	

Assessment Rubric 9: Oral presentation

- To be used when learners must give an oral presentation to the class on a selected topic.

Assessment criteria	0	1	2	3	Comments
Introducing the topic	Did not do	Present, but with no clear link to content	Present, clear links to content being covered	Interesting and catching introduction	
Speed of presentation	Too fast or too slow	Started off too fast or too slow but reaches optimal pace	Good speed throughout		
Pitch and clearness of voice	Too soft or unclear	Started off unclear or too soft, but improved	Speaks clearly and optimal pitch throughout		
Capturing audience's attention and originality	Did not make an impact or no attempt to capture interest	Interesting at times	Sustained interest and stimulating	Sustained interest throughout with originality	
Organisation of content during presentation	Illogical or unclear	Clear and mostly logical	Clear and logical throughout		
Factual content	Many errors in content	Some errors in content	All correct		
Concluding remarks	No conclusion or inappropriate	Make a satisfactory conclusion	Insightful or thought-provoking conclusion		
Answers to the educator and class's questions	Was not able to answer or gave incorrect answers	Was able to answer recall questions only	Was able to answer recall and application questions		

Assessment Rubric 10: Group work

- To be used to assess any work where learners are required to complete the task as a group. This rubric is designed to assess the group as a whole.

Assessment criteria	0	1	2	3	Comments
Member participation	Very few members participated	Only some members participated	At start, only some, but then full participation	Full participation throughout	
Discipline within the group	Lack of discipline	Some members disciplined	Most members disciplined	All members disciplined	
Group motivation	Unmotivated or lack focus	Some members motivated but others lack focus	Most members motivated and focused	All members focused and motivated	
Respect for each other	Show disrespect to each other	Some members show disrespect	All members are respectful		
Conflict within group	Considerable conflict and disagreements which were unresolved	Some conflict which was either resolved or unresolved	No conflict or issues were resolved maturely		
Time management	Disorganised and unable to stick to time frames	Mostly able to work within the given time	Effective use of time to complete the tasks		

Recording and Reporting

Recording is the process of documenting the level of a student's performance in an assessment or task. It shows their progress towards achieving the knowledge and skills within the Curriculum and Assessment Policy Statements. Records of the students' performance should show evidence of their *progression within a grade* and their *readiness to move to the next grade*. Records of performance are also a useful tool to show the progress made by the teachers in the learning process.

Reporting is a process of communicating the performance to the students, their parents, schools, and other stakeholders. It can be communicated through *reports, parents' meetings, school open days, parent-teacher conferences, phone calls, letters, newsletters*, etc. All reporting is done in percentages.

The various achievement levels and their corresponding percentage bands are as shown in the table below. The seven point scale should have descriptions that give sufficient information for each level and this should be contained within the report for efficient communication to parents and other stakeholders.

Codes and Percentages for Reporting in Grades R – 12:

Rating Code	Description of Competence	Percentage
7	Outstanding Achievement	80 - 100
6	Meritorious Achievement	70- 79
5	Substantial Achievement	60 - 69
4	Adequate Achievement	50 - 59
3	Moderate Achievement	40- 49
2	Elementary Achievement	30- 39
1	Not Achieved	0 - 29

Schools are required to provide *quarterly feedback to parents* on the Programme of Assessment using a formal tool such as a report. The report should indicate the *overall level of performance* of a student.

CHAPTER 1: BIODIVERSITY AND CLASSIFICATION OF MICRO-ORGANISMS

Overview

Time allocation: 3 weeks (12 hours)

This chapter consists of the following sections:

1. Introduction
2. Key concepts
3. The classification of organisms, based on structure and general characteristics – viruses, bacteria, Protista and fungi.
4. The role of micro-organisms play in maintaining a balance in the environment
5. Symbiotic relationships
6. Diseases caused by micro-organisms
7. Immunity
8. The use of drugs to fight infecting micro-organisms
9. Biotechnology
10. Traditional technology
11. Summary
12. End of topic exercises

Introduction

This chapter focusses on the variety and classification of micro-organisms. Not all micro-organisms are harmful. Many of them are useful and play an important role in the ecosystem. Man can use micro-organisms to produce medicines as well as foods such as bread and cheese.

Key concepts

- All living organisms are divided into 5 Kingdoms.
- Viruses do not fit into a Kingdom.

- Organisms can be either prokaryotic or eukaryotic.
- Micro-organisms can form symbiotic relationships with each other or with other organisms.
- Species from each group of micro-organisms are responsible for a variety of diseases.
- Micro-organisms can be used to manufacture medicines while others are used in the food industry.

The classification of organisms

Learners are introduced to the term biodiversity and the **five kingdom** classification of all living organisms. Only micro-organisms must be dealt with in detail as the Kingdom Plantae and Animalia are dealt with in later chapters.

Explaining classification: https://www.youtube.com/watch?v=oID1h-zL-uw

Viruses do not fit into any of the five kingdoms. Revise the **characteristics of living things** learnt in grade 10. Encourage learners to list all the non-living characteristics of viruses as well as all the living characteristics. Mention some of the diseases caused by viruses which learners are familiar with such as flu, chicken pox and HIV/Aids.

Bacteria belong to the Kingdom Monera. They occur in three basic shapes and these shapes are an important diagnostic tool used to identify the various types of disease causing bacteria. Learners should be able to draw and label a typical bacillus bacterium. The similarities as well as the differences between bacterial and plant cells should be emphasized. The concepts prokaryotic and eukaryotic must be explained. Binary fission which is a type of mitotic division (dealt with in grade 10) should be discussed. The rate of multiplication in bacteria should be emphasised.

Fresh pond algae or seaweeds can be used to introduce the Protista. It is important however, to emphasize that most Protista are microscopic and that some are plant-like while others are animal-like. Videos demonstration phagocytosis by an Amoeba are available on the internet.

Phagocytosis: https://www.youtube.com/watch?v=pvOz4V699gk

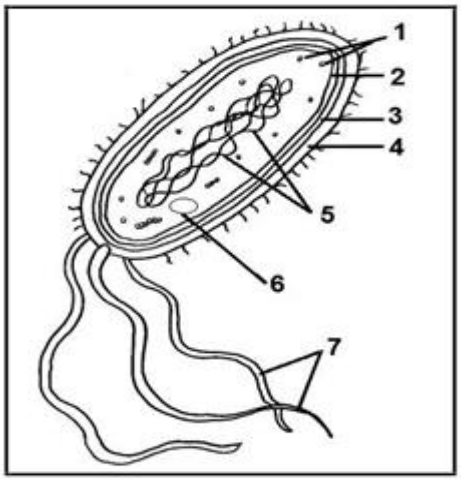
All fungi are made up of **hyphae** and all the hyphae together are called a **mycelium**.

Activity 1: Kingdoms

1. Name the five kingdoms which represent all living organisms. (5)

   Monera ✓, Protista ✓, Fungi ✓, Plantae ✓, Animalia ✓

2. Make a labelled diagram to show the internal structure of a bacterium. (6)



   1 ribosomes, 2 cell membrane, 3 cell wall, 4 waxy capsule, 5 chromosome, 6 plasmid, 7 flagella ✓ - for any 6 correct labels

3. Name one important characteristic which distinguishes fungi from algae. (2)

   Algae can photosynthesise ✓ whereas fungi cannot produce their own food ✓

4. Explain why viruses are not placed into one of the five kingdoms. (2)

   Viruses exhibit some non-living characteristic ✓ e.g. cannot feed, reproduce, respire etc. ✓

5. Complete the following table: (12)

Organism	Unicellular/ Multicellular	Prokaryotic / Eukaryotic	Mode of nutrition
Viruses	acellular	neither	none✓
Bacteria	cellular✓	prokayotic✓	Some are autotrophic and others are heterotrophic.✓
Phytoplankton	cellular✓	eukaryotic✓	autotrophic
Zooplankton	cellular✓	eukaryotic✓	heterotrophic✓
Fungi	cellular✓	eukaryotic✓	heterotrophic✓

(27)

Activity 2: Practical investigation

Aim: Investigating the growth of bread mould under different temperature conditions.

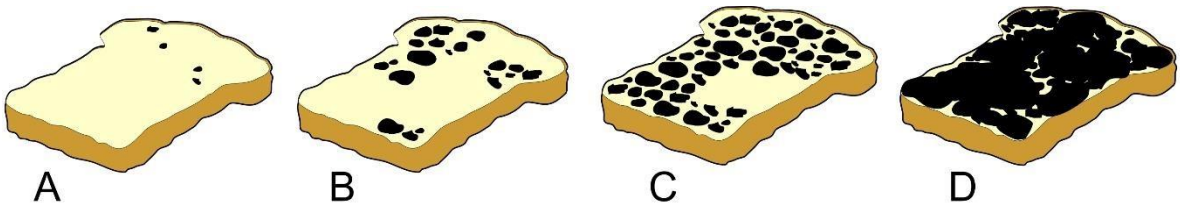
In this investigation learners are required to apply what they have learnt about the ideal growth requirements of fungi.

A Grade 11 learner investigated the optimum (ideal) temperature for growth of bread mould.

The learner used the following method:

- The learner selected four black plastic containers with lids.
- A slice of bread was placed in each container.
- Before closing the containers, 30 mL of water was sprinkled over each slice.
- Container **A** was placed in a fridge, container **B** was placed in a cool cupboard, container **C** was kept at room temperature and container **D** was placed on a warm window sill.
- After a week the slices of bread were removed from the containers and placed next to each other.

The results of the investigation are depicted below.



1. Formulate a hypothesis for the investigation. (2)

   The bread mould placed in the container on the warm windowsill will grow faster than any of the other bread moulds in the other containers. ✓ for each variable mentioned, and related

   The hypothesis does not have to be the correct result of the investigation but must compare two variables.

2. Name the (a) dependant and rate of growth of the bread mould ✓

   (b) independent variable in this investigation. temperature ✓ (2)

3. State the relationship between the growth of bread mould and temperature. (2)

   The warmer the temperature ✓ the faster the bread mould grows ✓.

4. Describe 3 ways in which the learner made sure that the results were valid. (3)

   The following variables were kept constant: size of bread slice, type of bread,

amount of water, type of container ✓ - any three

5. How could the learner have ensured that the results were reliable? (2)

   Repeat the experiment ✓ or increase the number of slices of bread ✓ investigated.

6. Use the following scale to determine the percentage of bread mould growing on the slices of bread. Record the estimations in a table. (5)

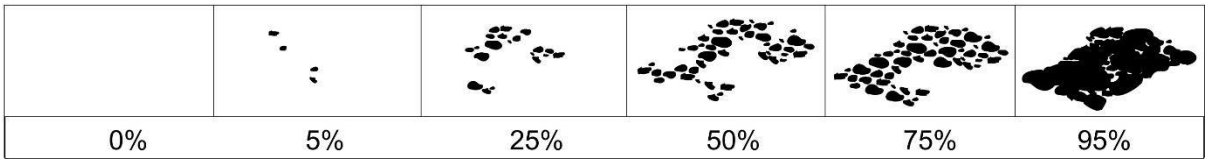
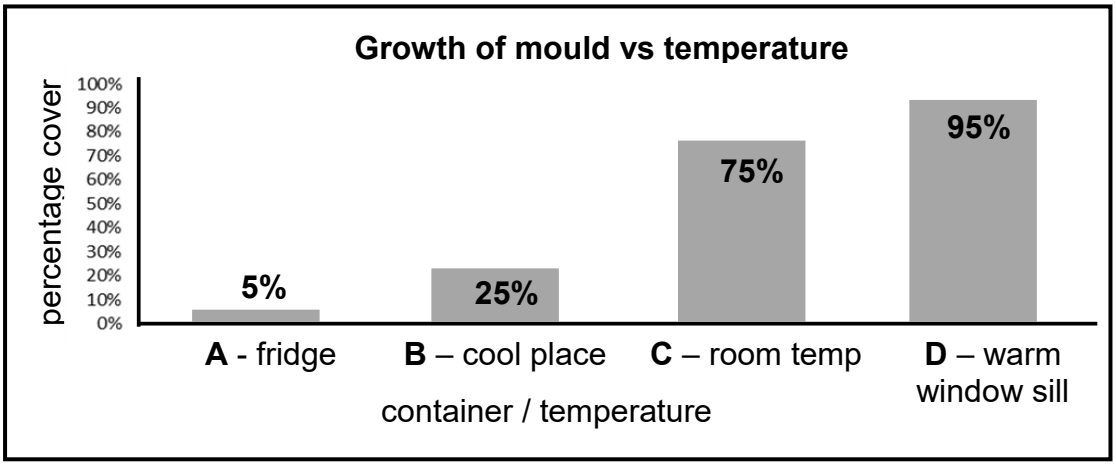


Table: Percentage cover of bread mould in the various containers.

Container	Percentage cover
A	5%
B	25%
C	75%
D	95%

✓ - for table, ✓ - for each correct estimation

7. Plot a bar graph to show the relationship between temperature (cold, cool, mild and warm) and the growth of breadmould using the table. (6)



Graph to include the following:

Title: The relationship between temperature and the growth of breadmould. ✓

X-axes: container A B C D ✓

Y-axes: Percentage cover ✓

Bar graph ✓

Correctly plotted ✓ ✓ (22)

The role that micro-organisms play in maintaining a balance in the environment

Without decomposing micro-organisms, dead plant and animal matter would accumulate, and soil would become depleted of nutrients. It is important to emphasize that not all micro-organisms are harmful. Micro-organisms form an integral part of the ecosystem.

The nitrogen cycle was taught in grade 10 but can be used to illustrate the importance of bacteria and the recycling of nutrients. Micro-organisms can also be used as biological control agents.

Symbiotic relationships

Symbiosis refers to the living together of two different types of organisms. Three types of symbiosis occur namely mutualism, parasitism and commensalism. Only examples of micro-organisms must be studied in this chapter. Examples of symbiosis in animals, are studied in Grade 12.

It is easy to show learners what lichens look like. Lichens can be found on trees and can often be found on pieces of wood sold as firewood. Learners will encounter the term lichen again in Grade 12 when they learn about the evolution of the peppered moth.

Types of symbiosis: https://www.youtube.com/watch?v=zSmL2F1t81Q

Activity 3: Nitrogen use

1. Name the form of nitrogen which higher plants use. (1)

   Nitrogen must be in the form of nitrates ✓

2. Describe three ways in which nitrogen becomes available to higher plants. (3)

   Lightening converts nitrogen and oxygen to nitrates ✓, free living soil bacteria can form nitrates ✓ as can root nodule bacteria ✓

3. What is a lichen? (3)

   A lichen is a mutualistic relationship ✓ between a fungus ✓ and an algal species ✓

4. Describe the role bacteria play in maintaining the nitrogen balance in an eco-system. (6)

   Plants cannot use nitrogen directly from the air✓. Bacteria are able to fix nitrogen ✓ in the form of nitrates which plants can use ✓. When plants and animals die ✓,

nitrogen is returned to the atmosphere ✓ by denitrifying (decomposing) bacteria ✓.

5.1 What is a mycorrhiza? (2)

It is a filamentous fungus ✓ that can penetrate the roots of plants ✓.

5.2. Explain why the seedling on the right-hand side is bigger than the seedling on the left-hand side. (3)

The fungus has penetrated the roots of the seedling on the right ✓, and so increased the absorption surface area of the roots ✓. Thus the plant can absorb more nutrients and water and grow faster than the seedling on the left ✓.

(18)

Diseases caused by micro-organisms

Only **one** disease caused by each of the following groups must be studied: viruses (rabies, HIV/aids, or influenza), bacteria (blight, cholera, tuberculosis, or anthrax) protists (malaria) and fungi (rusts, thrush, ringworm and athlete's foot).

Learners must be able to describe the symptoms of the disease as well as the effect it has on a community. Management of the disease includes not only the curing of the disease but also prevention.

Learners can be asked to bring infected plant leaves form their gardens to school to study. Rust fungi are common on roses and plants growing in the shade often have moulds on their leaves.

Activity 4: Diseases

Complete the following table: a mark for each block filled in correctly

Disease	Organism responsible	Symptoms	Management and cure
rabies	rabies virus	headaches, nausea, fatigue, fever / dogs foam at mouth	vaccination, immunization, destroying infected animals
AIDS	HIV (virus)	loss of weight, secondary infections	anti-retrovirals, no cure, education
influenza	virus	coughing, sneezing, aching body, fever	proper diet, antibiotics have no effect

cholera	Bacterium *Vibrio cholerae*	diarrhoea	education regarding clean water, sanitation
tuberculosis	*Mycobacterium tuberculosis*	coughing, blood in sputum, weight loss, loss of appetite, fever and chills	antibiotics, education
anthrax	*Bacillus anthracis*	itchy bumps with a black centre, breathing problems	antibiotics and vaccines
malaria	*Plasmodium* spp.	fever, headaches, flu-like symptoms	prevention, anti-malaria medications, medication if infected
thrush	*Candida* spp.	white coating in the mouth	anti-fungal mouth wash, antibiotics
ringworm	fungus	scaly round spot on the skin	fungicide cream
athlete's foot	fungus	blistering of skin	fungicide cream or powder
rusts	fungus	loss of green colour in the leaf, raised rust-like spots on the underside	fungicide, remove and burn affected plant material
blight	bacterium	wilting and dying back	fungicide, remove and burn infected plant matter

(36)

Immunity

Plants are adapted to prevent microorganisms from entering their cells. Learners should draw on the knowledge they gained in Grade 10 regarding plant structure e.g. the presence of a cuticle, an epidermis consisting of tightly packed cells etc. Plants produce chemicals (e.g. salicylic acid) in response to infections. Wounds are sealed with gum. In addition, healthy plants have a natural immunity.

Humans also have ways in which they prevent infections. Learners need to be able to distinguish between the different types of immunity; namely natural immunity, acquired immunity and artificially acquired immunity.

Learners should be able to explain why pre-school children are vaccinated.

Encourage them to research for which diseases vaccinations are produced.

The use of drugs to fight infecting micro-organisms

This section studies the use of antibiotics to destroy bacteria. Emphasise the importance of completing a course of antibiotics and the development of drug resistant organisms. Use TB treatment as an example. Also introduce the importance of probiotics although it is not examinable.

Biotechnology

This concept is dealt with again in Grade 12, so it is important that learners know the structure of bacterial cells. Briefly explain the importance of insulin in the treating of diabetes. Diabetes is studied in more detail in the Animal Nutrition chapter. The term biotechnology must be explained as well as use of bacterial plasmids in the manufacture of insulin.

For enrichment learners can be asked to research the accidental discovery of penicillin by Alexander Fleming. Fleming was culturing a staphylococcus bacterium when he noticed that a mould (later identified as *Penicillium*) had contaminated part of his culture. The mould inhibited the growth of the bacterial culture.

How insulin is made: https://www.youtube.com/watch?v=yIwXBaxA0TU

Traditional technology

The process of anaerobic respiration is dealt with in a later chapter on cellular respiration, so details are not required at this stage. Learners should be aware that the waste products of cellular respiration namely carbon dioxide and alcohol are used by man to make various products such as bread, wine, beer and cheeses.

Many of the organisms used occur naturally in the air and on the products produced e.g. yeasts on the skins of grapes.

Useful bacteria: https://www.youtube.com/watch?v=eksagPy5tmQ

Summary

- All living organisms are classified into 5 kingdoms: Monera, Protista, Fungi, Plantae and Animalia.
- Organisms are placed in separate kingdoms based on the presence or absence of a cell wall, whether or not they are prokaryotic or eukaryotic and their mode of nutrition.
- The Monera, Protista and Fungi are classified as micro-organisms. Viruses do not fit into any of these kingdoms because they display some non-living characteristics.
- A large number of diseases are caused by viruses and micro-organisms. Only one disease from each group must be studied.
- Organisms are born with a certain degree of natural immunity to diseases, but they can acquire immunity after being exposed to a disease. Artificially acquired immunity involves the administration of vaccines.
- Micro-organisms play an important role in the ecosystem. They are responsible for the break down of dead organic matter and the return of nutrients to the soil and atmosphere.
- Micro-organism can be used to manufacture medicines such as insulin and antibiotics.
- Anaerobic (alcoholic) fermentation by micro-organisms produces a variety of foods such as bread, mass and wine.

End of topic exercises

Section A

Question 1

1.1 Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A – D) next to the question number (1.1.1 – 1.1.5) on your answer sheet, for example 1.1.6 D

1.1.1 Antibodies are proteins that…

A break down pathogens.

B catalyse biochemical reactions.

C are produced by T-cells that kill disease carrying viruses.

D **bind with specific antigens.** ✓✓

1.1.2 Which organism does not belong to a kingdom?

A **Virus** ✓✓

B Fungus

C Bacterium

D Protozoan

1.1.3 The following is a list that describes viruses:

i) They play an important role as decomposers.

ii) They are major pathogens of humans.

iii) They are parasites.

iv) They reproduce within a host cell.

Which of the following are of biological importance in viruses?

A (i), (ii) and (iii)

B **(ii), (iii) and (iv)** ✓✓

C (i), (iii) and (iv)

D (ii) and (iv)

1.1.4 The cell walls of most fungi are mainly composed of:

A **Chitin** ✓✓

B cellulose

C protein

D lignin

1.1.5 The use of antibiotics is an effective treatment for …

A bacterial and viral infections.

B **bacterial infections only. ✓✓**

C viral infections only.

D neither viral nor bacterial infections.

(5 × 2) = (10)

1.2 Give the correct **biological term** for each of the following descriptions. Write only the term next to the question number.

1.2.1 Microbes which cause disease. pathogens ✓

1.2.2 Viruses that attack bacteria. bacteriophages ✓

1.2.3 A relationship between two organisms which live together for the benefit of one or both of the organisms. symbiosis ✓

1.2.4 The ability to produce antibodies. immunity ✓

1.2.5 The use of micro-organisms to make useful substances. biotechnology ✓

1.2.6 An organism that transfers a pathogenic organism from one host to another. vector ✓

1.2.7 Plant-like Protista. phytoplankton ✓

1.2.8 The mutualistic relationship between a fungus and an alga. lichen ✓

1.2.9 Organisms that have a definite nucleus. eukaryotes ✓

1.2.10 The process used by lymphocytes to engulf bacteria. phagocytosis ✓

(10 × 1) = (10)

1.3 Indicate whether each of the descriptions in Column I applies to **A ONLY**, **B ONLY**, **BOTH A AND B** or **NONE** of the items in Column II. Write **A only**, **B only**, **both A and B** or **none** next to the question number.

Column I	Column II
1.3.1 Organisms that feed on dead organic matter.	A: saprophytes B: parasites
1.3.2 Genetic material found in viruses.	A: DNA B: RNA
1.3.3 Malaria is caused by a…	A: bacterium B: virus
1.3.4 Whip-like structures used for locomotion in bacteria.	A: flagella B: cilia

(4 × 2) = (8)

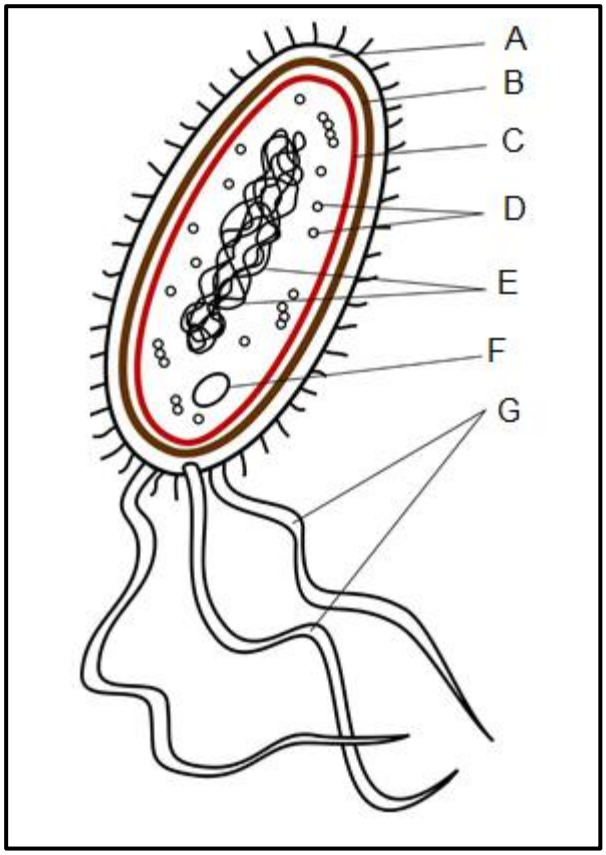
1.3.1 **A only ✓✓**

1.3.2 **Both ✓✓**

1.3.3 **None ✓✓**

1.3.4 **A only ✓✓**

1.4 The diagram below is that of a bacterial cell. Study it carefully and then answer the questions that follow.



1.4.1 Provide labels for the parts labelled A to D. (4)

A: slime layer ✓, B: cell membrane ✓, C: cell wall ✓, D: ribosomes ✓

1.4.2 State the function of the part labelled E. (1)

Contains the genetic information ✓

1.4.3 Describe how the structure labelled F can be used in the manufacturing of insulin for diabetics. (5)

A piece of DNA ✓ responsible for insulin production is removed from a human pancreas ✓ cell and inserted into the plasmid of a bacterium ✓ . The bacterium then manufactures insulin ✓. Bacteria are cultivated in large vats ✓

1.4.4 Briefly explain how bacteria develop resistance to antibiotics and how humans can contribute to this phenomenon. (3)

If a person does not finish a course of antibiotics, only the weaker bacteria are killed ✓ and the remaining bacteria start to multiply ✓

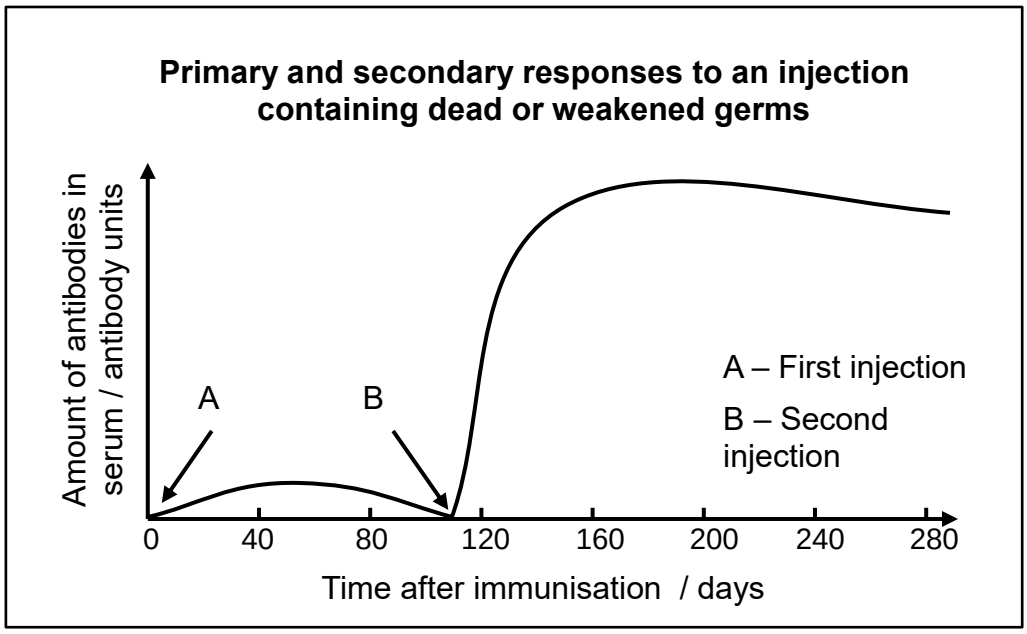
and become are more resistant to antibiotics ✓

1.4.5 Identify the structure labelled G and state its function. (2)

Structure G is a flagellum ✓ and is responsible for locomotion ✓.

(15)

1.5 Study the graph below, which gives the body's response to a vaccination given by an injection and a booster injection. Answer the questions that follow.



1.5.1 What happened to the antibody level after the first injection? (2)

Increased ✓ and then decreased again ✓

1.5.2 What would happen to the person if they encountered the disease organism after the second injection? (1)

They would be immune to the disease ✓

1.5.3 Mention two common ways of receiving vaccines. (2)

Injection ✓, orally ✓

1.5.4 From what is a vaccine made? (1)

A vaccine is a suspension of dead, weakened or fragmented micro-organisms or their toxins ✓

1.5.5 Which cells in the immune system produce the antibodies? (1)

B- lymphocytes ✓

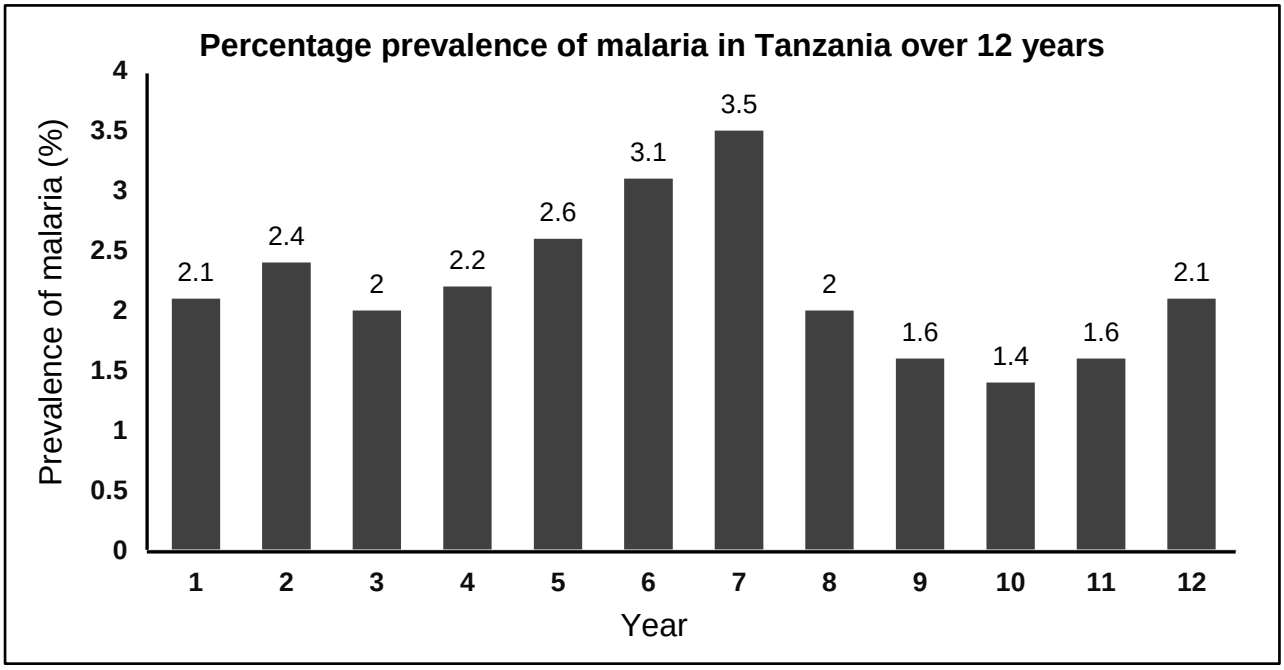
(7)

Section A: [50]

Section B

Question 2

Use the graph below to answer the following questions:



2.1 In which year was the percentage malaria the highest? (1)

7th year ✓

2.2 Calculate the percentage increase in malaria infections from year 3 to year 6. Show all working. (3)

3,1 ✓ – 2 ✓ = 1,1% ✓ increase

2.3 Name two precautionary methods that can be implemented to prevent contracting malaria when travelling in a malaria infested area. (2)

- prophylactic medication
- use insect repellent
- use mosquito nets
- stay inside when it is dark outside, preferably in a screened or air-conditioned room
- wear protective clothing
- avoid areas where malaria and mosquitoes are present if you are at higher risk (pregnant, very old, very young etc.)

(mark any two)

2.4 Give two symptoms of malaria. (2)

- high fever

- shaking chills and sweating
- throwing up or feeling nauseous
- headache
- diarrhoea
- being very tired (fatigued)
- body aches
- yellow skin (jaundice) from losing red blood cells
- kidney failure
- coma

  (mark first correct two)

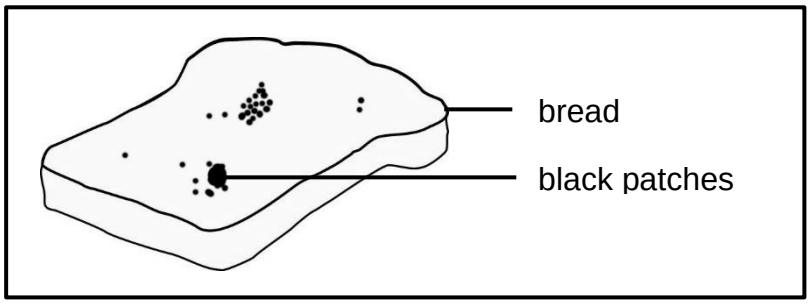
2.5 Give two possible reasons for the decline in the number of malaria cases after year 7. (2)

People used mosquito nets, the inside walls of houses were sprayed with insecticide, distribution of anti-malaria drugs, government sprayed mosquito infected areas (Mark any two correct answers)

[10]

Question 3

3.1 During the holidays a learner forgot to take his lunch box out of his school bag. Inside were some uneaten sandwiches. At the beginning of the following term his mother found black, furry patches growing on the left-over bread.



3.1.1 Identify the organism most likely to be responsible for the growth on the bread. (1)

rhizopus ✓

3.1.2 Name three conditions which made the lunch box a suitable environment for the organism mentioned in 3.1.1 to grow. (3)

adequate food ✓, moisture ✓, warmth ✓

3.1.3 Name three ways in which this type of growth on bread and other foods can be prevented. (3)

drying, canning, freezing, salting, vacuum packing ✓ – any three

(7)

3.2 A student investigated the number of bacteria on the skin of people's hands after they washed and dried it. The same washing method was employed, but hands were dried either by using hot air from a hot air blower or by using paper towels. Swabs were used to take samples from the dried skin and bacteria were cultured from the swabs. The table below shows the number of bacteria that was cultured.

Study the table below and answer the questions that follow.

Samples	**Number of bacteria ($\times 10^8$) per square centimetre (cm^2) on hand skin following washing and drying**	
	Air-dried skin	Towel-dried skin
1	8,91	1,11
2	9,75	0,98
3	6,14	0,42
4	8,72	1,02

3.2.1 Write down the aim for this investigation. (1)

To determine which method of drying your hands is better – air blowing or towel drying.✓

3.2.2 Suggest three factors that must be kept constant in this investigation to make this a valid test. (3)

Using the same conditions for washing (same type and amount of soap, same rinsing time, same water source etc.) ✓

Use the same people to test both methods ✓

Same environmental conditions (atmospheric pressure, temperature etc.) ✓

3.2.3 Write down the conclusion the student could make based on the results of this investigation. (3)

Air-dried skin samples ✓have a far greater number of bacteria ✓ than the towel-dried skin. ✓

(7)

3.3 A type of bacterium called *Escherichia coli (E.coli)* normally lives in the large intestine of humans. To determine whether *E.coli* is present in water, a chemical indicator is used. If the chemical indicator changes from a clear red colour to a cloudy yellow colour, this indicates that *E.coli* is present.

In an investigation conducted by a group of Grade 11 learners, samples taken from three rivers (X, Y and Z) were investigated for the presence of *E.coli*. Samples were taken from each river and put into glass bottles, which contained the clear red indicator solution. The bottles were then incubated at 37°C for two days. Only river Y showed presence of *E.coli*.

3.3.1 Explain two safety precautions that the learners should take when conducting this investigation. (2 × 2) = (4)

Wear rubber gloves ✓ to avoid contamination ✓.

Samples bottles should be attached to a string ✓ to prevent slipping and falling in the river / drowning / contamination ✓

3.3.2 Suggest ONE reason for incubating the sample at 37°C. (1)

Human body temperature at which the bacteria normally live ✓.

3.3.3 State how *E.coli* could have entered river Y. (1)

Lack or absence of proper sewage system ✓

Human faeces contaminating the water ✓

(Mark any one correct answer)

(6)

[20]

Section B: [30]

Total marks: [80]

Cognitive level distribution

Question	Level 1	Level 2	Level 3	Level 4	Marks
1.1.1	✓				2
1.1.2	✓				2
1.1.3		✓			2
1.1.4	✓				2
1.1.5	✓				2
	8	2			10
1.2.1	✓				1
1.2.2	✓				1
1.2.3	✓				1
1.2.4	✓				1
1.2.5	✓				1
1.2.6	✓				1
1.2.7	✓				1
1.2.8	✓				1
1.2.9	✓				1
1.2.10	✓				1
	10				10
1.3.1		✓			2
1.3.2		✓			2
1.3.3		✓			2
1.3.4		✓			2
		8			8
1.4.1	✓				4
1.4.2	✓				1
1.4.3			✓		5
1.4.4				✓	3
1.4.5	✓				2
	7		5	3	15
1.5.1		✓			2

1.5.2			✓		1
1.5.3	✓				2
1.5.4	✓				1
1.5.5	✓				1
	4	2	1		7
2.1.1		✓			1
2.1.2				✓	3
2.1.3	✓				2
2.1.4	✓				2
2.1.4				✓	2
	4	1		5	10
3.1.1	✓				1
3.1.2		✓			3
3.1.3		✓			3
	1	6			7
3.2.1			✓		1
3.2.2		✓			3
3.2.3		✓			3
		6	1		7
3.3.1			✓		4
3.3.2		✓			1
3.3.3		✓			1
		2	4		6
	34	27	11	8	80

CHAPTER 2: BIODIVERSITY OF PLANTS

Overview

Time allocation: 3 weeks (12 hours)

Four divisions of plants are considered: bryophytes, pteridophytes, gymnosperms and angiosperms. They have a number of characteristics in common placing them in the Kingdom Plantae. They show a decreasing dependence on water to complete their life cycles. Most plants are able to reproduce asexually as well as sexually and the advantages and disadvantages of both are discussed. Flowers are leaves modified to attract certain pollinators. The significance of seeds is also discussed.

This chapter consists of the following sections:

1. Key concepts
2. Introduction
    a. Division Bryophyta
    b. Division Pteridophytes
    c. Division Gymnosperms
    d. Division Angiosperms
3. The decreasing dependence on water for reproduction
4. Asexual and sexual reproduction
5. Flowers as reproductive structures
6. Adaptations of flowers for pollination
7. The significance of seeds
8. Seed banks
9. Summary
10. End of topic exercises

Key concepts

- All plants are thought to have evolved from unicellular algae.
- There are four major plant groups: bryophytes, pteridophytes, gymnosperms and angiosperms.
- As plants have evolved, they have become less dependent on water to complete their life cycles.

- Plants in the Kingdom Plantae have an alternation of generation in their life cycles.
- Angiosperms produce flowers to protect their seeds and to attract pollinators.
- It is important to maintain biodiversity and for this reason seeds are stored in seed banks.
- Many types of seeds form the staple diet of poorer countries.

Introduction

All plants are thought to have evolved from simple unicellular algae. Four major plant groups exist:

- Division Bryophyta
- Division Pteridophyta.
- Division Gymnospermae (Gymnosperms)
- Division Angiospermae (Angiosperms)

Leaners must be familiar with the function of a phylogenetic tree i.e. it shows the evolutionary relationship between organisms. Once the chapter has been completed it is important to refer back to the phylogenetic tree to emphasize the characteristics which separate the groups from each other. When discussing each of the groups, the four major characteristics:

- the presence or absence of true conducting tissues, e.g.: xylem and phloem
- the presence or absence of true, roots stems and leaves
- the type of reproduction and reproductive structures formed
- the degree of dependence on water for reproduction must be referred to

The characteristics which the four groups of plants have in common must also be stressed as well as the characteristics which separate the kingdom Plantae from all other kingdoms.

Division Bryophyta

While the division Bryophyta includes mosses, liverworts and hornworts, the learners only need to learn about mosses in more detail. It is important that learners understand the concepts of a thallus and a life cycle with an alternation of generation. Learners do not need to be able to draw and label a figure of a typical moss but should recognize a moss plant.

Division Pteridophytes

Learners must be able to recognise and label the sporophyte generation of a fern. Revise the structure of simple and compound leaves, as well as nodes and internodes, as learnt in Grade 10. Ferns are the first group to show vascular tissue. Emphasize how important this and other features are in allowing ferns to grow larger than mosses. Both ferns and mosses are dependent on water for fertilization and therefore require a damp shady habitat.

Division Gymnosperms

Learners must focus mainly on the pine tree as an example of this division.

Gymnosperms have true roots, stems and leaves. Vascular tissues, namely xylem and phloem are present. Learners must be able to distinguish between gymnosperms and angiosperms. Pine trees are common in South Africa although they are not indigenous. Collect pine cones or ask learners to bring some to school. A practical lesson where learners open cones to find the winged seeds on the scales will help them to understand the features which separate gymnosperms from angiosperms.

Division Angiosperms

Learners must be able to draw and label a longitudinal section through a typical flower. They do not need to distinguish between monocotyledonous and dicotyledonous flowers. The characteristics which make angiosperms successful on land must be emphasized. Detailed study of the divisions is NOT required.

The decreasing dependence on water for reproduction

As plants have increased in size over millions of years, they have become progressively less dependent on water for their survival and for the completion of their life cycles. The decreasing dependence of higher plants on water can be used to explain why higher plants tend to be bigger and more successful than both mosses and ferns.

Asexual and sexual reproduction

Animals and plants are capable of asexual and sexual reproduction. Learners must be able to compare the advantages and disadvantages of both forms of reproduction.

Flowers as reproductive structures

Learners must be able draw and label a longitudinal section through a typical flower. They must also be able to distinguish between self- and cross-pollination.

Adaptations of flowers for pollination

Adaptation shown by flowers for wind, insect and bird pollination must be studied and compared.

Activity 1: Pollination and parts of flowers

1. Study the pictures below and indicate if they are pollinated by insects, birds or by the wind. Give a reason that is visible in picture for your answer. (10)

A

B

C

D

E

A. insect pollinated ✓ – bright colour, open flower ✓

B. wind pollinated ✓ – stamens protrude from the flower ✓

C. wind pollinated ✓ – large amounts of pollen produced ✓

D. bird pollinated ✓ – narrow flowers on a study stem ✓

E. insect pollinated ✓ – colourful, distinct markings ✓

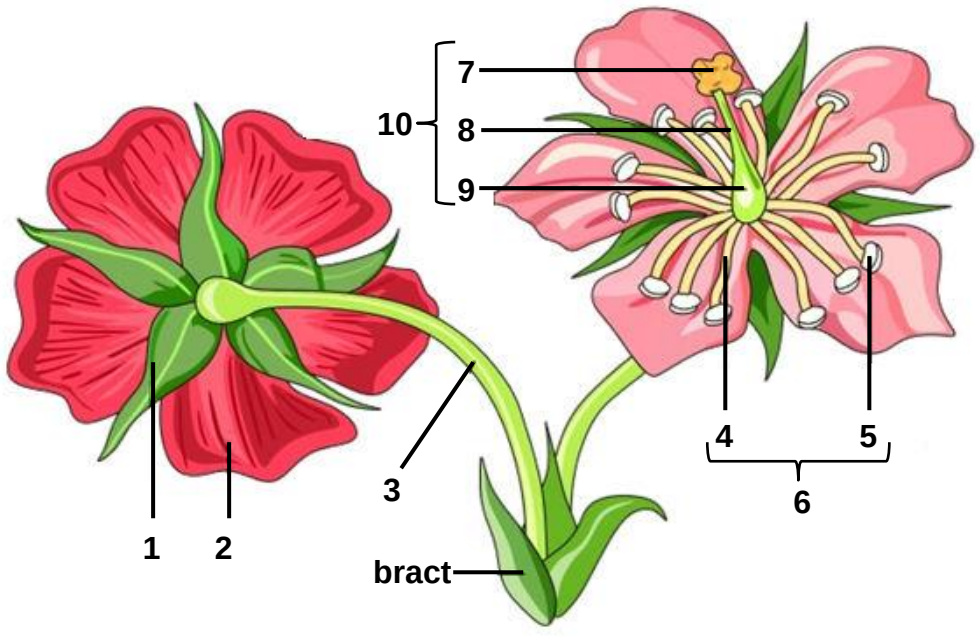
2. The following table compares flowers which are pollinated by pollinators with flowers which are wind pollinated. Copy the table into you book and complete it.

Table: The difference between pollinator and wind pollinated flowers.

Feature	Pollination by a pollinator	Wind pollinated
Flower	colourful	small and inconspicuous
Stigma	held inside the flower	protrude from the flower
Stamens	inside the flower	protrude from the flower
Pollen	sticky pollen	large amounts of dry pollen
Scent	strongly scented	no scent
Energy spent	energy spent making nectar and pollen	large amount of energy wasted on producing pollen

(✓ – for each block correctly filled in) (11)

3. Supply labels for the following diagram.



1. sepal (calyx) ✓, 2. petal (corolla) ✓, 3. pedicel ✓, 4. filament ✓, 5. anther ✓, 6. stamen ✓, 7. stigma ✓, 8. style ✓, 9. ovary ✓, 10. pistil ✓

(31)

The significance of seeds

While the syllabus does not emphasize the difference between mono- and dicotyledonous plants, the concept of a cotyledon is best explained using, for example, a bean and a maize seed. Learners should be able to draw a longitudinal section through a bean seed.

Seed banks

There are more than 1000 seedbanks worldwide. The concept of a seedbank and the importance of seedbanks must be emphasized. This topic reiterates the concepts of biodiversity, genetic diversity and hybridization. Learners must be made aware that plants are not only an important food source and producer of oxygen, but many of them have medicinal value. The value of some may not even have been discovered yet so it is important that we do not let them die out.

Activity 2: Seed banks

1. Give two reasons why seed banks are important. (2)

   Maintain biodiversity, research purposes, keep seeds of rare and endangered species, often store original seeds rather than hybridized seeds. ✓ – any 2

2. Before seeds are frozen in a seed bank they are dried. Explain why. (2)

   Prevents the seeds from rotting ✓, frozen water forms ice crystal which could damage the seeds ✓

(4)

For enrichment

The following YouTube videos are relevant to this chapter:

https://www.youtube.com/watch?v=jINRLEYp3ck
https://www.youtube.com/watch?v=dbCqJllF6kw
https://www.youtube.com/watch?v=HP21hIVJhWI
https://www.youtube.com/watch?v=h9oDTMXM7M8
https://www.youtube.com/watch?v=iWaX97p6y9U

Summary

Classification

- The plant kingdom is divided into four major divisions: Bryophytes, Pteridophytes, Angiosperms and Gymnosperms
- All the plants in the four divisions are multicellular and eukaryotic. They have cell walls made of cellulose and chloroplasts for photosynthesis.
- Characteristics such as the type of reproduction, the presence or absence of conducting tissues, true roots etc. are used to distinguish the divisions.

Division Bryophyte (mosses)

- Bryophytes (mosses) are characterised by a lack of vascular tissues and do not have true roots, stems or leaves.
- Mosses exhibit an alternation of generation. The gametophyte is the dominant generation.
- Water can be absorbed directly through the leaflets of mosses because there is no cuticle on the surface of moss leaflets.
- Moss sperm cells are motile and rely on water to reach the ovum for fertilization.

Division Pteridophyte (ferns)

- Pteridophytes (ferns) are slightly better adapted to life on land than mosses. They have vascular tissues and true roots, stems and leaves.
- The sporophyte generation is dominant in ferns. Fertilization depends on water.

Division Gymnosperms

- Gymnosperms include cycads, *Gingko biloba*, *Welwitschia* and pine trees.
- Gymnosperms all produce seeds which develop in cones.
- Pine trees are characterised by needle-like leaves, vascular tissues and true roots, stems and leaves.
- The sporophyte generation is the dominant generation.
- Large amounts of pollen are produced by male cones and carried by wind to the ovules in female cones.
- Gymnosperms are well adapted to life on land.

Division Angiosperms (flowering plants)

- The sporophyte generation is the dominant generation in angiosperms. It

consists of true roots, stems and leaves. Xylem and phloem are responsible for transporting water and photosynthetic products, respectively.

- Angiosperms produce flowers that show various adaptations to make sure that pollination takes place.
- The ovules of angiosperms are protected by an ovary. After fertilization the ovule forms a seed and the ovary wall forms the fruit.

The decreasing dependence on water for reproduction

- As plants have increased in size over time, they have become progressively less dependent on water for their survival and for the completion of their life cycles. Both mosses and ferns rely on water to complete their life cycles.
- Gymnosperms and angiosperms are better adapted for life on land.

Sexual and asexual reproduction

- The advantage of asexual reproduction is that only one parent is required. Asexual reproduction is quicker, and all the offspring are identical. Asexual reproduction does not rely on pollinators or dispersion agents.
- All the offspring produced by asexual reproduction are genetically identical. If conditions become unfavourable, they will all die. Poor characteristics in the parents will be passed on to the offspring.
- Rapid multiplication by asexual reproduction may lead to overcrowding.
- Sexual reproduction produces offspring that are genetically different. This is an advantage because they can withstand a variety of conditions.
- Farmers can select organisms with desirable characteristics and cross-breed with them.
- Two parent plants are required for sexual reproduction which is a disadvantage.
- Plants that reproduce sexually rely on pollinating agents and dispersal agents to spread their seeds.

Flowers as reproductive structures

- Flowers are made up of four whorls: the calyx, corolla, androecium and gynoecium.
- The calyx and consists of a number of green sepals. All the floral parts are attached to a receptacle. The corolla is made up of coloured petals to attract pollinators. The calyx and corolla are known collectively as the perianth.
- The androecium is the male part of the flower and is made up of several stamens.

- Each stamen consists of a filament and a bi-lobed anther.
- The female part of the flower usually consists of carpels fused together to form one or more pistils. Each pistil consists of a stigma, style and ovary. Ovules are formed inside the ovary by meiosis.
- Flowers contain and protect the reproductive organs and attract pollinators.

Pollination

- Pollination is the transfer of pollen from an anther to a stigma.
- Self-pollination occurs when pollen is transferred between flowers of the same plant or the anther and the stigma of the same flower.
- Cross-pollination occurs when pollen is transfer from the flower of one plant to the flower of another plant of the same species.

Adaptations of flowers for pollination

- Flowers that are pollinated by insects are usually large, brightly coloured and sweetly scented. They produce nectar and large amounts of sticky pollen.
- Flowers pollinated by birds produce large amounts of dilute nectar, little or no scent and are usually red in colour. The ovules are protected.
- Wind pollinated flowers are generally colourless and have no scent. The anthers and stamens usually protrude from the flowers. Large amounts of dry pollen are produced.

The Significance of Seeds

- Seeds are formed from fertilised ovules.
- Seeds either have one cotyledon (monocotyledons) or two cotyledons (dicotyledons) which store food for the developing embryo.
- Seeds are surrounded by a tough, protective seed coat called a testa. Seed banks
- A seed bank is a facility established to store seeds of both crop plants and wild crops to ensure that they do not become extinct.

Seeds as a food source

- Examples of seeds that humans cultivate, and harvest include coffee, maize, wheat, peas, soya beans and rice. Seeds such as beans, peas and soya beans are called pulses.
- Endemic seeds are seeds that are only found in a particular area.

End of topic exercises

Section A

Question 1

1.1 Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A – D) next to the question number (1.1.1 – 1.1.5) on your answer sheet, for example 1.1.6 D

1.1.1 Bryophytes are terrestrial plants that have no…

A cellulose
B rhizoids
C **vascular tissue** ✓✓
D sporophyte phase

1.1.2 The sporangia on the underside of fern leaves are called …

A sporophylls
B **sori** ✓✓
C cones
D sporogonia

1.1.3 Conserving endemic seeds in South Africa will enable the following:

A The protection of plants against disease.
B A lot of money to be made for South Africa.
C **The restoration of over-exploited medicinal plants** ✓✓.
D Food crops to be grown in dry conditions.

1.1.4 Alternation of generations is exhibited by…

A bryophytes
B pteridophytes
C spermatophytes
D **all plants** ✓✓

(4 × 2) = (8)

1.2 Give the correct **biological** term for each of the following descriptions. Write only the term next to the question number.

1.2.1 Reproduction which uses non-reproductive parts of a plant to produce new plants. vegetative reproduction ✓

1.2.2 Plants without true roots, stems and leaves. thallus ✓

1.2.3 Places where seeds are stored to help preserve biodiversity. seed banks ✓

1.2.4 A reproductive structure found in gymnosperms and angiosperms only, consists of a plant embryo with a protective coat. seed ✓

1.2.5 A group of plants that have seeds enclosed in an ovary. angiosperms ✓

1.2.6 The part of the plant embryo that develops into the root. radicle ✓

1.2.7 The tough outer coat of a seed. testa /seed coat ✓

1.2.8 The part of the flower that the fruit is derived from. ovary ✓

1.2.9 The collective name for a filament and an anther. stamen ✓

(9 x 1) = (9)

1.3 Indicate whether each of the descriptions in Column I applies to **A ONLY**, **B ONLY**, **BOTH A AND B** or **NONE** of the items in Column II. Write **A only**, **B only**, **both A and B** or **none** next to the question number.

Column I	Column II
1.3.1 A division of plants with a vascular system, seeds, and no flowers	A: Gymnosperm B: Angiosperm
1.3.2 The purpose of flowers	A: Attract pollinators B: Form fruit
1.3.3 Gametophyte is dominant	A: Ferns B. Mosses
1.3.4 Thallus plant	A: Bryophytes B: Pteridophytes
1.3.5 The part that is formed from a fertilised ovule	A: Fruit B: Seed

(5 × 2) = (10)

1.3.1 **A only ✓✓**

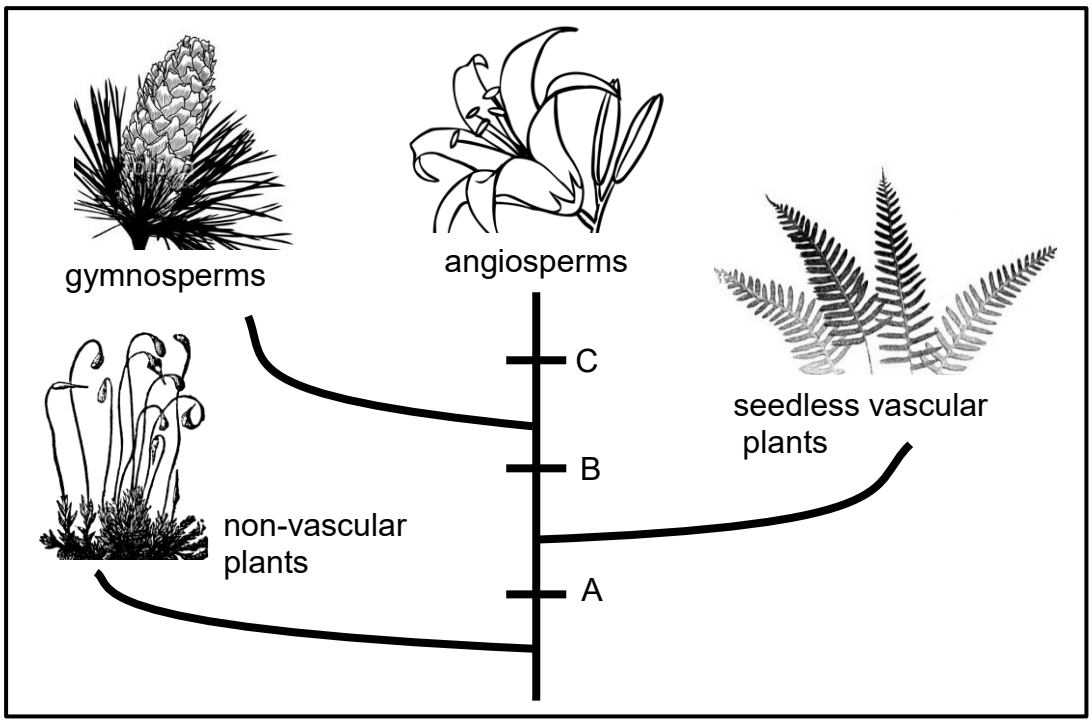
1.3.2 **A only ✓✓**

1.3.3 **B only ✓✓**

1.3.4 **A only ✓✓**

1.3.5 **B only ✓✓**

1.4 The diagram below is a cladogram of plants and their algal ancestors. A, B and C indicate key structural features in the evolution of higher plants. Study the diagram and answer the questions which follow.



1.4.1 Name the most important adaptation(s) that evolved at each of the positions labels A, B and C. (3)

A: Vascular tissue / conducting tissue / xylem and phloem ✓– any one

B: Seeds ✓

C: Flowers ✓

1.4.2 Which division of plants is represented as non-vascular plants in the diagram? (1)

Bryophytes ✓

1.4.3 Explain why seedless vascular plants are able to grow taller than the nonvascular plants. (2)

Possess vascular / conducting tissue ✓ which provide support, enabling plants to grow taller ✓

1.4.4 In what way are the seeds of gymnosperms different to seeds of angiosperms? (2)

Gymnosperm seeds are naked ✓ exposed on a cone

Angiosperm seeds are enclosed in an ovary ✓

1.4.5 What is the collective name for all seed-bearing plants? (1)

Spermatophytes/ Spermatophyta ✓

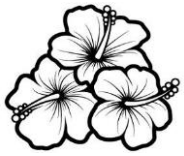
(9)

1.5 Study the different plant diagrams shown, and answer the questions below.


A – moss


B – fern


C – pine


D – flowering plant

1.5.1 Identify the Divisions to which each of the above plants belongs. (4)

A: Bryophytes ✓, B: Pteridophytes✓, C: Gymnosperms ✓, D: Angiosperms ✓

1.5.2 Name one of the divisions identified in question 1.5.1 that is ….

a) dependent on water for fertilization? (1)

Bryophytes – moss (A) ✓ **OR** pteridophytes – ferns (B) ✓

b) produces seeds for fertilization? (1)

Gymnosperms – pine (C) ✓ **OR** angiosperms - flowering plants (D) ✓

1.5.3 Mention three similar structural adaptations of the prothallus in ferns and the gametophyte in mosses, which make them to be poorly adapted to a terrestrial life. (3)

no true root, stem or leaves ✓, no conducting tissue ✓, no stomata ✓, have rhizoids ✓, no cuticle ✓

(any three correct answers)

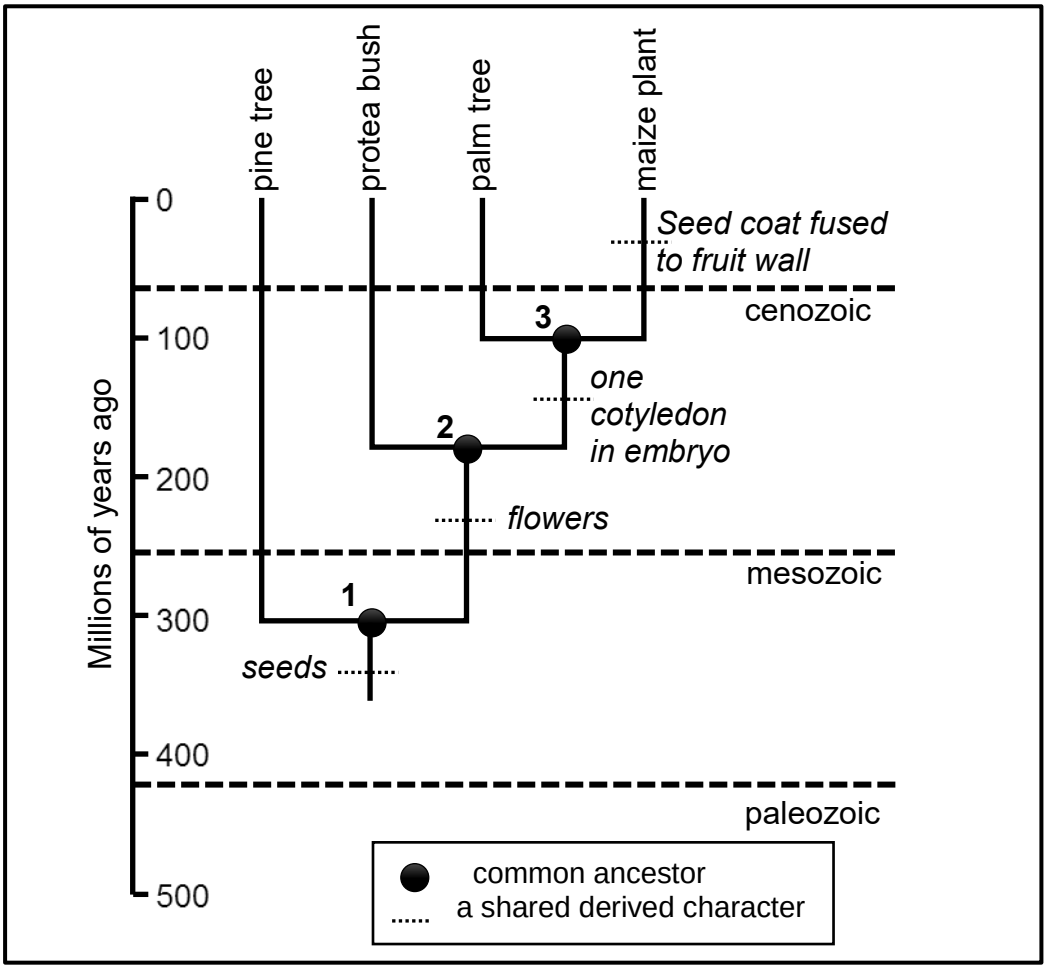
(9)

Section A: [45]

Section B

Question 2

2.1 Study the diagram which shows the phylogenetic tree of four plant species and answer the questions that follow.



2.1.1 Provide a definition of a *phylogenetic tree.* (1)

A phylogenetic tree is a diagram that shows the evolutionary relationships among a group of organisms. ✓

2.1.2 State whether the following statements are true or false. In each case give a reason for your answer.

a) The solid circle numbered **3** represents the common ancestor of the protea bush, palm tree and maize plant. (2)

False ✓. The circle numbered 2 represents the common ancestor of the protea bush, palm tree and maize plant. ✓ **OR**

The circle numbered 3 represents the common ancestor of the palm tree and maize plant. ✓

b) The protea bush is more closely related to the pine tree than it is to the maize plant because they are located next to each other on the phylogenetic tree, (2)

False ✓. Proteas are more closely related to maize plants because they share a more recent common ancestor. ✓

c) Palm trees evolved from pine trees. (2)

False ✓. Palm trees and pine trees share a common ancestor which is now extinct. ✓

d) Protea bushes, palm trees and maize plants are all flowering plants. (2)

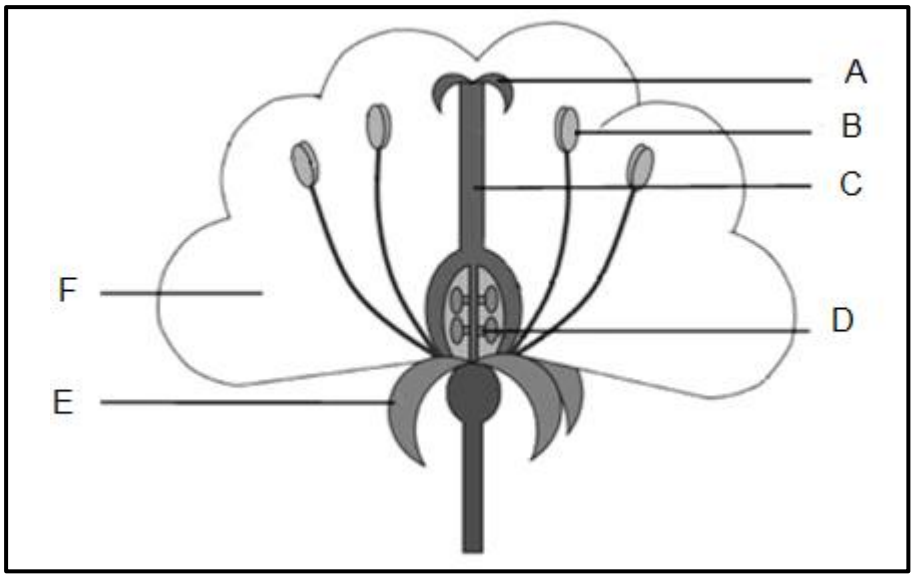
True. ✓ They all share a common ancestor that had flowers. ✓

2.1.3 How many millions of years ago did the ancestor of the palm tree and maize diverge? (1)

100 million years ago ✓

(10)

2.2 Study the diagram below showing the structure of a flower.



2.2.1 What type of pollination can be linked to this flower? (1)

Insect ✓

2.2.2 Identify the parts labelled A and B. (2)

1: Stigma ✓

2: Anther ✓

2.2.3 What do we call F and E together? (1)

Perianth ✓

2.2.4 Using the number only, identify the following:

a) Part which receives pollen. (1)

A ✓

b) Structure where a seed can form. (1)

D ✓

c) Part where pollen is produced. (1)

B✓

2.2.5 A seedbank in Norway has been storing seeds of a rare and endangered plant. To keep the seeds fresh, 120 of the seeds of this plants were selected to be grown. Of the 120 seeds, only 90 germinated.

What percentage of the seeds was not fertile? Show all your workings. (2)

(120 – 90 = 30) ✓, (30/120 x 100 = 25%) ✓

2.2.6 Plants have to spend a lot of energy to produce flowers. Explain why it is still an evolutionary advantage to produce flowers in plants. (5)

The physical appearance of flowers / its coloured petals ✓ attracts pollinators ✓ such as insects and birds for pollination which ensures reproductive success ✓. Seed dispersal mechanisms help to disperse seeds over a wide area ✓, reducing competition amongst plants ✓, after fertilisation ovary develops into fruit ✓ which can be eaten ✓ (✓– any five correct answers)

(14)

2.3 Tabulate five structural differences between wind-pollinated and insect pollinated flowers. (11)

Differences between wind-pollinated and insect-pollinated flowers.

Wind-pollinated	**Insect-pollinated**
Sepals and petals are absent or small and are not brightly coloured.	Flowers are conspicuous and brightly coloured.
Flowers do not produce nectar.	Some flowers have petals with dark lines leading from the edge of the petals to the nectaries which produce nectar.
Anthers are large and have long filaments that hang outside the flower.	Anthers are located inside the flower where insects are likely to brush past them and pick up pollen.
Stigmas are large, feathery and dangle outside the flower where they act like a net to trap pollen as it floats through the air.	Stigmas are arranged in such a way that visiting insects can come into contact with them. Stigmas have sticky surfaces that collect pollen.

Pollen grains are small, light and smooth and are easily carried by the wind.	Pollen is large and spiny/sticky so that it clings to the insect's body.

(✓✓ – for each correctly completed row – a mark per column, one mark for a table)

Section B: [35]

Total marks: [80]

Cognitive level distribution

Question	Level 1	Level 2	Level 3	Level 4	Marks
1.1.1	✓				2
1.1.2	✓				2
1.1.3	✓				2
1.1.4	✓				2
	8				8
1.2.1	✓				1
1.2.2	✓				1
1.2.3	✓				1
1.2.4	✓				1
1.2.5	✓				1
1.2.6	✓				1
1.2.7	✓				1
1.2.8	✓				1
1.2.9	✓				1
	9				9
1.3.1		✓			2
1.3.2		✓			2
1.3.3		✓			2
1.3.4		✓			2
1.3.5		✓			2
		10			10
1.4.1			✓		3
1.4.2	✓				1
1.4.3		✓			2
1.4.4	✓				2
1.4.5	✓				1
	4	2	3		9

1.5.1		✓			4
1.5.2 a - b	✓				2
1.5.3		✓			3
	2	7			9
2.1.1	✓				1
2.1.2 a – d			✓		8
2.1.3	✓				1
	2		8		10
2.2.1		✓			1
2.2.2	✓				2
2.2.3	✓				1
2.2.4 a – c	✓				3
2.2.5		✓			2
2.2.6				✓	5
	6	3		5	14
2.3		✓			11
		11			11
	31	33	11	5	80

CHAPTER 3: BIODIVERSITY OF ANIMALS

Overview

Time allocation: 2 weeks (8 hours)

This chapter consists of the following sections:

1. Introduction
2. Key concepts
3. Key features of body plan
4. Animal phyla
5. The role of invertebrates in agriculture and ecosystems
6. Summary
7. End of topic exercises

Introduction

This chapter focuses on the taxonomy of animal classification. It looks at the features of animals that separate them from each other, focusing on the four main body plans. These four body plans are used to identify and compare the six selected phyla for this chapter. Each of these phyla also have a unique set of features that differentiates them from other animals. Furthermore, we discuss how invertebrates perform ecosystem functions that are vital to life on Earth including pollination, decomposition and soil aeration.

Key concepts

- All living organisms are sorted into groups according to their features or body plans, namely: body symmetry and cephalisation; number of tissue layers; number of openings to the gut; the presence of a coelom.
- These body plans are used to differentiate between six selected phyla, namely: Porifera; Cnidaria; Platyhelminthes; Annelida; Arthropoda; Chordata
- Invertebrates provide benefits to ecosystems and agriculture by pollinating flowers, decomposing dead organic matter and aerating the soil.

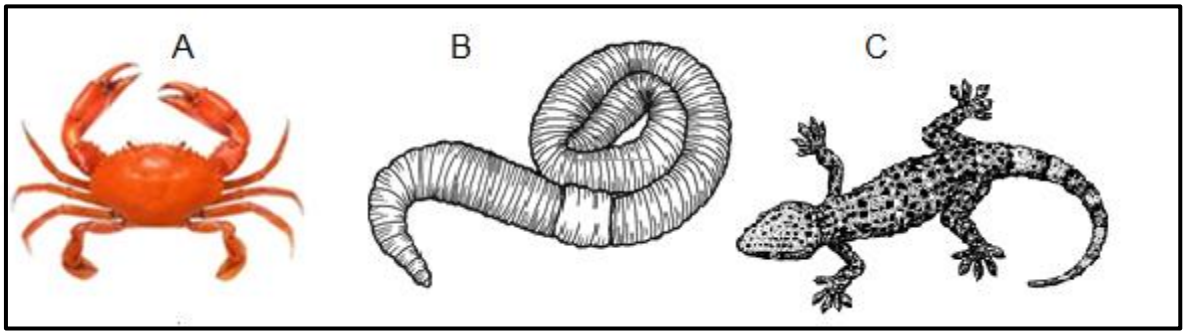
Key features of body plans

Learners must be able to draw and label diagrams of the body plans and discuss the characteristics of these. It is also important that the learners be able to identify and compare the types of body plans. Body plans must be linked to the mode of living (i.e. sessile or mobile) of different animals. Learners must know what each tissue layer develops into and the importance of the coelom in animals. The information in this chapter must be understood before progressing to the next section because this information is applied to different phyla in the next section.

Video that explains body plans of different phyla:
https://www.youtube.com/watch?v=PSdgbCwq5kA

Activity 1: Body symmetry and tissue layers

1. Study the diagrams below and answer the questions that follow.



1.1 Give the body symmetry of the organisms A – C respectively. (3)

A – Bilateral ✓, B – Bilateral ✓, C – Bilateral ✓

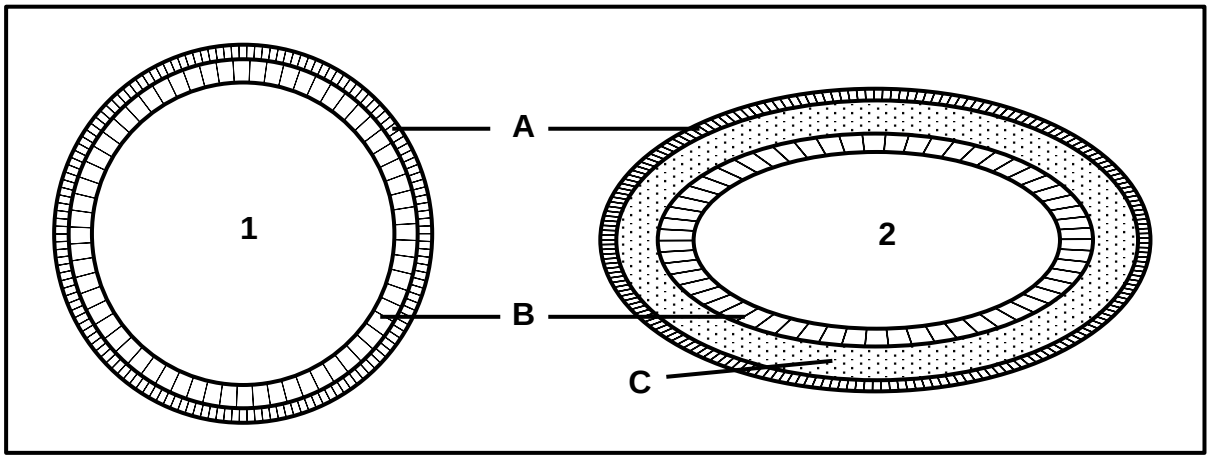
1.2 What are the advantages of an organism that has bilateral symmetry? (2)

The animal is able to move through the environment in one direction and focus senses on this direction which helps with feeding and avoiding predators ✓✓.

1.3 Give the letters of the organisms that show cephalisation. (3)

A, B and C ✓✓✓

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



2.1 Provide labels for A, B and C. (3)

A – Ectoderm ✓, B – Endoderm ✓, C – Mesoderm ✓

2.2 Which diagram, 1 or 2, is a diploblastic organism? (1)

1 – diploblastic ✓

2.3 Give a reason for your answer in question 2.2. (1)

1 – diploblastic because it only has 2 tissue layers ✓, (2 – triploblastic: has 3 tissue layers)

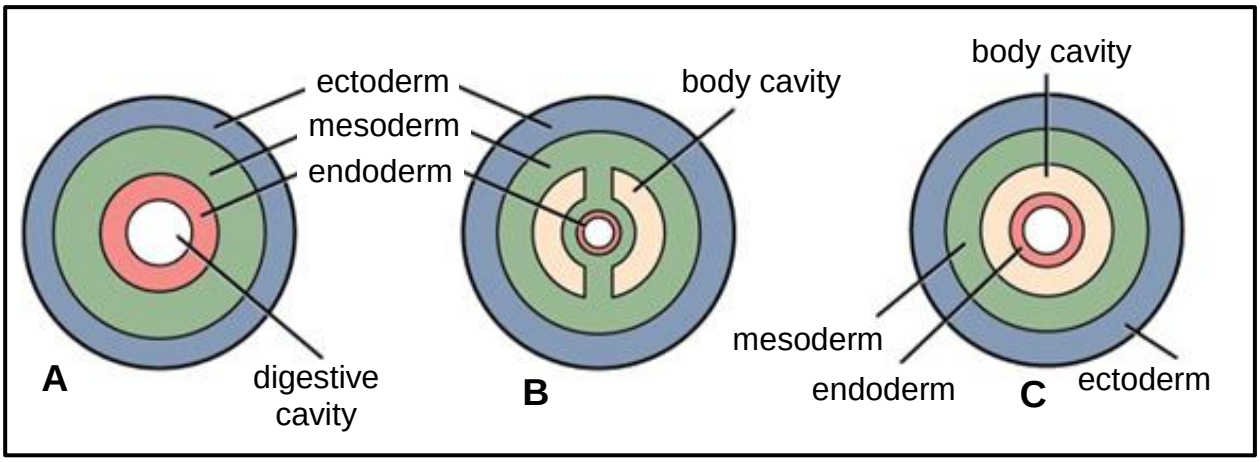
2.4 What advantages does an organism with a mesoderm have? (2)

Mesoderm can develop organs ✓ such as connective tissue, bone, blood, reproductive organs, cartilage, blood and lymphatic systems ✓ - any one organ.

(15)

Activity 2: Gut openings and coeloms

Study the diagram below and answer the questions that follow.



1. Which diagram (A, B or C) represents a:

   1.1 pseudocoelomate?

   C ✓ because body cavity is outside of the mesoderm – not a true coel

   1.2 acoelomate?

   A ✓ because it does not contain a body cavity

   1.3 coelomate? (3)

   B ✓ because the coelom is situated between the mesoderm

2. Which diagram represents the most advanced organism? B ✓ (1)

3. What advantages does a coelom give to an animal? (4)

   - Allows more complex organs to develop such as digestive organs, muscular system, blood system etc. ✓
   - Allows the creation of a hydrostatic force to be generated for movement in soft-bodied animals ✓
   - It separates the endoderm and ectoderm from each other with a cavity which allows the layers to move independently of each other. This allows peristalsis to occur ✓
   - In some organisms, the coelomic fluid (fluid found in the coelom) helps to transport nutrients and waste in the body ✓

   (8)

Animal phyla

Six animal phyla are selected to discuss and compare various body plans. Learners must be able to identify the different phyla using appearance as well as the animal's characteristics. The table of the phyla and their body plans in the summary section will help. In addition to the body plans of the phyla, there are other common characteristics of the phyla which can also be used to characterise or differentiate the phyla .i.e. the two different body forms of phylum Cnidaria. Learners must also understand a phylogenetic tree of the animal phyla and differentiate the characteristics in each clade.

Learners must be able to do simple surface area and volume calculations to find the ratio between these two. They must also understand that a larger organism has a less favourable surface area to volume ratio and is more likely to have specialised respiratory surfaces i.e. lungs or gills.

These videos explain the characteristics of the phyla:
https://www.youtube.com/watch?v=tIfsHPpkSPs&t=5s
https://www.youtube.com/watch?v=YQb7Xq0enTI
https://www.youtube.com/watch?v=kgZRZmEc9j4

Activity 3: Phyla characteristics

1. Study the diagrams below and answer the questions that follow.

a) 

b) 

c) 

d) 

e) 

f) 

1. Identify in which phyla each organism belongs. (6)

a) Porifera ✓, b) Chordata ✓, c) Cnidaria ✓, d) Annelida ✓, e) Arthropoda ✓, f) Platyhelminthes ✓

2 Tabulate the characteristics of Cnidaria and Platyhelminthes. Table ✓ (13)

Characteristics	Cnidaria	Platyhelminthes
Body symmetry	Radial ✓	Bilateral, dorso-ventrally flattened ✓
Cephalisation	None ✓	Yes ✓
Number of gut openings	One ✓	One ✓
Tissue layers	Diploblastic ✓	Triploblastic ✓
Coelom	Acoelomate ✓	Acoelomate ✓

Mode of living	Aquatic, sessile, free-floating, ✓ dimorphic lifecycle	Most are internal parasites, some aquatic, free-living ✓

3. Which organism is considered the most advanced? Explain your answer. (2)

   Chordata ✓, because they have the most advanced characteristics ✓

4. Which phyla do not have tissues or organs? Porifera ✓ (1)

5. Describe what a notochord is. (2)

   It is a cartilaginous rod ✓ which supports the body in all chordata ✓

6. Name the phylum that has nematocysts and describe the purpose of these nematocysts. (2)

   Cnidaria ✓, to capture prey and for defence ✓

7. What is the function of the haemocoel in arthropods? (2)

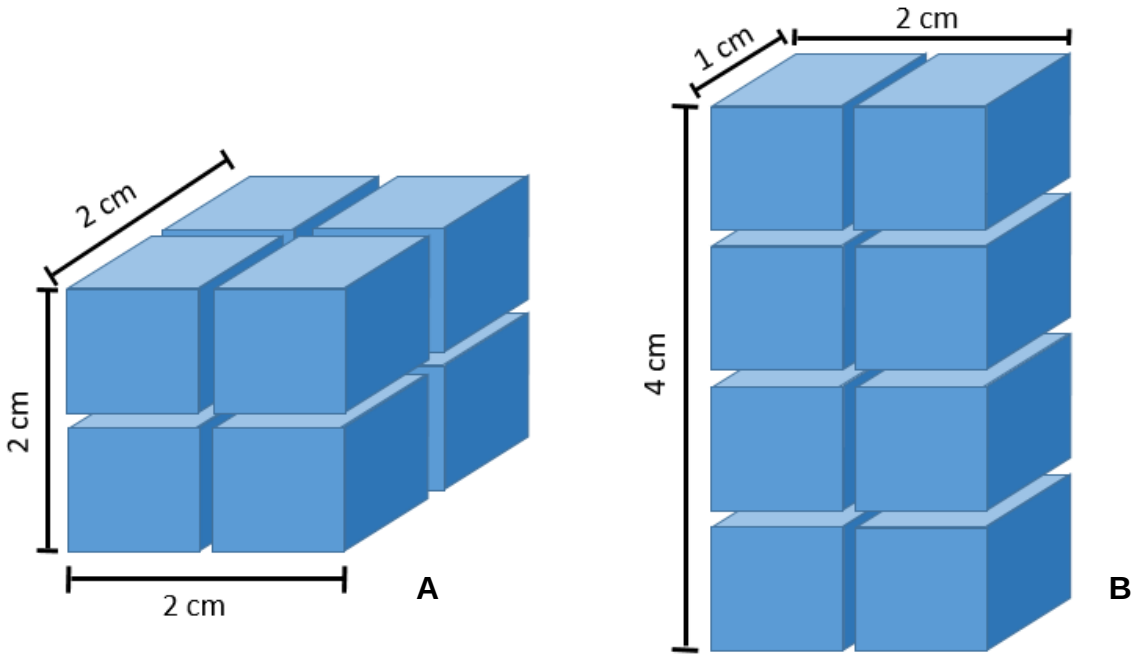
   Haemocoel is the cavity that is filled with fluid which acts like blood to carry nutrients and gases around the body ✓. It forms the open circulatory system of arthropods ✓.

8. Explain why arthropods cannot grow larger than they do. (2)

   Their exoskeleton must be shed regularly because it does not grow with the body ✓. The exoskeleton takes a lot of energy to build and therefore limits the size of arthropods ✓. (30)

Activity 4: Surface area and volume

1. Calculate: (a) the surface area (b) volume and (c) the surface area to volume ratio of the two models representing organisms that are shown below: (12)



Model A	Model B
Surface area: Length × width of all sides ✓ = 2 cm × 2 cm × 6 sides (all equal) = 24 cm^2 ✓	Surface area: Length × width of all sides = 4 cm × 2 cm × 2 sides = 16 cm^2 ✓ Length × width of all sides = 1 cm × 2 cm × 2 sides = 4 cm^2 ✓ Length × width of all sides = 4 cm × 1 cm × 2 sides = 8 cm^2 ✓ Total: 16 cm^2 + 4 cm^2 + 8 cm^2 = 28 cm^2 ✓
Volume: Length × width × height ✓ = 2 cm × 2 cm × 2 cm = 8 cm^3 ✓	Volume: Length × width × height = 4 cm × 1 cm × 2 cm = 8 cm^3 ✓
Surface area/volume: 24/8 ✓ = 3 ✓	Surface area/volume: 28/8 ✓ = 3,5 ✓

2. By referring to the surface area to volume ratios calculated, explain the advantage that the phylum Platyhelminthes (flat worms) have over the phylum Annelida (segmented worms). (3)

Flat worms with have a more favourable surface area to volume ratio ✓ than segmented worms because they are flatter ✓. This means they have more surface area for gases to diffuse in and out of their bodies than segmented worms ✓.

(15)

The role of invertebrates in agriculture and ecosystems

Learners are required to name and explain the role of invertebrates in both ecosystems and agricultural lands. Although invertebrates have many roles in these habitats, the focus is on the three mentioned in the CAPS documents namely: pollination, decomposers and soil aeration. Ensure that the learners can name the invertebrate that play these roles and explain how they perform the role in the ecosystem and agricultural land.

Video to understand pollination:
https://www.youtube.com/watch?v=FiwkJui2mh0

Video to understand soil aeration and decomposition:
https://www.youtube.com/watch?v=SxIBlAZmeaI

Activity 5: The role of invertebrates

1. Name three ways in which invertebrates play an important role in agriculture and ecosystems. (3)

   Pollination ✓, soil aeration ✓, decomposition ✓

2. Describe the earthworm's contribution to decomposition and soil aeration and how it contributes to soil fertility. (3)

   The earthworm is responsible for creating tunnels in the soil allowing more water and air to penetrate into the soil ✓. They also act as a piston that pushes and pulls air through the tunnels as they move ✓. Earthworms also consume dead organic matter such as leaf litter and their waste is further broken down by bacteria releasing the nutrients back into the soil ✓.

3. Explain how decomposition contributes to nutrient cycling in the soils. (3)

   Nutrients that are locked in dead organic matter must be decomposed to release these nutrients back into the soil ✓ so that plants can absorb the and use them for growth ✓. Therefore, decomposition ensures that nutrients are broken down from dead organic matter to be used in plant growth ✓.

4. How can decreasing bee populations affect the sustainability of natural ecosystems? (3)

   If bee populations decrease the amount of pollination will decrease ✓ and will potentially result in fewer plants being pollinated ✓ which will decrease the production of seeds and therefore regrowth ✓.

(12)

Summary

Key features of body plans

- A phylum is the taxonomic rank just below Kingdom and just above class.
- There are 4 key features that are used to divide the phyla.
    - Body symmetry and cephalisation
    - Tissue layers
    - Number of openings to the gut
    - Presence of a coelom

Animal phyla

- There are six phyla that learners need to know.
    - Phylum Porifera (sponges) – Asymmetrical, no cephalisation, diploblastic, acoelomate, no gut
    - Phylum Cnidaria (jellyfish, blue bottles, sea anemones) – Radially symmetrical, no cephalisation, diploblastic, acoelomate, one opening to the gut
    - Phylum Platyhelminthes (flat worms, tapeworm) – Bilaterally symmetrical, cephalisation, triploblastic, coelomate
    - Phylum Annelida (segmented worms, earthworm) – Bilaterally symmetrical, cephalisation, triploblastic, coelomate, metameric segmentation
    - Phylum Arthropoda (insects, millipedes, crabs, spiders) – Bilaterally symmetrical, cephalisation, triploblastic, coelomate, segmented bodies, many jointed legs, chitin exoskeleton
    - Phylum Chordata (Fish, frogs, birds, humans) – Bilaterally symmetrical, cephalisation, triploblastic, coelomate, segmented bodies, presence of notochord, dorsal nerve cord, gill slits during development, post-anal tail

Role of invertebrates

- Invertebrates play important roles in ecosystems and agriculture such as the pollination of flowers, decomposition and aeration of soil.

End of topic exercises

Section A

Question 1

1.1 Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A- D) next to the question number (1.1.1 – 1.1.5) on your answer sheet, for example 1.1.6 D

1.1.1 A characteristic of the Chordata is that they…

A have no coelom.

B have mammary glands.

C are diploblastic.

D **have bilateral symmetry**. ✓✓

1.1.2 Name the phylum to which the organism below belongs:

A Cnidaria

B **Arthropoda** ✓✓

C Annelida

D Chordata

1.1.3 Triploblastic animals that lack a through-gut and coelom.

A Cnidaria

B **Flatworms** ✓✓

C Arthropods

D Annelids

1.1.4 *Dicrocoelium dendriticum* is a flatworm parasite of grazing vertebrates such as sheep and cattle.

Which combination in the table correctly shows the phyla to which the parasite and host species belong?

	Dicrocoelium	**Cattle/Sheep**
A	Annelida	Chordata
B	Platyhelminthes	Arthropoda
C	Annelida	Arthropoda
D	**Platyhelminthes**	**Chordata** ✓✓

1.1.5 Which one of the following is NOT a characteristic of Porifera?

A Asymmetrical

B Lack nerve tissue

C Diploblastic ✓✓

D Aquatic

(5 × 2) = (10)

1.2 Give the correct **biological term** for each of the following descriptions. Write only the term next to the question number.

1.2.1 The concentration of sense organs at the anterior end of an animal leading to the formation of a head. cephalisation ✓

1.2.2 Blood-filled cavity found in Arthropoda. haemocoel ✓

1.2.3 An animal phylum that lacks true tissues and organs. Porifera ✓

1.2.4 The germ layer that gives rise to muscles and other internal organs, other than the gut. mesoderm ✓

1.2.5 Animals that are attached to a substrate. sessile ✓

1.2.6 A rod-like structure in Chordata usually replaced with a vertebral column. notochord ✓

1.2.7 Body cavity filled with fluid and lined with mesoderm. Coelom ✓

1.2.8 An organism in which the body wall is made up of two layers of cells. diploblastic ✓

1.2.9 Organisms that use stinging cells and tentacles to catch their prey. Cnidaria ✓

1.2.10 Arrangement of the body such that cutting through the centre of the structure in any direction produces two identical halves. radial symmetry ✓ (10 × 1) = (10)

1.3 Indicate whether each of the descriptions in Column I applies to **A ONLY**, **B ONLY**, **BOTH A AND B** or **NONE** of the items in Column II. Write **A only**, **B only**, **both A and B** or **None** next to the question number.

Column I	Column II
1.3.1 The body has jointed appendages and an exoskeleton.	A: Arthropoda B: Chordata

1.3.2	Gel-like, non-cellular layer in Cnidaria	A: Mesoderm B: Mesoglea
1.3.3	The division of the body into a series of similar units.	A. Segmentation B. Cephalisation
1.3.4	A fluid-filled body cavity found in some animals.	A: Gut B: Coelom
1.3.5	Many are parasitic and therefore have a negative impact on agriculture.	A: Platyhelminthes B: Annelida

(5 × 2) = (10)

1.3.1 **A only ✓✓**

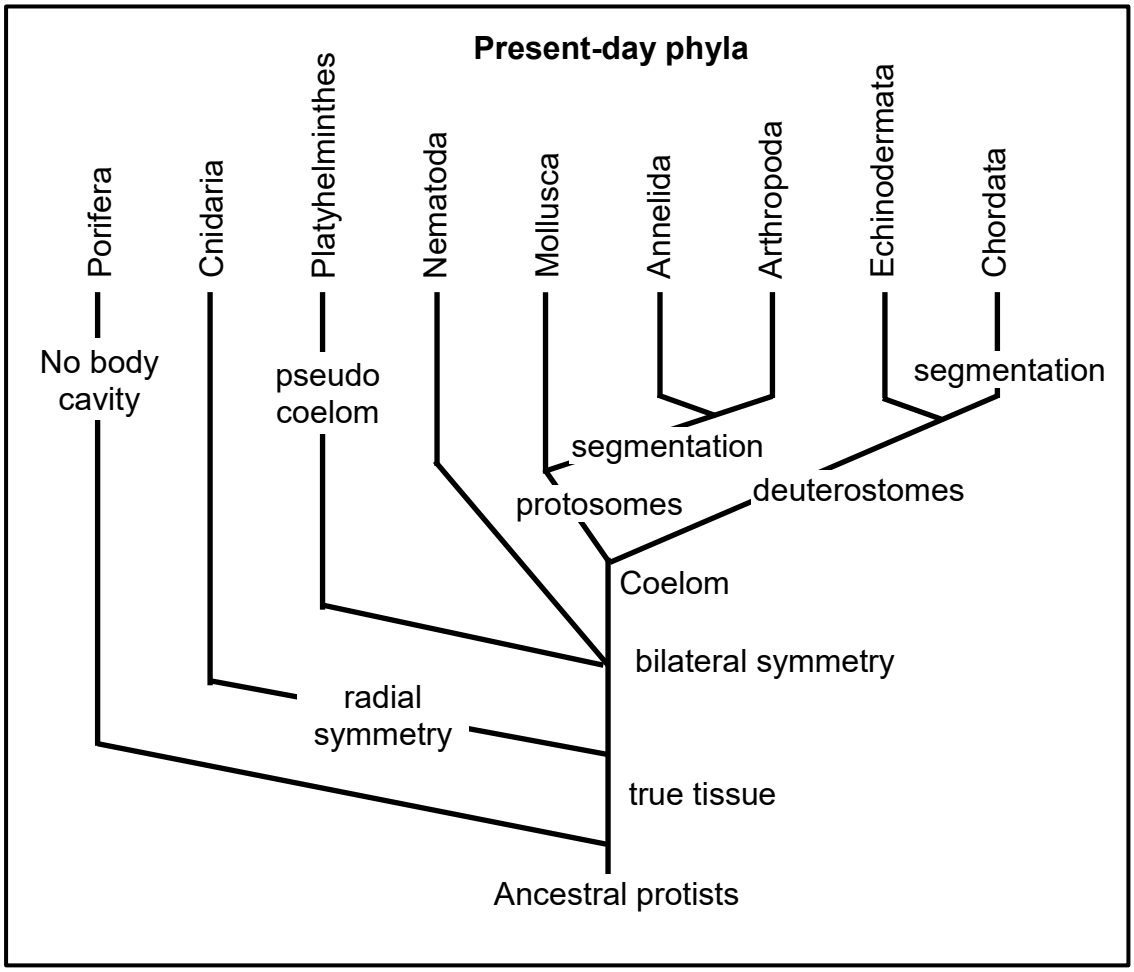
1.3.2 **B only ✓✓**

1.3.3 **A only ✓✓**

1.3.4 **B only ✓✓**

1.3.5 **A only ✓✓**

1.4 The diagram below shows a phylogenetic tree of different animals. Study the diagram and answer the questions that follow.



1.4.1 According to this phylogenetic tree, which group was the ancestor of the animal kingdom? Protists ✓ (1)

1.4.2 How many phyla are depicted in the phylogenetic tree? Nine ✓ (1)

1.4.3 The first major split in the animal kingdom was into radial- and bilateral symmetry:

a) Which phylum does not form part of the split? Porifera ✓ (1)

b) Which phylum has radial symmetry? Cnidaria ✓ (1)

1.4.4 The second split is animals which have a coelom and animals which lack a body cavity:

a) Which phylum has no body cavity? Porifera ✓ (1)

b) Which phylum has a pseudo-coelom? Platyhelminthes ✓ (1)

1.4.5 From the phylogenetic tree, identify three phyla which have a true body cavity as well as bilateral symmetry. (3)

Mollusca ✓ **OR** Annelida ✓ **OR** Arthropoda ✓ **OR** Echinodermata ✓ **OR** Chordata ✓ (any 3 correct answers)

1.4.6 Name one of the phyla that underwent segmentation. (1)

Annelida ✓ **OR** Arthropoda ✓ **OR** Chordata ✓

(10)

Section A: [40]

Section B: Question 2

2.1 Figures A, B and C represent different phyla of animals.

2.1.1 Identify the phylum represented in figures A, B and C. Write the letter with the correct phylum. (3)

A: Arthropoda ✓, B: Porifera ✓, C: Platyhelminthes ✓

2.1.2 What type of symmetry does figure A have? (1)

bilateral symmetry ✓

2.1.3 Give one benefit of the type of symmetry mentioned in 2.1.2. (1)

The animal is able to move through the environment ✓ in a consistent direction.
The animal has a definite left and right side, and a front and rear end. ✓
This helps with feeding and escaping predators. ✓ (any 1)

2.1.4 Which figure(s) has/have the following characteristics? Write only the letter A, B or C for example 2.1.4 (e) D (6)

a) triploblastic A ✓ and C ✓

b) dorso-ventrally flattened C ✓

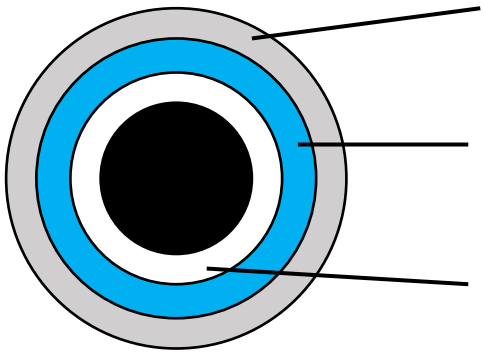
c) cephalisation A ✓ and C ✓

d) coelomate A ✓

2.1.5 Give one advantage of having a high surface area to volume ratio for animals. (1)

Animals do not need any special means to circulate nutrients / gasses to different parts of the body ✓, it takes place through diffusion.

2.1.6 Draw a diagram of a cross section of a triploblastic body plan labelling labelling each tissue layer, then indicate what each tissue layer gives rise to. (6)



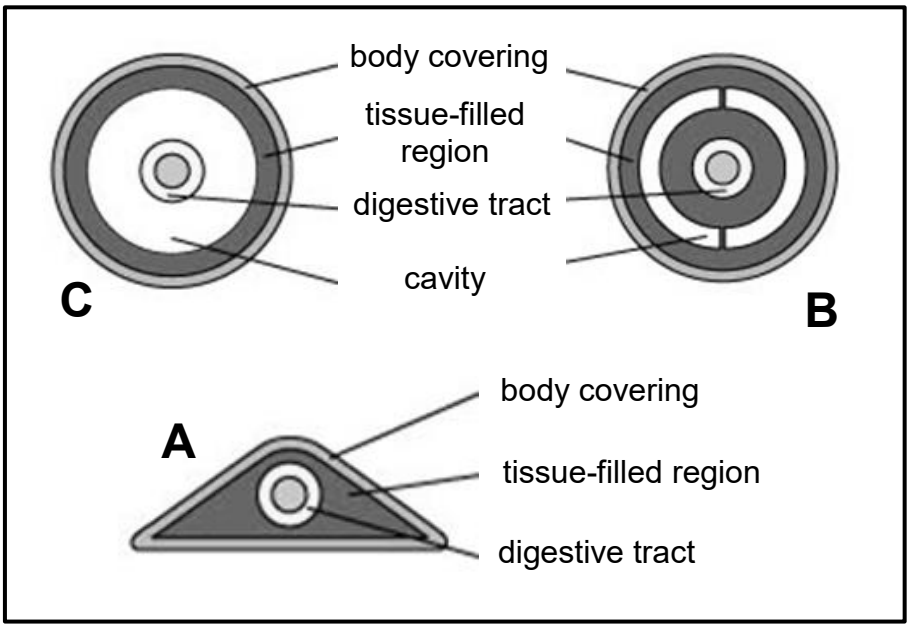
Ectoderm ✓ gives rise to epidermis and nervous system ✓

Mesoderm ✓ gives rise to body systems and organs ✓ and nervous system

Endoderm ✓ forms lining of alimentary canal and digestive glands ✓

(18)

2.2 Study the diagrams below and answer the questions that follow.



2.2.1 Write only the letter(s) of the diagram(s) that represent the following:

a) pseudo-coelomate C ✓

b) acoelomate A ✓

c) triploblastic A ✓ and B ✓ and C ✓

d) chordate B ✓ (6)

2.2.2 Name one advantage of a through-gut in Annelida. (2)

- No mixing of food ✓ food moves in one direction
- It allows digestion to take place continuously ✓
- The gut is specialised ✓ where different regions become adapted for different functions
  (✓✓ – for any one correct answer)

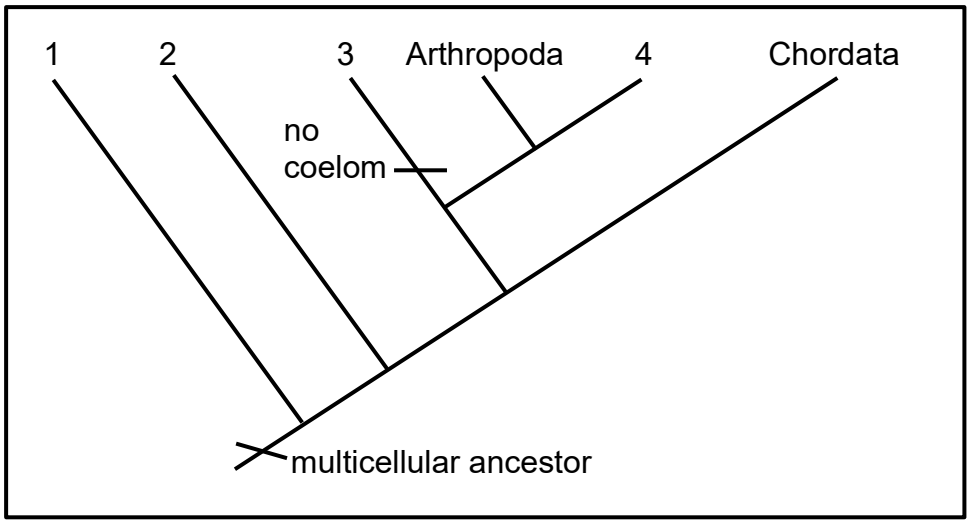
2.2.3 From which embryonic layer does the tissue-filled layer develop? (1)
mesoderm ✓

(9)

[27]

Question 3

3.1 The diagram below shows a cladogram of animal phyla. Study it and answer the questions that follow.



3.1.1 Name the feature common to all the phyla illustrated in the cladogram. (1)
All are multicellular organisms ✓

3.1.2 What is a cladogram? (1)
A cladogram is a type of phylogenetic tree that shows features that separates one group of organisms from another. ✓

3.1.3 Name the feature common to animal phyla labelled 3 and 4 as well as Arthropoda and Chordata. (1)
Bilateral symmetry ✓

3.1.4 Provide labels for animal phyla labelled 1, 2 and 3. (3)

1: Porifera ✓, 2: Cnidaria ✓, 3: Platyhelminthes ✓

(6)

3.2 Invertebrates play an important role in agriculture and ecosystems.

3.2.1 Distinguish between a vertebrate and an invertebrate. (2)

Invertebrates are animals without a backbone ✓whereas vertebrates have a spinal cord or backbone✓

3.2.2 Name one phylum which contains invertebrates. (1)

Arthropoda ✓, Porifera ✓, Cnidaria ✓, Platyhelminthes ✓, Annelida ✓ (any 1 correct answer)

3.2.3 To which phylum do each of the following organisms belong? (3)

a) Bees Arthropoda ✓

b) Earthworms Annelida ✓

c) Butterflies Arthropoda ✓

3.2.4 Invertebrates play a vital role in pollination of plants.

a) Define the term pollination. (2)

Pollination is the transfer of pollen ✓ from the male parts (stamen / anthers) of a flower to the female parts (stigma) of a flower ✓ of the same species by a pollinator.

b) What class of Arthropods is mainly involved in the pollination process? (1)

Insects ✓

c) What role does this group play in the pollination process? (2)

Insects act as pollinators ✓ by transferring pollen from the anther to the stigma of a flower. ✓

d) What effect will the elimination of this class of pollinators have on an ecosystem? (3)

No pollination will occur ✓ thus no fertilization occurs, and no fruits and seeds are produced ✓ which can ultimately threaten the survival of the species ✓

3.2.5 Discuss the role of invertebrates, such as earthworms, in the decomposition process. (3)

Earthworms feed on decaying plant matter (detritus) in the soil, ✓ earthworms / micro-organisms break down or decompose the organic matter into simpler nutrients ✓ which is a valuable source of minerals for plants ✓

(17)

[23]

Section B: [50] Total marks: [90]

Cognitive level distribution

Question	Level 1	Level 2	Level 3	Level 4	Marks
1.1.1	✓				2
1.1.2	✓				2
1.1.3	✓				2
1.1.4		✓			2
1.1.5	✓				2
	8	2			10
1.2.1	✓				1
1.2.2	✓				1
1.2.3	✓				1
1.2.4	✓				1
1.2.5	✓				1
1.2.6	✓				1
1.2.7	✓				1
1.2.8	✓				1
1.2.9	✓				1
1.2.10	✓				1
	10				10
1.3.1	✓				2
1.3.2	✓				2
1.3.3	✓				2
1.3.4	✓				2
1.3.5	✓				2
	10				10
1.4.1		✓			1
1.4.2		✓			1
1.4.3		✓			2
1.4.4		✓			2
1.4.5		✓			3
1.4.6		✓			1
		10			10

2.1.1			✓		3
2.1.2			✓		1
2.1.3	✓				1
2.1.4			✓		6
2.1.5	✓				1
2.1.6			✓		6
	2		16		18
2.2.1				✓	6
2.2.2	✓				2
2.2.3	✓				1
	3			6	9
3.1.1	✓				1
3.1.2	✓				1
3.1.3				✓	1
3.1.4		✓			3
	2	3		1	6
3.2.1	✓				2
3.2.2		✓			1
3.2.3		✓			3
3.2.4a	✓				2
3.2.4b	✓				1
3.2.4c		✓			2
3.2.4d			✓		3
3.2.5		✓			3
	5	9	3		17
Total	40	24	19	7	90

CHAPTER 4: PHOTOSYNTHESIS

Overview

Time Allocation: 3 weeks (12 hours)

This chapter consists of:

1. Introduction
2. Key concepts
3. The definition of photosynthesis
4. The structure of a chloroplast
5. The process of photosynthesis
6. Importance of photosynthesis
7. Environmental factors affecting the rate of photosynthesis
8. Investigations
9. Summary
10. End of topic exercises

Introduction

All living organisms require energy to survive. This energy can either be obtained directly from the sun (plants) or from the food that is eaten (animals). In this chapter, learners will look at how plants convert radiant energy into chemical potential energy using the raw materials available to them. The term **photosynthesis** means light is used (photo) to manufacture (synthesis) energy.

Key terminology

metabolism	chemical processes in organisms controlled by enzymes
anabolism	building up chemical reactions
catabolism	breaking down chemical reactions

iodine solution	chemical used to test for starch – a positive test results in the colour changing from brown to blue-black
autotrophic	green plants that produce their own food through photosynthesis
heterotrophic	organisms that cannot photosynthesize and obtain food from other organisms

Key concepts

- Photosynthesis requires carbon dioxide, water and radiant energy as well as enzymes and chlorophyll to produce carbohydrates (glucose) and oxygen. This can be represented using word and chemical equations.
- To obtain the raw materials required, plants are adapted in various ways.
- The process of photosynthesis occurs in two phases. The light phase which requires light and the dark phase in which light is not required.
- Photosynthesis is important to maintain the balance of oxygen and carbon dioxide in the atmosphere and provides food for other organisms which use cellular respiration to release the energy from the food.
- Light intensity, carbon dioxide concentration and temperature affect the rate of photosynthesis.
- Greenhouses can be used to control these factors to ensure optimal growth of plants.
- ATP is an energy carrier molecule used in the process of photosynthesis. Adenosine Triphosphate and Adenosine Diphosphate go through a cycle where energy is released and obtained.
- The investigations for photosynthesis are essential to know, specifically the investigations for starch, light, carbon dioxide, chlorophyll and oxygen.

The definition of photosynthesis

Key terminology

radiant energy	energy from the sun, needed by plants for photosynthesis
chloroplast	organelle in plants, site for photosynthesis
chlorophyll	green pigment needed for photosynthesis
thylakoids	part of the chloroplast that contains chlorophyll

grana	stacks of thylakoids, light dependent phase of photosynthesis takes place here
stroma	liquid part of the chloroplast, light independent phase of photosynthesis takes place here

Learners need to know the requirements and products of photosynthesis. These can be represented in word and chemical equations.

These raw materials are obtained from different places, through various means because of the adaptations of plants to their environment. Learners must be able to discuss how the raw materials are obtained from the environment.

The Structure of a Chloroplast

Learners must know the functions of the various parts of the chloroplast and be able to identify the structures as well as draw the organelle as a whole.

The Process of Photosynthesis

Key terminology

photolysis	splitting of water molecules into oxygen atoms and hydrogen atoms. photo = light, lysis = split
phosphorylation	formation of energy transporting molecules called ATP
ATP	adenosine triphosphate, energy carriers in cells
Calvin cycle	cyclical process during light independent phase of photosynthesis
glucose	carbohydrate formed during photosynthesis
starch	stored form of glucose in plants
glycogen	stored form of glucose in animals

Learners are required to know that photosynthesis takes place in two phases: the light and dark phase. No biochemical detail is required. The process should be explained simply.

Learners must know where each phase occurs in the chloroplast and which reactions take place in which phase.

Activity 1: Photosynthesis

1. Provide a definition for photosynthesis. (2)

   Photosynthesis is the process by which plants produce carbohydrates (glucose) ✓ using radiant energy from the sun ✓.

2. Name the organelle in which this process occurs. (1)

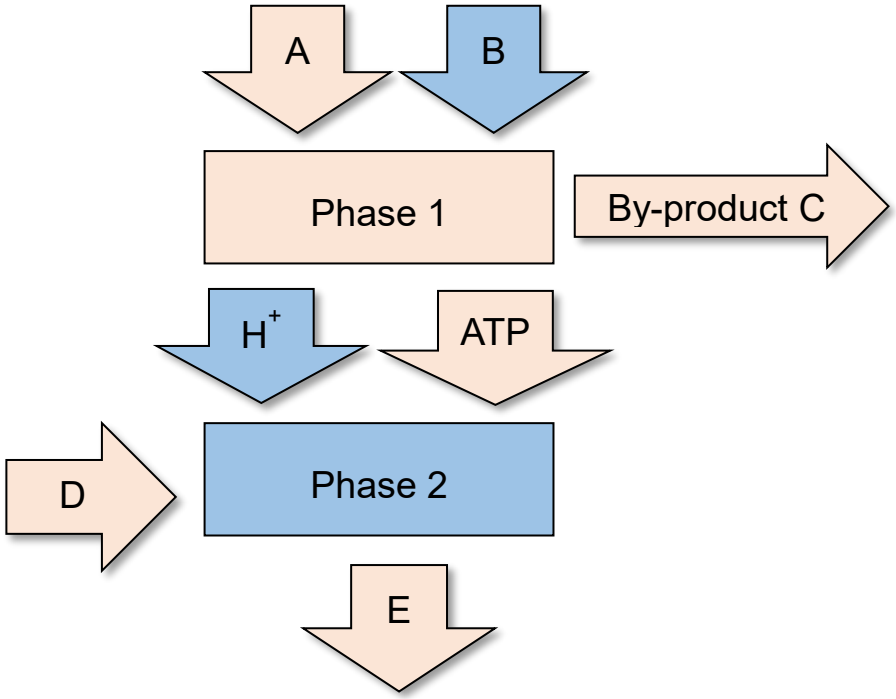
   Chloroplast ✓

3. Name the two phases of photosynthesis and provide the names of the specific structures in the organelle mentioned above, where each phase of photo-synthesis takes place. (4)

   Phase 1: light dependent phase ✓, occurs in the grana ✓

   Phase 2: light independent phase ✓, occurs in the stroma ✓

4. The diagram below represents the process of photosynthesis



   a) Identify the phases labelled as Phase 1 and Phase 2 (2)

      Phase 1- light dependent phase ✓

      Phase 2- light independent phase ✓

   b) Provide the two raw materials labelled as A and B. (2)

      A – light ✓; B – water ✓

   c) Name the by-product labelled as C. (1)

      Oxygen ✓

   d) Which substance labelled as D is essential for Phase 2? (1)

      Carbon dioxide ✓

e) Name the product E that is produced during Phase 2. (1)

Glucose ✓

f) In what form is E stored in plants? (1)

Starch ✓

(15)

Importance of Photosynthesis

Photosynthesis plays an important role in the environment. It regulates the balance between oxygen and carbon dioxide in the atmosphere and provides food for organisms.

It is important for teachers to explain that the other organic compounds such as lipids and proteins are formed using the carbohydrates produced during photosynthesis.

Environmental Factors affecting the Rate of Photosynthesis

Key terminology

greenhouse	a glass or plastic structure that traps heat and allows light to enter, used to grow plants
greenhouse effect	phenomenon where heat from the sun is trapped on Earth by CO_2 in the atmosphere

Light intensity, carbon dioxide concentration and temperature affect the rate of photosynthesis. As these factors increase, so does the rate of photosynthesis until an optimal level is reached. Beyond this optimum, a limiting factor will prevent photosynthesis from increasing and it will decrease.

It is important for learners to understand how these limiting factors affect photosynthesis. It is imperative that learners are able to apply these concepts to analysing graphs and case studies.

Investigations

There are a number of investigations which are vitally important. These have been explained in the learner's textbook. Learners must know that any form of carbonate increases the concentration of carbon dioxide and any form of hydroxide decreases

the concentration of carbon dioxide.

These investigations are essential for assessment purposes and are asked in one form or another every year.

Activity 2: Investigating photosynthesis

A learner has conducted an experiment in the classroom by following various steps. Study the procedure and diagram below to answer the questions that follow.

a) A variegated plant was left in the dark for 3 to 4 days

b) A starch test was conducted by removing one of the leaves

c) The plant was then left in the light for four hours

d) A leaf was removed and a drawing of it was made to show the distribution of green and white areas (Diagram 1)

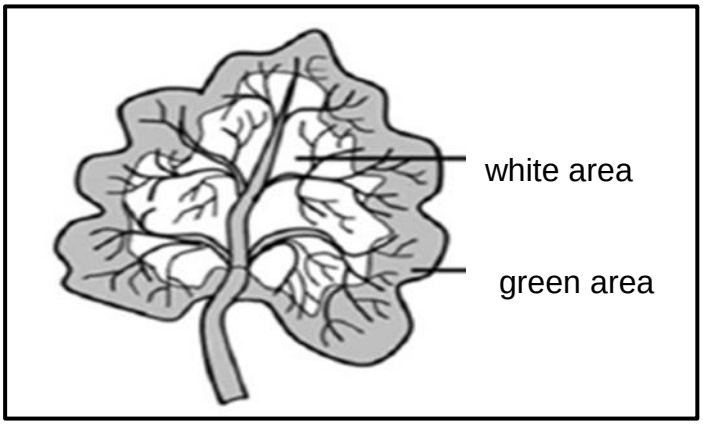


Diagram 1: leaf before second starch test

e) The leaf was then tested for the presence of starch

f) After the addition of a few drops of diluted iodine solution, a second drawing of the leaf was made to show the distribution of blue- black and brown areas of the leaf (Diagram 2 – not shown here)

Questions

1. State the aim of this experiment. (1)

   To determine whether chlorophyll is necessary for photosynthesis ✓.

2. Why was the plant left in the dark for 3 to 4 days? (1)

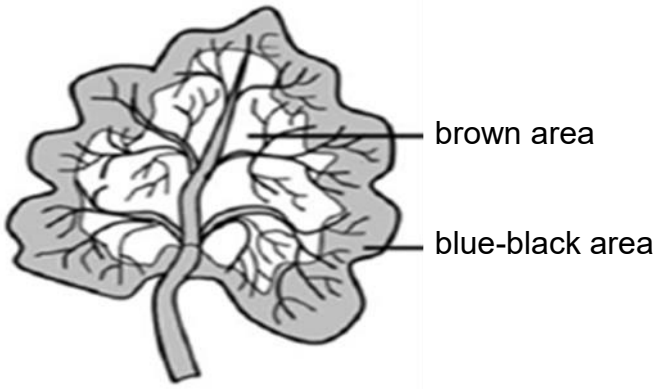
   To destarch the plant ✓.

3. Why should the plant have been tested for the presence of starch after step (a) , that is before exposing the plant to light? (2)

To ensure that the leaves are completely destarched ✓✓.

4. Draw and label Diagram 2 that shows the result of the second starch test as mentioned in step (f). (Diagram 1 should be used as a template) (5)

Diagram 2:
Leaf after the second starch test



Guidelines for assessing diagram:

Correct caption / title	✓
Correct drawing / shape	✓
Correct drawing of shadow	✓
Correct labels for previously white and green areas.	✓ ✓

5. Is it necessary to set up a control for this investigation? (1)
No ✓

6. Supply a reason for your answer to question 5. (2)
Result obtained from the area of the leaf containing chlorophyll ✓ can be compared with the result obtained from the area of the leaf not containing chlorophyll. ✓

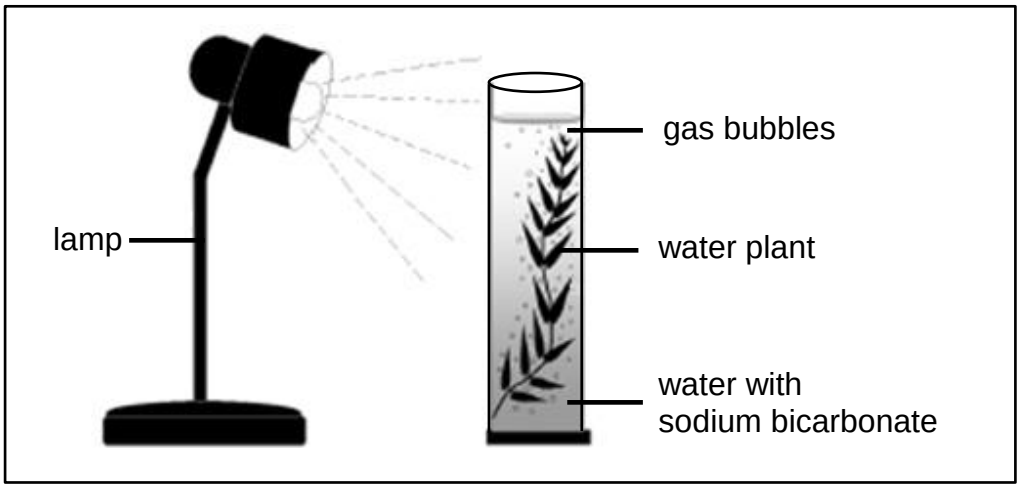
7. What conclusion can be drawn from this experiment? (2)
Chlorophyll ✓ is necessary for photosynthesis ✓

(14)

Activity 3: Investigating gas bubbles released

The diagram below illustrates an investigation in progress. The distance between the light source and the apparatus have been altered at regular intervals to record the number of bubbles released at various distances. The data gathered has been

represented in a table below. Study the diagram and the data table below to answer the following questions.



1. What is the function of sodium bicarbonate? (1)

   To increase the concentration of carbon dioxide in the water. ✓

2. Name the gas released during the experiment. (1)

   Oxygen ✓

3. Provide a suitable hypothesis for the above experiment. (2)

   The closer / further the lamp, the faster / slower the rate of photosynthesis will be **OR** the lamp will have no effect on the rate of photosynthesis.

   ✓✓ - one for each variable mentioned with relationship

4. Explain a simple test that can be done to confirm the presence of the gas mentioned in question 3. (2)

   A glowing splint glows brighter (re-ignites) when inserted into a test tube containing oxygen ✓✓.

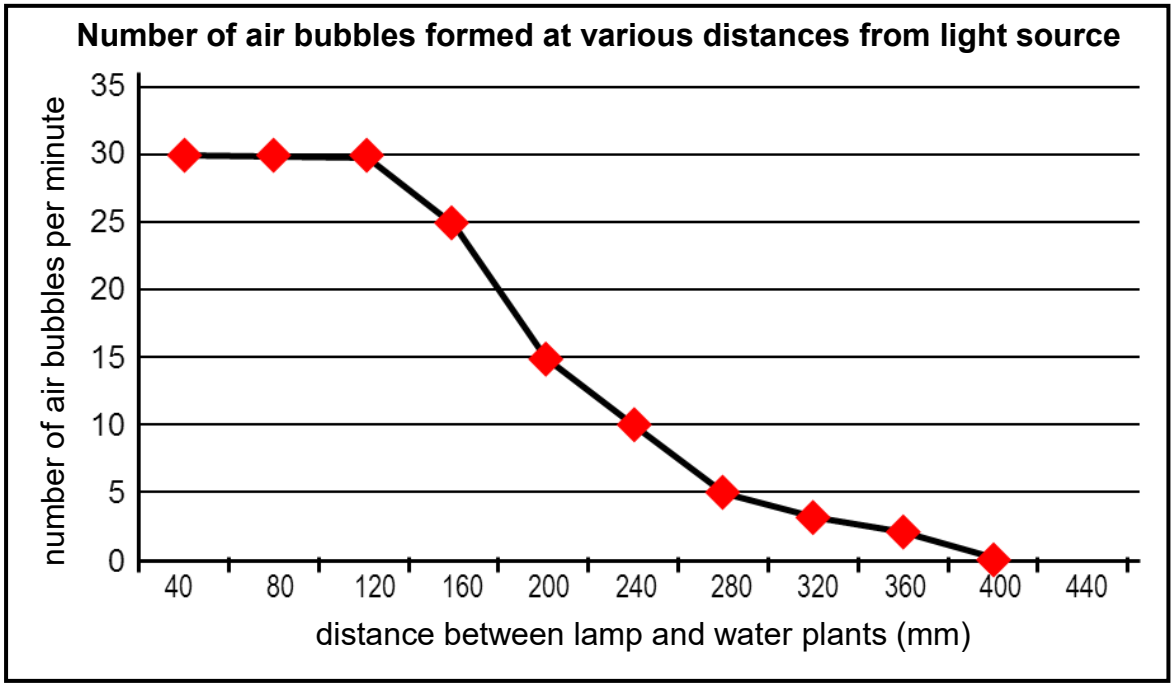
5. Name any two environmental factors, besides light intensity, that could affect the chemical process shown in the diagram above. (2)

   Amount of carbon dioxide ✓; the temperature of the water ✓.

6. The table below contains the following data: The number of air bubbles counted when the distance between the lamp and apparatus is altered at regular time intervals

Distance between lamp and plant (mm)	40	80	120	160	200	240	280	320	360	400	440
Number of bubbles per minute	30	30	30	25	15	10	5	3	2	0	0

   Plot a line graph to represent the data obtained during the experiment. (6)



✓ - each for: title of graph, for each axis labelled and appropriate scale, line drawn connecting points, two for correct plotting of points

7. Identify:

(a) the dependent the rate of photosynthesis ✓

(b) independent variables the distance between the lamp and the plant ✓. (2)

8. What conclusion can be derived at, from the information supplied in question 6? (2)

The light intensity is directly proportional to the rate of photosynthesis ✓✓

OR

When the light intensity increases / decreases the rate of photosynthesis increases / decreases. ✓✓

Summary

- Photosynthesis is the process by which glucose is formed using radiant energy from the sun.
- The requirements for photosynthesis are carbon dioxide (from the atmosphere), water (from the soil) and radiant energy (from the sun). The process uses enzymes and chlorophyll to produce carbohydrates (glucose) and oxygen.
- The requirements and products of photosynthesis can be represented in word and chemical equations.
- Radiant energy is trapped by the chlorophyll, water is absorbed by osmosis and carbon dioxide is taken into the leaf by diffusion.
- All of the raw materials are stored in the chloroplast to be used during photosynthesis.
- Photosynthesis takes place in two phases. The light phase occurs in the grana of chloroplasts where water molecules are split and the dark phase occurs in the stroma of chloroplasts where glucose is formed.
- Photosynthesis is important to maintain a stable environment. It does this by regulating oxygen and carbon dioxide levels and forming organic molecules to be used as food.
- The rate of photosynthesis is dependent on the amount of light intensity, carbon dioxide and temperature available. As these factors increase so does the rate of photosynthesis, up to a certain point.
- Greenhouses can be used in order to ensure optimum levels of these factors are obtained. This allows for maximum photosynthesis and therefore growth of plants.
- ATP stores energy to be used for metabolic processes. ATP is formed by adding a phosphate to ADP. Energy is added during this reaction which can then be released when splitting a phosphate from ATP.
- There are a five investigations used to determine the requirements and products of photosynthesis as well as the rate of photosynthesis.
- In these investigations, the control is given all of the requirements and the experiment has one factor removed, which is the factor being investigated.

End of topic exercises

Section A

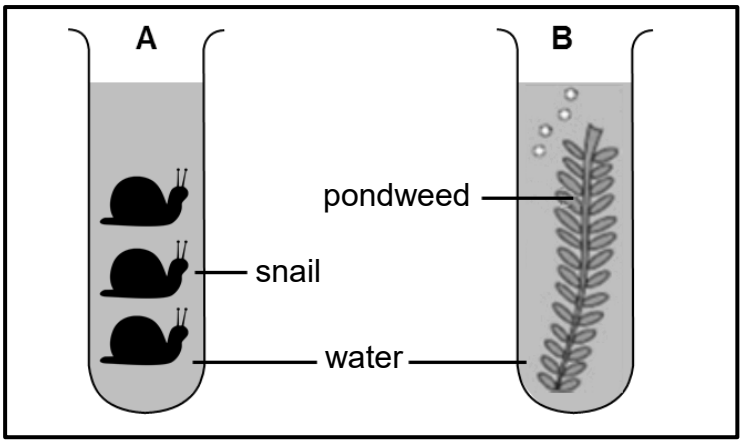
Question 1

1.1 Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A- D) next to the question number (1.1.1 – 1.1.5) on your answer sheet, for example 1.1.6 D

1.1.1 Plants use oxygen…

A **continuously ✓✓**
B during the day only.
C during the night only.
D during photosynthesis only

1.1.2 Test tubes A and B below were placed in bright light.



Which of the following is correct regarding the test tubes?

A The amount of CO_2 in test tube A will decrease.
B The amount of CO_2 in test tube B will increase.
C **The amount of O_2 in test tube B will increase ✓✓**
D The amount of O_2 in test tube A will increase.

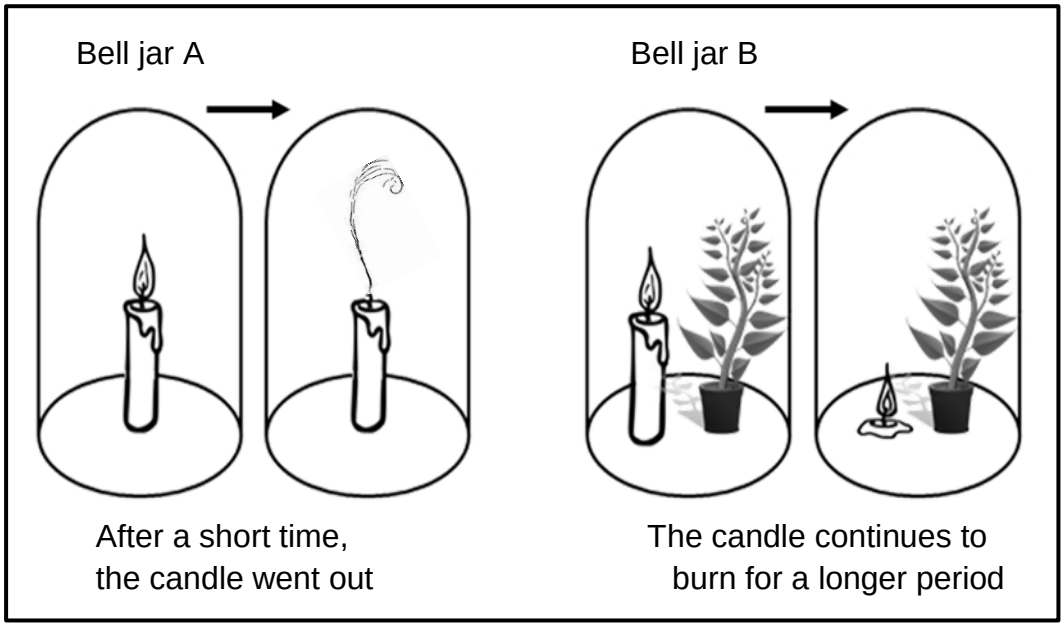
1.1.3 What are the products of the light reactions of photosynthesis that are used in the light independent phase?

A CO_2 and glucose
B H_2O and O_2
C **ATP ✓✓**
D ADP

1.1.4 Which factor does not affect the rate of photosynthesis?

A **Oxygen concentration ✓✓**
B Light intensity
C Temperature
D Carbon dioxide concentration

1.1.5 An experiment was set up to investigate whether oxygen is released during photosynthesis. The result of the experiment is represented in the following diagram.



The following deductions were made before arriving at the conclusion.

(i) Photosynthesis reduces the amount of CO_2 inside bell jar B
(ii) The oxygen in bell jar A was completely used up and combustion is not supported
(iii) Photosynthesis increases the amount of oxygen inside bell jar B
(iv) The vapour produced inside bell jar A due to the extinguished burning candle.

Which one of the following sets of deductions is correct?

A (i) and (iv) only
B **(i), (ii) and (iii) only ✓✓**
C (i), (iii) and (iv) only
D (iii) and (iv) only (5 x 2) = (10)

1.2 Give the correct **biological** term for each of the following descriptions. Write only the term next to the question number.

1.2.1 The green, light-trapping pigment in photosynthesis found in plant leaves. Chlorophyll ✓

1.2.2 The splitting of water molecules into hydrogen and oxygen in the presence of light. Photolysis ✓

1.2.3 Site of reactions of the light independent phase in the chloroplast.
Stroma ✓

1.2.4 The process in plants in which radiant energy is converted into chemical energy. Photosynthesis ✓

1.2.5 Expected colour change of diluted iodine solution when the presence of starch in a leaf is confirmed. Blue-black ✓

1.2.6 The general energy carrier in the cells of living organisms. ATP ✓

1.2.7 The form of carbohydrate in which energy is stored in most plants.
Starch ✓

1.2.8 The organelle that absorbs radiant energy during photosynthesis.
Chloroplast ✓

1.2.9 The reagent used to test for the presence of starch.
Iodine solution ✓

1.2 10 The organic molecules that act as catalysts and control the chemical reactions during photosynthesis.
Enzymes ✓ (10 × 1) = (10)

1.3 Indicate whether each of the descriptions in Column I applies to **A ONLY**, **B ONLY**, **BOTH A AND B** or **NONE** of the items in Column II. Write **A only**, **B only**, **both A and B** or **none** next to the question number.

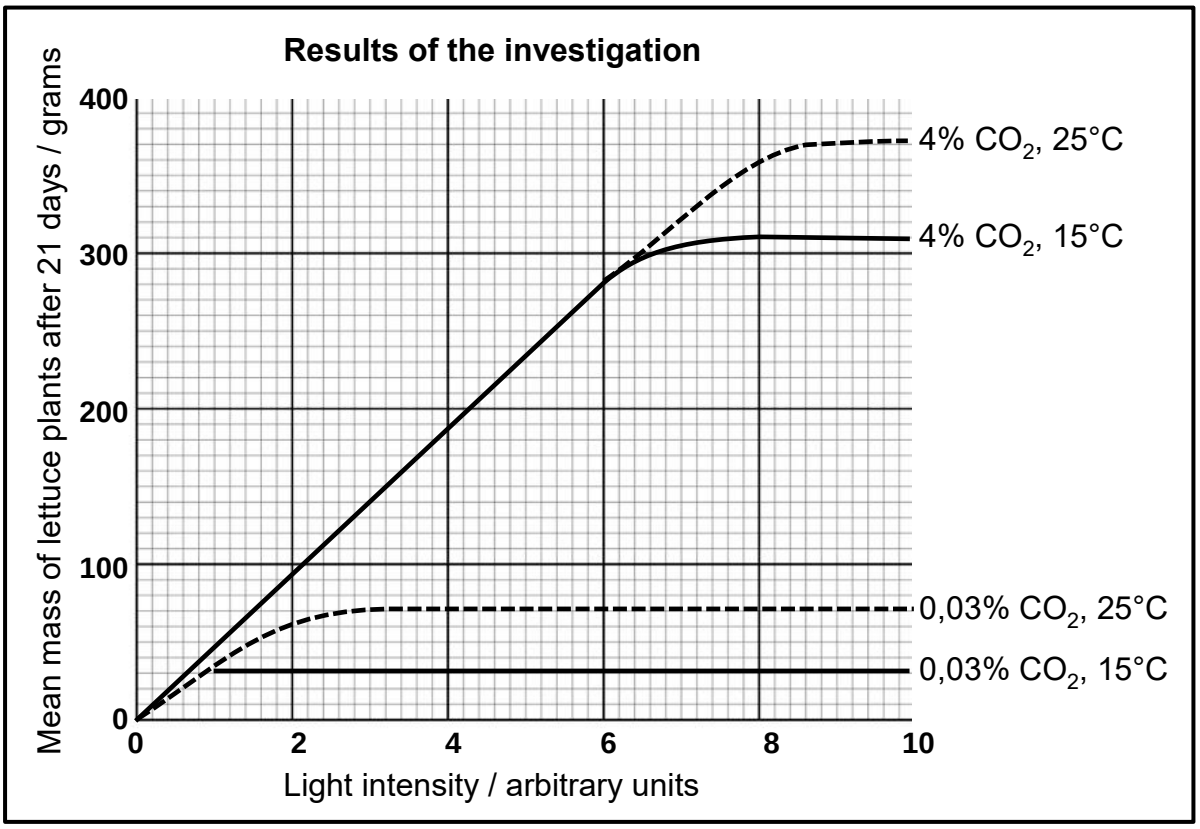
Column I	Column II
1.3.1 Molecule that stores energy	A: ATP B: ADP
1.3.2 The organelle in which photosynthesis takes place	A: mitochondria B: chloroplast
1.3.3 Storage of chlorophyll	A: grana B: lamella
1.3.4 Light dependent phase of photosynthesis	A: matrix B: stroma
1.3.5 Gas given off by green plants during photosynthesis	A: O_2 B: CO_2

1.3.1 **A only ✓✓**
1.3.2 **B only ✓✓**
1.3.3 **A only ✓✓**
1.3.4 **None ✓✓**
1.3.5 **A only ✓✓** (5 x 2) = (10)

1.4 Scientists set up an apparatus to investigate the effect of temperature, light intensity and carbon dioxide concentrations on plant growth. Using this apparatus, they could control each factor.

- The scientists set different temperatures, CO_2-concentration and light intensity for four different groups of lettuce plants.
- The average mass of lettuce plants serves as an indication of the rate of photosynthesis.

Study the results below and answer the questions that follow.



1.4.1 What is the influence of light intensity on average mass of lettuce plants? (3)

The rate of photosynthesis increases ✓ as the light intensity increases ✓ therefore the average mass of lettuce plants increases. ✓

1.4.2 Name two limiting factors that influence the rate of photosynthesis as the light intensity increases? (2)

Carbon dioxide ✓ Temperature ✓

1.4.3 How were the scientists able to increase the rate of photosynthesis to the maximum level? (3)

They raised the CO_2 level to an optimum level of 4% ✓ and the temperature to 25°C ✓ as they increased the light intensity to 8 arbitrary units. ✓

1.4.4 What would happen to the rate of photosynthesis if the temperature is raised beyond 35°C? Give a reason for your answer. (2)

The rate of photosynthesis would drop drastically ✓ because at higher temperatures the enzymes would denature / become functionless ✓

(10)

Section A: [40]

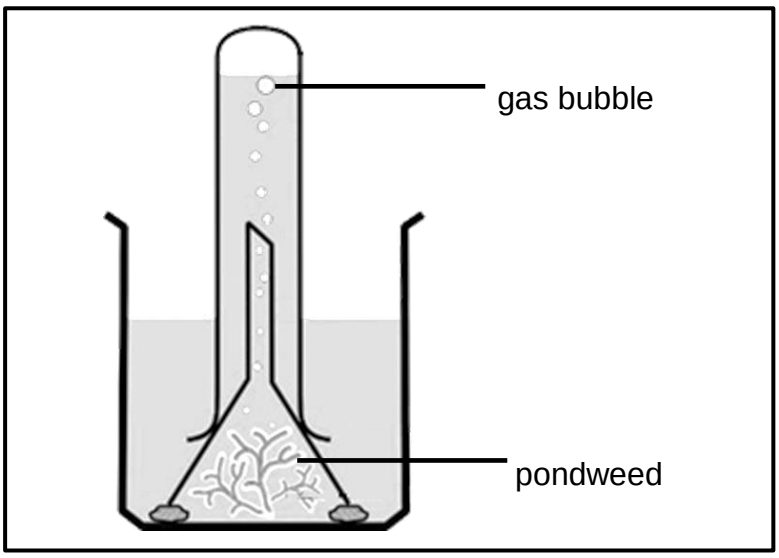
Section B

Question 2

2.1 When light shines on pondweed, *Elodea Sp*, bubbles of gas are released. The rate at which bubbles of gas are produced can be used to measure the rate of photosynthesis.

An investigation was carried out to study the effect of different colours of light on the rate of photosynthesis in the pondweed.

- The pondweed was exposed to one colour of light and left for 5 minutes before measurements were taken.
- The time taken for the release of 20 bubbles was recorded.
- The procedure was repeated using light of a different colour of equal intensity.
- The apparatus was set up as shown in the diagram below.



The results are shown in the table below:

Colour of light	Time taken to release 20 bubbles (seconds)
Violet	80
Blue	40
Green	160
Yellow	140
Red	70

2.1.1 Which colour light is the best for photosynthesis? Blue ✓ (1)

2.1.2 State the:

a) independent variable Colour of light ✓ (1)

b) dependent variable Time taken to release 20 bubbles ✓ (1)

2.1.3 Calculate the average time taken for the release of 20 bubbles for all colours. Show all working. (3)

$$average\ time = \frac{80 + 40 + 160 + 140 + 70}{5} ✓ = \frac{490}{5} ✓$$
$$= 98 \text{ ✓seconds}$$

2.1.4 Express bubble production under violet, blue and green light as a ratio. (2)

2:1:4 ✓✓

2.1.5 Explain why the apparatus is left for 5 minutes under each colour of light before taking measurements. (2)

To allow the plant to adjust ✓ its rate of photosynthesis to the new conditions ✓

2.1.6 Without modifying the apparatus, how could the reliability of the results be increased? (2)

Repeat ✓ the experiment

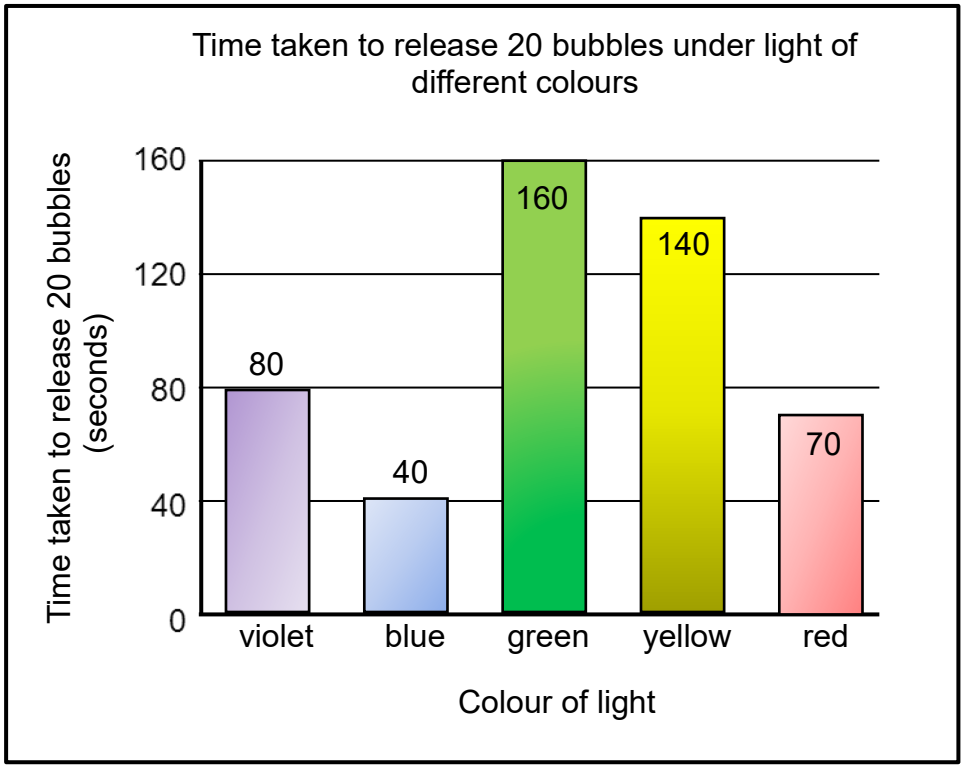
Take more readings for each light colour. ✓

2.1.7 Using the results, explain how, when white light shines on the plant, the leaves appear to be green. (2)

Green light poorly absorbed ✓ compared to other colours ✓ **OR**

More green light ✓ will be reflected ✓ by the leaves

2.1.8 Draw a bar graph of the results shown in the table. (6)

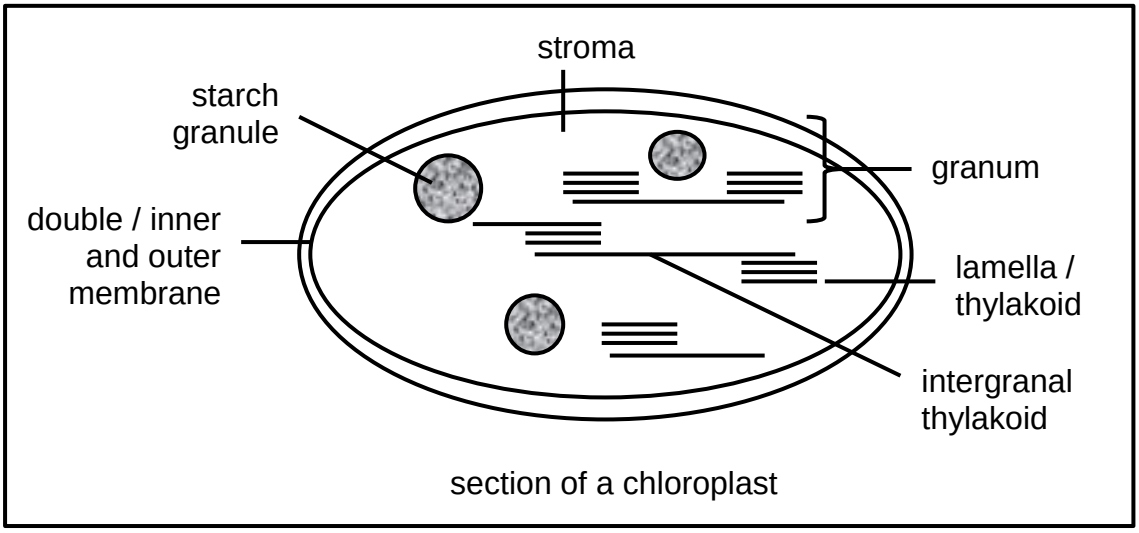


Guidelines for assessing graph:

Correct type of graph	✓
Title of graph	✓
Correct label for x-axis and Y-axis	✓
Appropriate scale for x-axis and y-axis	✓
Drawing of bars	✓: Drew 1 to 4 bars correctly ✓✓: Drew 5 bars correctly

NOTE: If wrong type of graph is drawn, marks will be lost for "correct type" and "drawing of bars". (20)

2.2 Draw a labelled diagram of an organelle present in the leaves of plants where photosynthesis takes place. (5)



Guidelines for marking diagram:

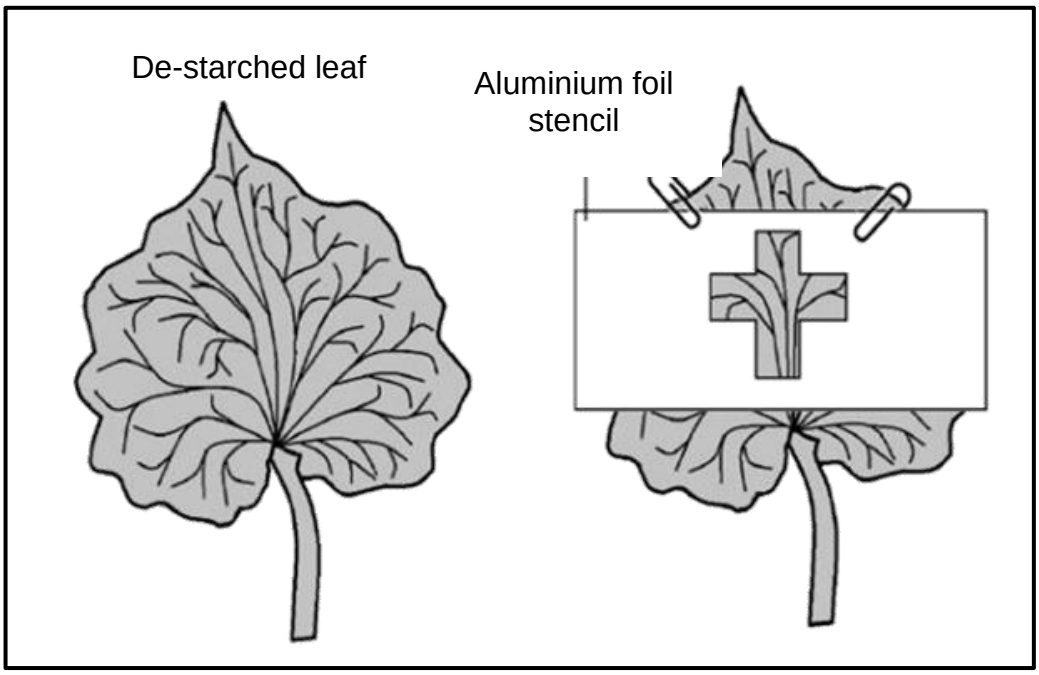
Caption	✓
Correct drawing	✓
Labels (any three)	✓ × 3

[25]

Question 3

An experiment was conducted to determine whether light is necessary for photosynthesis. The procedure followed is given below:

- A geranium potted plant was de-starched.
- A cross-shaped light slit was cut out on an aluminium foil.
- The aluminium foil stencil was then clipped onto one of the de-starched leaves as shown in the diagram below.
- The potted plant was exposed to bright sunlight for 4 to 5 hours.
- After 5 hours the aluminium foil stencil was removed, and the leaf was tested for starch.



3.1 Describe in the correct sequence the various steps that were followed during a starch test. (6)

1. Boil the leaf in water for 3 – 4 minutes ✓ to break down the cell walls ✓
2. Boil the leave in alcohol for about 2 minutes ✓ to remove the chlorophyll ✓
3. Rinse the leaf in cold water ✓
4. Spread the leaf on a tile and add a few drops of iodine solution ✓

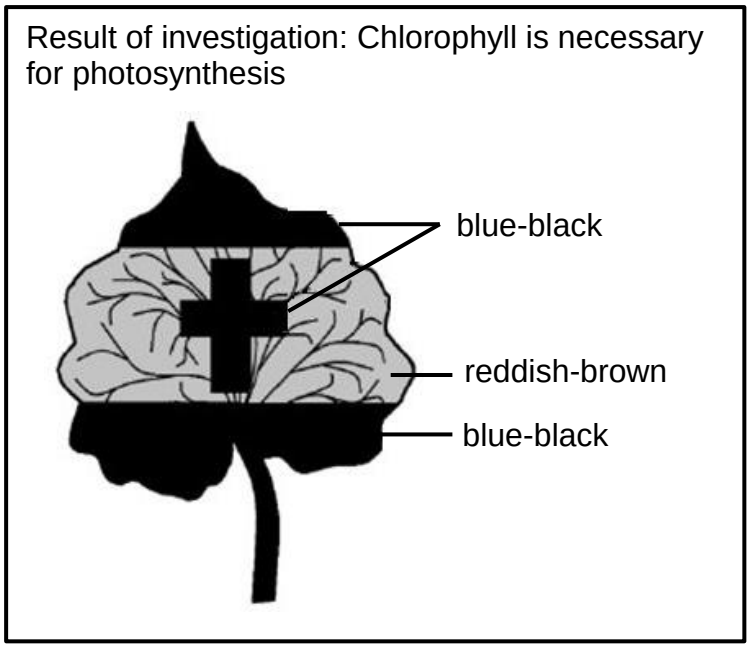
3.2 Mention one safety precaution that should be taken during this experiment. (2)

Care should be taken when working with alcohol – no open flame to be brought near alcohol ✓ as alcohol is highly flammable. ✓

OR

Alcohol should be boiled using a water bath ✓ as alcohol is highly flammable. ✓

3.3 Draw a labelled diagram of the leaf showing the result of the investigation. (5)



Rubric: Caption ✓
Diagram ✓
Shading ✓
Labels ✓✓

3.4 Provide a conclusion for this experiment. (2)

It can be concluded that light is required for starch ✓ to be produced during photosynthesis. ✓

[15]

Section B: [40]

Total marks: [80]

Cognitive level distribution

Question	Level 1	Level 2	Level 3	Level 4	Marks
1.1.1		✓			2
1.1.2		✓			2
1.1.3	✓				2
1.1.4	✓				2
1.1.5			✓		2
	4	4	2		10
1.2.1	✓				1
1.2.2	✓				1
1.2.3	✓				1
1.2.4	✓				1
1.2.5	✓				1
1.2.6	✓				1
1.2.7	✓				1
1.2.8	✓				1
1.2.9	✓				1
1.2.10	✓				1
	10				10
1.3.1	✓				2
1.3.2	✓				2
1.3.3	✓				2
1.3.4	✓				2
1.3.5	✓				2
	10				10
1.4.1			✓		3
1.4.2	✓				2
1.4.3				✓	3
1.4.4				✓	2
	2		3	5	10
2.1.1		✓			1
2.1.2 a – b	✓				2

2.1.3			✓		3
2.1.4		✓			2
2.1.5		✓			2
2.1.6		✓			2
2.1.7		✓			2
2.1.8	✓		✓		6 (2+4)
	4	9	7		20
2.2	✓	✓	✓		5 (1+3+1)
	1	3	1		5
3.1	✓				6
3.2	✓				2
3.3	✓	✓	✓		5(1+2+2)
3.4			✓		2
	3	2	4	6	15
	34	18	17	11	80

CHAPTER 5: ANIMAL NUTRITION

Overview

Time allocation: 3 weeks (12 hours)

This chapter consists of the following sections:

Introduction

This chapter focuses on the structure and function of the human digestive system. It provides a description of how food is digested, absorbed and assimilated into the body. It also provides a description of how the blood glucose level is controlled using hormones. A number of different cultural, religious or ethical diets are discussed and what can happen when a person does not eat a balanced diet. These deficiencies lead to a number of nutritional disorders. The effect of alcohol and drug abuse are also discussed.

Key concepts

- The digestive system is responsible for the digestion and absorption of nutrients.
- The digestive system consists of the alimentary canal and accessory organs that aid in digestion.
- Physical and chemical digestion takes place to break large food particles into small particles to be absorbed by the small intestine.

- Nutrients are absorbed and assimilated (incorporated into the body).
- Undigested waste is excreted through the anus.
- The hormones insulin and glucagon are released by the pancreas to control the amount of sugar in the blood.
- A balanced diet with all the correct nutrients is required to be healthy.
- Some cultural, religious or ethical diets exclude certain foods and alternative sources to these nutrients must be used.
- Some people are allergic to certain food groups.
- Malnutrition occurs when an individual eats an imbalanced diet which can result in: kwashiorkor; marasmus; anorexia, bulimia, coronary heart disease, diabetes or obesity.
- Alcohol and drug abuse is harmful to your health and can have many negative consequences.

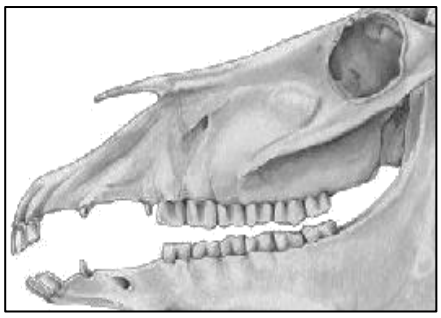
Different teeth for different lifestyles

Learners must be able to identify the four different type of teeth as well as the type of food that an organism eats by looking at the types of teeth the animal has. This must be linked to the position of an animal in a food chain/web e.g. a primary consumer is a herbivore and will therefore have well-developed molars and premolars.

Activity 1: Dentition

Study skull A and skull B below and answer the questions that follow.

Skull **A**



Skull **B**

1 Identify which skull (A or B) belongs to a …

a) herbivore skull B ✓

b) carnivore skull A ✓ (2)

2 Provide reasons for your answers in the above questions 1.a) and b). (2)

Skull A – carnivore, because it has canines for biting and holding flesh of prey; has carnassial teeth instead of flat molars ✓

Skull B – herbivore, there are large flat molars for grinding plant material. There are no canines. ✓

3 Does skull B have carnassial teeth? Explain your answer. (2)

No ✓, carnassial teeth are specialized molars and premolars that have triangular edges that can cut through meat. ✓

(6)

Human nutrition

The digestive system

The section on the digestive system includes a diagram of the alimentary canal and accessory organs. The labels and functions of which must be known. There are five important stages in human nutrition: ingestion, digestion, absorption, assimilation and egestion. The learners must be able to name and explain each stage including what occurs and where it occurs.

Activity 2: Dissection of sheep's digestive system

A sheep's carcass can be obtained from an abattoir to investigates its digestive system.

1. Identify the different types of teeth found in the animal.

   Sheep will have incisors and well developed molar and premolars but no canines.

2. Follow the pharynx that leads to the division of two pipes: the trachea to the lungs and the oesophagus to the stomach.
3. Follow the oesophagus to the stomach, into the small intestine and the colon.
4. Notice the large size of the rumen (first stomach).

   The rumen is an enlarged stomach of the sheep which contains bacteria to assist with the digestion of plant material – it is specialized to assist digestion because plant material takes a long time to digest.

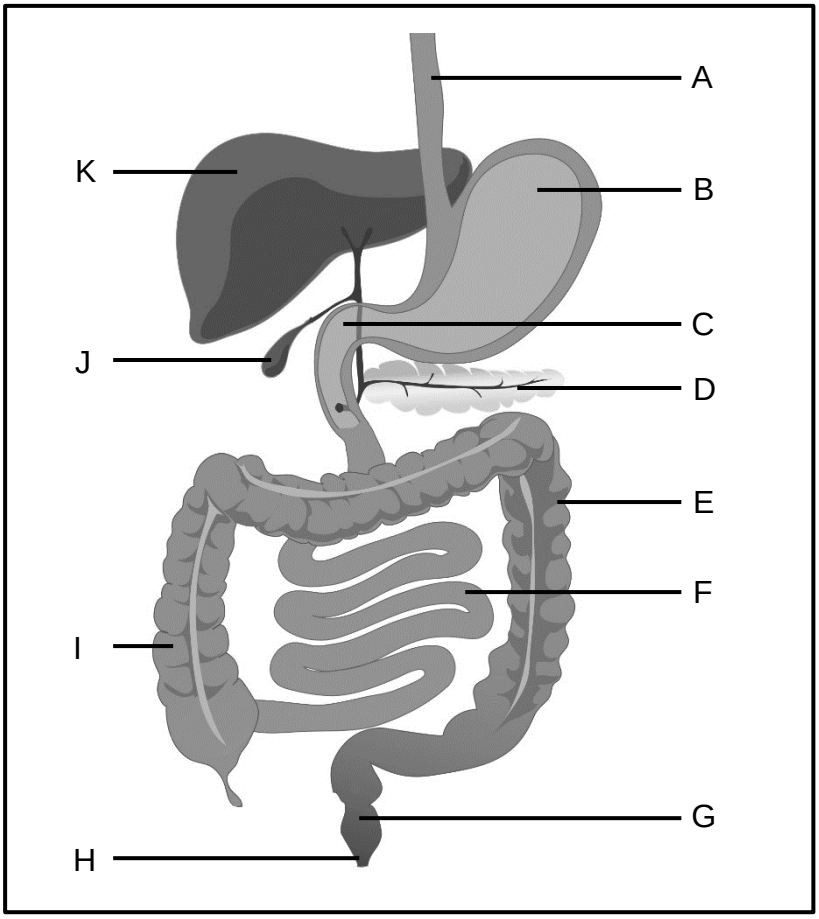
5. Compare the inner surfaces of the stomach, small intestine and the colon.

   The inner surface of the stomach should be smooth and soft.

The inner surface of the small intestine should have tiny transverse folds.
The inner surface of the colon will be smooth without the transvers folds.
All will be lubricated.

Activity 3: Human digestive system

Study the diagram below and answer the questions that follow.



1. Provide labels for A – K. (11)

   A – oesophagus, B – stomach, C – duodenum, D – pancreas, E – descending colon, F – small intestine (ileum), G – rectum, H – anus, I – ascending colon, J – gall bladder, K – liver ✓ - for each correct answer

2 Give the letter of the structure that:

   (a) produces bile K ✓

   (b) controls blood glucose D ✓

   (c) absorbs most of the nutrients F ✓

(d) absorbs most of the water I or J ✓ (4)

3. Name the structure where chyme can be found. stomach ✓ (1)

(16)

Digestion

Examples of both mechanical (physical) and chemical digestion must be discussed. Concerning mechanical digestion, it is important that learners understand the process of peristalsis. For chemical digestion, learners must know the general name for the enzymes that break down carbohydrates, proteins and lipids but do not have to know the specific names e.g. sucrase.

Activity 4: Stages of animal nutrition

1 Name the five main stages of animal nutrition. (5)

Ingestion ✓, digestion ✓, absorption ✓, assimilation ✓, egestion ✓

2 What are the three main food groups? (3)

Carbohydrates ✓, Proteins ✓, Lipids (fats and oils) ✓

3 Where does the chemical digestion of protein first take place? (1)

Stomach ✓

4 Briefly explain the process of peristalsis. (3)

- Peristalsis is the rhythmic contraction of the muscles ✓
- in the alimentary canal above the bolus/digesting food to push it along the canal ✓.
- The muscles below the bolus/digesting food must relax to allow the food to continue to move along the canal ✓.

5 Name the parts of the alimentary canal where peristalsis is used to move food along. (3)

Oesophagus ✓, small intestine ✓, large intestine / colon ✓

(15)

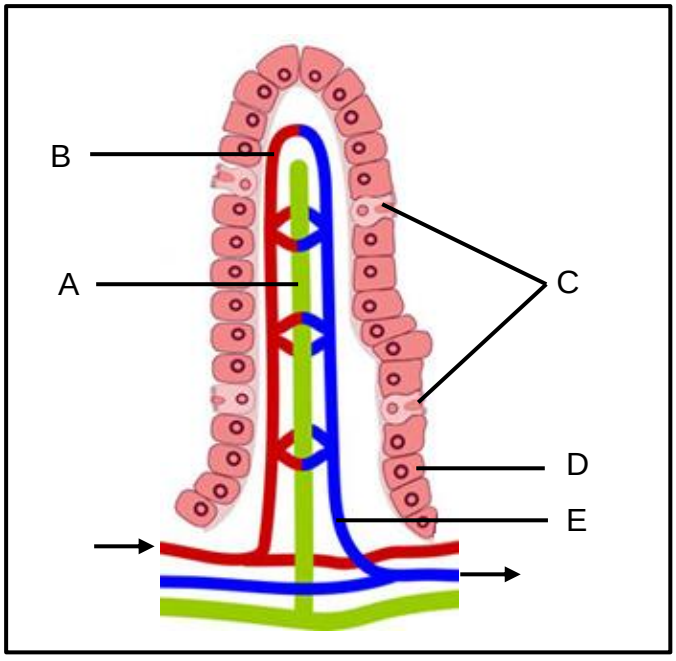
Absorption

The methods of absorption for the end products of digestion (glucose, amino acids, glycerol and fatty acids) are important. Learners must be able to identify whether absorption is active or passive and into which structure the end products are absorbed. The structure of absorption in the small intestine, the villus, must also be drawn and labelled. Learners must also be able to list and discuss the adaptations of the small intestine as well as the villus for absorption.

The pathway that absorbed nutrients take must be explained. i.e. fatty acids and glycerol are absorbed into the lacteal which is transported along the lymphatic system to the body; amino acids and glucose are absorbed into blood capillaries and travel through the hepatic portal vein to the liver where they are processed. This can easily be linked with the next section.

Activity 5: Villi

Study the diagram below and answer the questions that follow.



1. Provide an appropriate title to this diagram. (1)

   A section through a villus from the small intestine ✓

2. Provide labels for A – E. (5)

   A – lacteal, B – arteriole, C – goblet cell, D – epithelial cell / columnar epithelium, E – venule ✓ - for each correct answer

3. What structures would you expect to find on cells labelled D? (1)

   microvilli ✓

4. Provide the letter of the structure where absorbed glucose and amino acids will be found. (1)

   B / E ✓ (E will contain more of these nutrients because they have had a longer time to absorb than B.)

5. Is the absorption of glucose and amino acids active or passive? (1)

   Active ✓, it requires energy

6. Give the letter for the structure into which fatty acids and glycerol are absorbed?
   A ✓ (1)

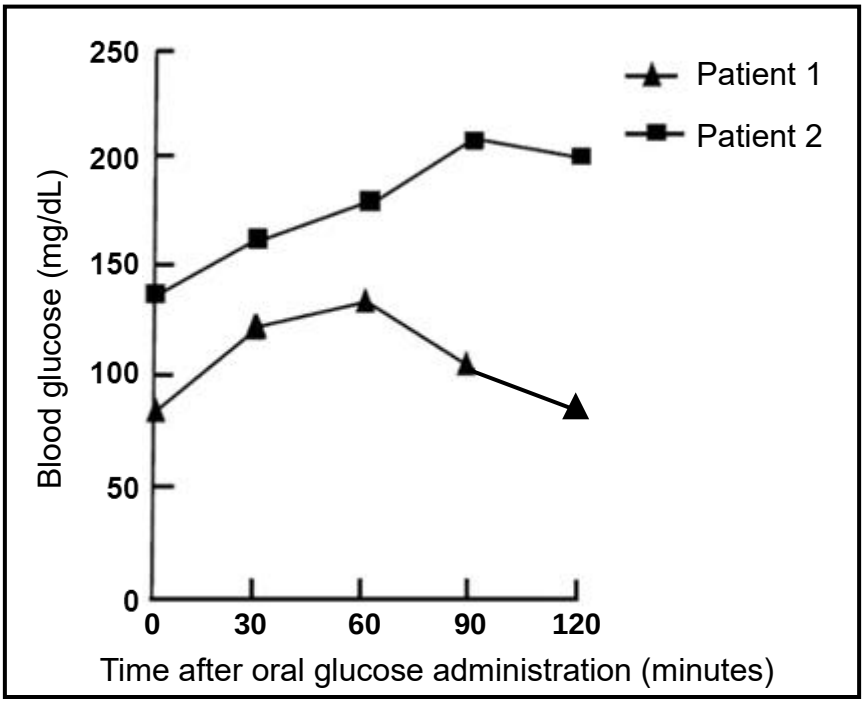
(10)

Homeostatic control of blood glucose level

Control of blood glucose level is very important and is covered again in Grade 12. Learners must understand that the pancreas monitors and controls blood glucose levels. The effect of insulin and glucagon must be understood to control blood glucose. Learners must be able to combine knowledge from the previous section to explain how eating food with high glucose levels will result in the release of insulin from the pancreas. When insulin does not work correctly or is not produced in adequate amounts, it results in the nutritional disorder diabetes mellitus where the blood glucose levels are too high. Learners must also be able to differentiate between type 1 and type 2 diabetes and the causes of each.

Activity 6: Diabetes mellitus

An oral glucose tolerance test is used to determine if a person is diabetic. This test was performed on two people. After fasting for 12 hours, each person was given the same glucose solution to drink and then their blood glucose levels were measured every 30 minutes for two hours. The results of the investigation are shown in the graph below.



1. Which patient is diabetic? Patient 2 ✓ (1)
2. Give two reasons for your answer in question 1. (2)

Patient 2 has an elevated blood glucose level even after 120 minutes have passed since the administration of glucose ✓ whereas Patient 1's blood glucose has returned to normal ✓

3. How long does it take for the blood glucose of patient 1 to return to normal? (1)

   Approximately 120 minutes ✓

4. What is the name of the hormone that:

   a) increase blood glucose levels? Glucagon ✓ (1)

   b) decreases blood glucose levels? Insulin ✓ (1)

(6)

The relationship between food intake and health

This section discusses many different aspects relating to diets. Learners must be able to identify and discuss various diets and the potential nutrient deficiencies they may result in if the diet is not properly balanced. Learners also need to understand the nutritional information from food products and discuss the suitability of it for a balanced diet. The need for supplements in various diets must also be understood. The nutritional disorders that arise from a lack of different nutrients or an excess of certain nutrients must be understood and the symptoms of these to be identified. Common food allergies must also be identified and understood.

Activity 7: Food

1. Name the diet that does not include any meat products. (1)

   Vegetarian / vegan ✓

2. Which disorder arises when a diet lacks protein. (1)

   Kwashiorkor ✓

3. Differentiate between the two psychological nutrition disorders. (4)

   Anorexia nervosa ✓ – a person refuses to eat in fear of gaining weight ✓

   Bulimia ✓ - when a person overeats and feels guilty and induces vomiting ✓

4. Study the nutritional information from a carbonated cooldrink below and answer the questions that follow.

Typical values	Standard serving (240 ml)	This package (360 ml)
Energy	400 kJ	600 kJ
Total fat	0 g	0 g
Sodium	40 mg	60 mg
Total carbohydrates	28 g	42 g
of which total sugars	28 g	42 g
Protein	0 g	0 g

4.1 Which nutrient occurs in the highest amount in this cooldrink? (1)

Carbohydrates / sugars ✓

4.2 Name the mineral that is mentioned on this packaging. (1)

Sodium ✓

4.3 Is this cooldrink a good option for an inactive individual to drink regularly? Explain your answer. (4)

No, ✓ it has a high sugar content ✓and excess sugar will be stored ✓ in the body if not used, potentially leading to obesity. ✓

4.4 Name three disorders/diseases that are the result of diets that contain too many foods rich in sugar. (3)

Obesity, diabetes, coronary heart disease ✓

(15)

Alcohol and drug abuse

Learners must understand the short-term and long-term consequences of alcohol and drug abuse.

Summary

Animal dentition

- Animals have different types and arrangements of teeth depending on their diets:
    - Herbivores have well developed molars for grinding plant material and canines are often absent.
    - Carnivores have well developed canines for holding and biting prey and carnassial teeth for slicing meat.
    - Omnivores have teeth that resemble both herbivores and carnivores and are suited to consume all types of food.

Human Nutrition

- The digestive process consists of ingestion; digestion; absorption; assimilation and egestion.
    - Digestion can include mechanical breakdown of food (physical digestion) or enzymes breaking larger compounds into smaller compounds (chemical digestion).
    - Most absorption takes place in the small intestine which are efficient organs of absorption called villi.
    - Carbohydrates and proteins are absorbed into capillaries in the villi whereas lipids are absorbed into the lacteals in the villi.
    - Absorbed nutrients are incorporated into the body (assimilation).
    - Undigested waste is egested through the anus.
- Blood glucose levels in blood are maintained at a constant level (homeostasis).
    - When blood glucose levels are too high, insulin is released from the pancreas to convert blood glucose into glycogen in the liver and muscles to return blood glucose to normal.
    - When blood glucose levels are too low, glucagon is released from the pancreas to convert stored glycogen in the liver and muscles into glucose which enters the blood and returns blood glucose to normal.
    - The metabolic disorder diabetes mellitus occurs when insulin is not released or does not function properly resulting in high blood glucose levels.

- Different diets
    - There are a number of different diets from different cultures, religions, personal and health choices.
    - A balanced diet is required to obtain all the nutrients on the correct amounts. Different forms of malnutrition occur if we do not have a balanced diet: kwashiorkor; marasmus; anorexia, bulimia, coronary heart disease, diabetes and obesity.
    - If a diet is lacking a particular nutrient, then that nutrient can be added to the diet in the form of a supplement to ensure nutritional health.
    - A number of food allergies exist that prevent people from eating these particular foods: milk, peanuts, shellfish, eggs etc.
- Alcohol and drug abuse result in many negative consequences such as: loss of memory, slurred speech, depression, unconsciousness and death.

End of topic exercises

Section A

Question 1

1.1 Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A- D) next to the question number (1.1.1 – 1.1.5) on your answer sheet, for example 1.1.6 D

1.1.1 Which of the following substances can directly be absorbed by blood without further digestion?

A Proteins
B Starch
C **Glucose ✓✓**
D Fats

1.1.2 The concentration of which of the following substances are normally higher in the hepatic portal vein than in most other veins in the human body?

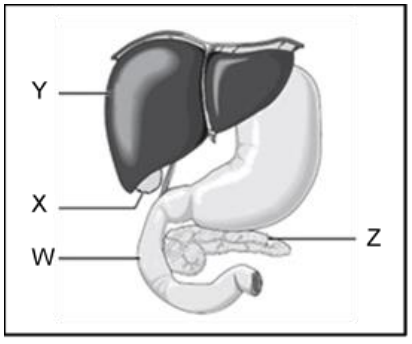
A Oxygen
B **Glucose ✓✓**
C Urea
D Carbon dioxide

1.1.3 Where does the emulsification of fat occur?

A In the liver.
B In the colon.
C In the gallbladder.
D **In the small intestine**. ✓✓

1.1.4 Which labelled structure secretes a hormone which causes an increased production in glycogen?

A W
B X
C Y
D **Z ✓✓**



1.1.5 Irritable bowel syndrome (IBS) is a medical term used to describe a disease of the digestive system. Symptoms usually occur after certain foods or drinks were consumed. It can cause sudden and severe diarrhoea. What consequence can this have for a person?

A Too much water and nutrients will be absorbed in the digestive tract.

B Too little water will be absorbed, but the nutrients will be absorbed.

C Too little nutrients will be absorbed, but water will be absorbed

D **Too little water and nutrients will be absorbed**. ✓✓

(5 × 2) = (10)

1.2 Give the correct **biological** term for each of the following descriptions. Write only the term next to the question number.

1.2.1 The disorder resulting from insufficient intake of proteins. kwashiorkor ✓

1.2.2 A type of malnutrition in which the person consumes large quantities of high-energy food. obesity ✓

1.2.3 The ejection of solid waste from the body. defaecation / egestion ✓

1.2.4 The tiny finger-like projections in the small intestine. villi ✓

1.2.5 The process where the products of digestion become part of the protoplasm of the body cells. assimilation ✓

1.2.6 Substance secreted by the liver to emulsify fats. bile ✓

1.2.7 The form in which excess glucose is stored in humans. glycogen ✓

1.2.8 The wave-like contractions of the muscles of the alimentary canal that move food along. peristalsis ✓

1.2.9 Ball of chewed food mixed with saliva formed in preparation for swallowing. bolus ✓

1.2.10 The muscular tube that connects the mouth cavity to the stomach. oesophagus ✓

(10 × 1) = (10)

1.3 Indicate whether each of the descriptions in Column I applies to **A ONLY**, **B ONLY**, **BOTH A AND B** or **NONE** of the items in Column II. Write **A only**, **B only**, **both A and B** or **none** next to the question number.

Column I	Column II
1.3.1 Substances that need to be digested before absorption	A: amino acids B: glucose

1.3.2 A lymph vessel in the villus of the small intestine.	A: lacteal B: lymphatic node
1.3.3 The enzymes secreted by the pancreas	A: proteases B: carbohydrases
1.3.4 The structure where chemical digestion does not take place.	A: oesophagus B: large intestine

(4 × 2) = (8)

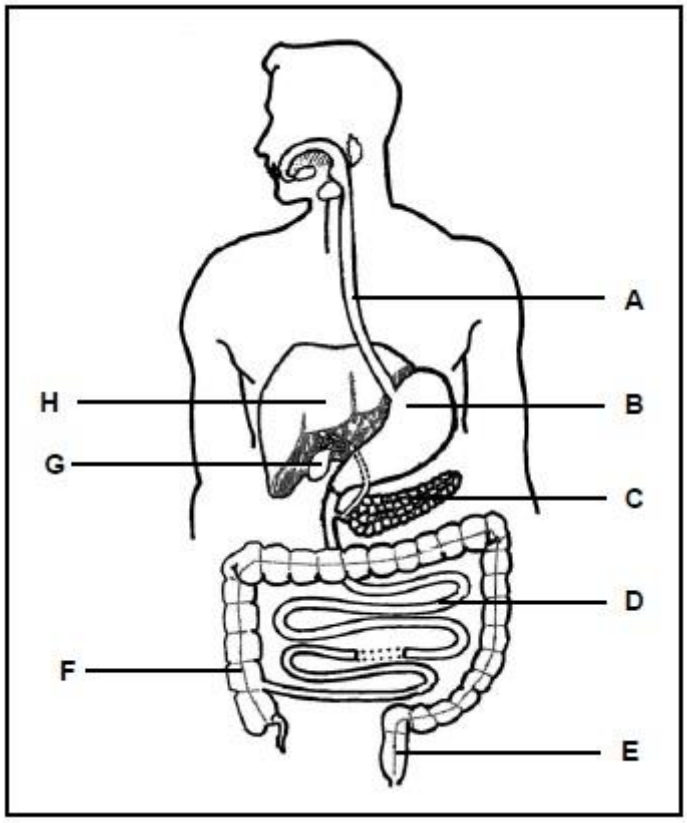
1.3.1 **None ✓✓**

1.3.2 **A only ✓✓**

1.3.3 **Both A and B ✓✓**

1.3.4 **Both A and B ✓✓**

1.4 Study the diagram below which shows the human digestive system.



1.4.1 Labels parts A, B, C, D, E, F and H. (7)

A – oesophagus ✓, B – stomach ✓, C – Pancreas ✓, D – small intestine / ileum ✓, E – rectum ✓, F – ascending colon / colon ✓, H – liver ✓

1.4.2 Write the letter only of the part:

a) that stores bile G ✓ (1)

b) where chemical digestion of proteins begins B ✓ (1)

c) where most water and mineral salts are absorbed F ✓ (1)

1.4.3 Why can the part labelled C be regarded as…

a) an exocrine gland? (1)
It secretes pancreatic juice containing digestive enzymes into ducts. ✓

b) an endocrine gland? (1)
It secretes hormones / insulin and glucagon into the blood vessels. ✓

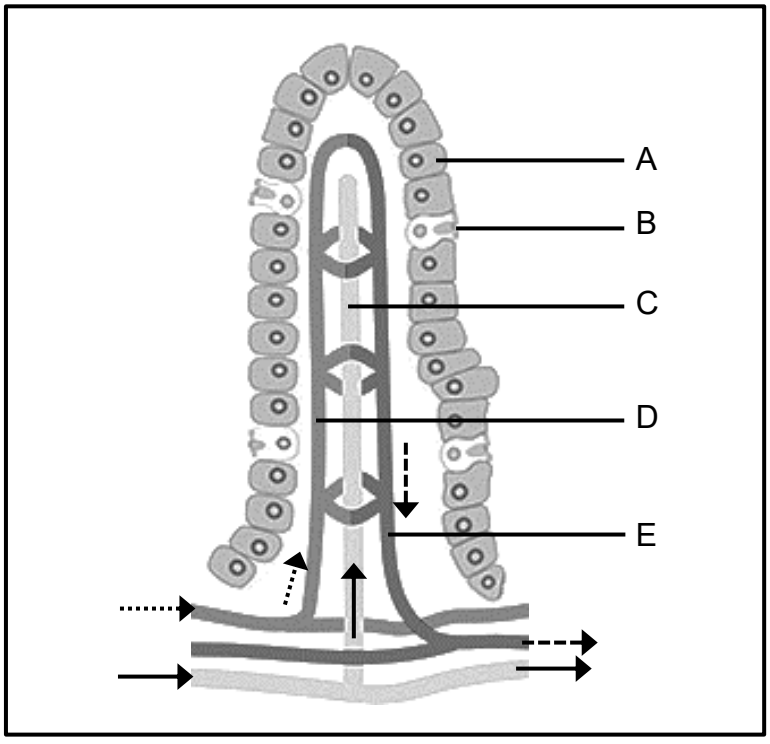
(12)

Section A: [40]

Section B

Question 2

2.1 The diagram below shows a structure associated with the digestive system.



2.1.1 Identify the structure shown in the diagram. Villus ✓ (1)

2.1.2 Name part C in the diagram. Lacteal ✓ (1)

2.1.3 In which part of the digestive tract would this structure be found? (1)
small intestine ✓

2.1.4 Explain three structural adaptations of the part mentioned in question 2.1.3 that enables it to perform its functions. (6)

- It is long, ✓ which means it has a very large surface area for absorption ✓
- It has many folds ✓ which enlarges the surface area for maximum absorption of nutrients ✓
- Millions of villi and microvilli ✓ which enlarge the surface area even further ✓
- The thin-walled ✓ villi (outer walls of villi are lined by a single layer of columnar epithelium) facilitate easy absorption ✓
- Villi are well supplied with blood capillaries and lacteals ✓ to ensure that absorbed nutrients are quickly transported away ✓

(Mark the first three only)

2.1.5 In which part (D or E) would you expect to find more nutrients? (1)

Part E✓

2.1.6 Explain your answer in question 2.1.5. (2)

Blood low in nutrients flows in at D ✓

Absorption of nutrients will take place ✓

From the small intestine into the capillaries in the villus ✓

When the blood leaves at E it will be rich in nutrients ✓

(Mark any two × 1)

2.1.7 Name the process that enables humans to absorb the nutrients in part E. (1)

Diffusion / active transport✓

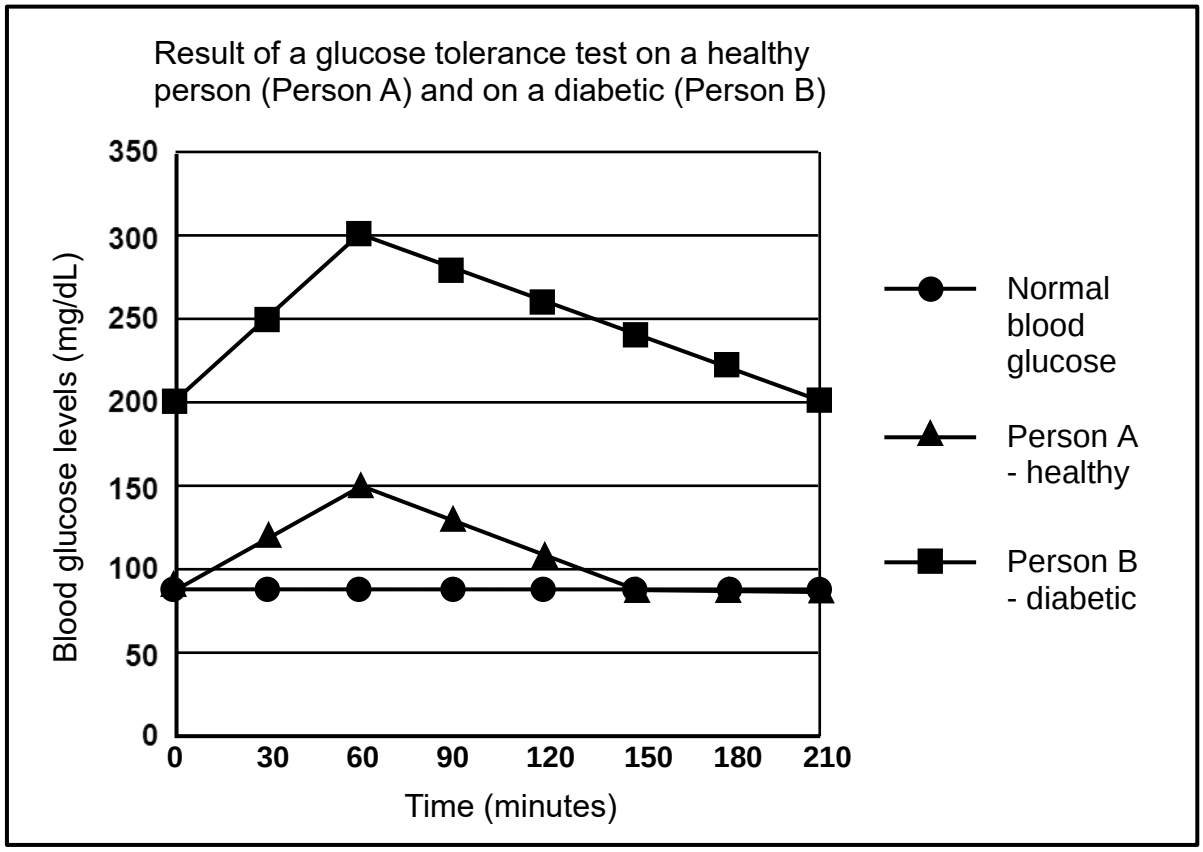
2.1.8 Celiac disease is a disorder that makes human bodies react to gluten (a protein found in wheat, rye, barley and grains). The response by the immune system eventually damages the structures illustrated in the diagram above. Explain the effects of this disease in the human body. (2)

- The body will not be able to absorb nutrients ✓* (minerals or vitamins)
- They will run the risk of malnutrition ✓
- which will lead to retarded growth ✓ / fatigue / weight loss

(*Compulsory mark + any 1)

(15)

2.2 The graph below shows the results of a glucose tolerance test on a healthy individual (Person A) and on a diabetic (Person B). After fasting for ten hours they each were given a drink of glucose solution containing 50 g glucose. The amount of glucose in their blood was then measured every 30 minutes for the next 3 hours.



2.2.1 What was the greatest concentration of glucose in the diabetic's blood? (1)

300 ✓ mg / dL

2.2.2 From the graph, determine how long it would take for the glucose concentration of:

a) the healthy person to return to the level when the glucose solution was consumed. (2)

2 hours 30 minutes / 150 minutes ✓✓

b) the diabetic person to return to the level when the glucose solution was consumed. (2)

3 hours 30 minutes / 210 minutes ✓✓

2.2.3 What effect would injecting insulin into the diabetic person have on the results of the test? (1)

Regular injections of insulin would lower the blood glucose concentration of the diabetic to normal. ✓

OR

It will also shorten the time it takes for the blood glucose concentration to return to normal after ingestion. ✓

2.2.4 What is the function of insulin? (1)

To reduce the blood glucose levels ✓ **OR**

To convert glucose into glycogen ✓

2.2.5 Explain briefly why insulin, which is a protein, is injected into a diabetic person, rather than given orally. (2)

Insulin is a protein and therefore digested in the human digestive system.✓ It would therefore not be absorbed as insulin, but as its amino acids.✓

(9)

2.3 Briefly describe the homeostatic control of blood glucose. (6)

When the blood glucose level rises:

- (Beta cells) of the islets of Langerhans ✓ in the pancreas ✓ secrete
- Insulin ✓ which regulates blood glucose level.
- It facilitates absorption of glucose from blood into the cells and
- glucose level of blood is lowered .✓
- It increases the rate of glucose utilisation in the cells. ✓
- It stimulates the conversion of excess glucose into glycogen in the liver and muscles. ✓ (max 3 marks)

When the blood glucose level drops:

- (Alpha cells) of the islets of Langerhans in the pancreas secrete glucagon ✓ which regulates blood glucose levels.
- It stimulates the conversion of stored glycogen into glucose, ✓ and increases the level of glucose in the blood.✓
- High concentration of glucose inhibits secretion of glucagon ✓ but stimulates the secretion of insulin.✓ Similarly, low concentrations of glucose inhibits secretion of insulin ✓ but stimulates the secretion of glucagon. ✓ This is known as the negative feedback mechanism.✓ (max 3 marks)

(15)

Section B: [30]

Total marks: [70]

Cognitive levels distribution

Question	Level 1	Level 2	Level 3	Level 4	Marks
1.1.1	✓				2
1.1.2	✓				2
1.1.3	✓				2
1.1.4	✓				2
1.1.5	✓				2
	10				10
1.2.1	✓				1
1.2.2	✓				1
1.2.3	✓				1
1.2.4	✓				1
1.2.5	✓				1
1.2.6	✓				1
1.2.7	✓				1
1.2.8	✓				1
1.2.9	✓				1
1.2.10	✓				1
	10				10
1.3.1	✓				2
1.3.2	✓				2
1.3.3	✓				2
1.3.4	✓				2
	8				8
1.4.1	✓				7
1.4.2		✓			3
1.4.3			✓		2
	7	3	2		12
2.1.1	✓				1
2.1.2	✓				1
2.1.3	✓				1
2.1.4		✓			6

2.1.5				✓	1
2.1.6				✓	2
2.1.7	✓				1
2.1.8			✓		2
	4	6	2	3	15
2.2.1	✓				1
2.2.2 a – b		✓			4
2.2.3	✓				1
2.2.4	✓				1
2.2.5			✓		2
	3	4	2		9
2.3		6			6
		6			6
TOTAL	42	19	6	3	70

CHAPTER 6: CELLULAR RESPIRATION

Overview

Time Allocation: 1½ weeks (6 hours)

This chapter consists of the following sections:

- Introduction
- Definition of cellular respiration
- Importance of energy
- The process of cellular respiration
    - Aerobic respiration
    - Anaerobic respiration
- Comparison of aerobic and anaerobic respiration
- Investigations
- Summary
- End of topic exercises

Introduction

By now learners should know that all living things require energy to live. In this chapter, learners will study the process by which this energy is transformed so that organisms can make use of it.

Key terminology

metabolism	chemical processes in organisms which are controlled by enzymes
catabolic	a metabolic process in which complex molecules are broken down into simple ones to release energy
anabolic	the synthesis of more complex substances from simple molecules

Definition of cellular respiration

Cellular respiration is the chemical process where glucose is broken down gradually, in the **presence** of oxygen (aerobic respiration) or in the **absence** of oxygen (anaerobic respiration), to release **energy**.

The process of cellular respiration can be quite complicated, however learners only need to know the very basics of the process.

For a more detailed overview watch this video:
https://www.youtube.com/watch?v=2f7YwCtHcgk

Importance of energy

Energy is used by organisms in a variety of ways – for growth, for cell division, for movement, for transport of substances, etc. The main uses of energy are listed, but there are many others.

Process of cellular respiration

Key terminology

aerobic respiration	respiration in presence of oxygen
mitochondria	organelle / site for respiration
ATP	general energy carrier molecule in cells

Aerobic respiration

The mitochondrion was dealt with in the Grade 10 syllabus, but it is advisable to revise the structure of the mitochondrion with learners.

Learners should know the process of aerobic respiration well using both words and diagrams as well as the chemical and word formulae.

The stages of aerobic respiration

The process is broken down into three stages for convenience. Learners are required to know which stage takes place where, in the cytoplasm or mitochondria.

NOTE: NO biochemical detail of the process is required, therefore the process can be explained simply.

Anaerobic respiration

Key terminology

anaerobic respiration	respiration in absence of oxygen
fermentation	type of anaerobic respiration in yeast cells
alcoholic fermentation	breaking down of glucose in absence of oxygen, that gives rise to the production of alcohol in plant cells
lactic acid fermentation	breaking down of glucose in absence of oxygen, in animal cells
lactic acid	acid formed in muscle cells, during anaerobic respiration; leads to muscle exhaustion

There is a difference between anaerobic respiration in plants and animals. Learners must know that lactic acid production occurs in animals and that alcohol fermentation occurs in plants.

Anaerobic respiration in animals

Learners must know the word equations for the process. This is also known as lactic acid fermentation.

Anaerobic respiration in plants

Learners must know the word equations for the process. This is also known as alcohol fermentation.

Uses of anaerobic respiration in industry

Learners must know that anaerobic respiration is used in industry, particularly for the brewing of beer and bread making. There are many other examples of use in industry, but these are the two required by CAPS.

Comparison between aerobic and anaerobic respiration

Learners must know the similarities and differences, they should also be able to tabulate these.

The following videos give a good insight into the differences between aerobic and anaerobic respiration.

https://www.youtube.com/watch?v=ZkqEno1r2jk&index=17&list=PLW0gavSzhMlQYSpKryVcEr3ERup5SxHl0

https://www.youtube.com/watch?v=HZtXLhm7ISA&index=60&list=PLW0gavSzhMlQYSpKryVcEr3ERup5SxHl0

Experiments on cellular respiration

Key terminology

lime water	used to test for carbon dioxide
glycogen	from in which glucose is stored in animal cells
germinating	starting to grow

There are a number of investigations to show the requirements and products of cellular respiration. These are important to know and three investigations are discussed in particular.

To test for oxygen

A glowing splint test can be used to test for the presence of oxygen. A wooden splint/ stick is lit and then extinguished. In the presence of oxygen, the glowing end of the splint will re-ignite or glow brighter.

To test for carbon dioxide

A clear lime water solution will turn milky in the presence of carbon dioxide

CAPS requires learners to know investigations to show that oxygen is required during respiration and that carbon dioxide is produced by cellular respiration. They must be able to interpret data, identify variables, and suggest controls as well as record observations for such investigations.

There are many variations which can be discussed with learners, the end of year examinations contain different diagrams and investigations. Learners must be able to apply knowledge to these various investigations or diagrams used. As long as they have a good grounding and understanding, they should be able to do so.

Summary

- Cellular respiration is required by all living organisms to produce energy for all of their metabolic processes such as growth, movement, cell division and transport of substances.
- This energy is gained from nutrients acquired, mainly glucose.
- Glucose can be broken down aerobically in the presence of oxygen during a three stage process namely glycolysis, Kreb’s cycle and oxidative phosphorylation.
- Aerobic respiration produces a high amount of ATP stored energy.
- Glucose can also be broken down anaerobically in the absence of oxygen. In animals, this leads to lactic acid build up which can cause muscle soreness. In plants and yeast cells, this leads to the formation of alcohol and carbon dioxide.
- Anaerobic respiration is important in industry for the production of beer and bread.

End of topic exercises

Section A

Question 1

1.1 Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A – D) next to the question number (1.1.1 – 1.1.5) on your answer sheet, for example 1.1.6 D

1.1.1 Cellular respiration in a green leaf takes place

A during the day only.
B **continuously ✓✓**
C during the night only.
D during photosynthesis only.

1.1.2 The following components are involved in cellular respiration:

(i) Energy
(ii) Carbohydrates
(iii) Carbon dioxide
(iv) Water
(v) Oxygen

Which ONE of the following combinations show the correct way in which the components are involved?

A (ii) + (iii) → (i) + (iv) + (v)
B (ii) + (iv) → (i) + (iii) + (v)
C (i) + (ii) → (iii) + (iv) + (v)
D **(ii) + (v) → (i) + (iii) + (iv) ✓✓**

1.1.3 The conversion of pyruvic acid into lactic acid occurs during

A photolysis.
B glycolysis.
C **anaerobic respiration**. ✓✓
D oxidation of glucose.

1.1.4 A phase that does not require oxygen during cellular respiration is:

A Krebs cycle.
B **Glycolysis. ✓✓**
C Oxidative phosphorylation
D All of the above

(4 × 2) = (8)

1.2 Give the correct **biological** term for each of the following descriptions. Write only the term next to the question number.

1.2.1 The process during which glucose is converted into pyruvic acid.
Glycolysis ✓

1.2.2 The reagent used to test for the presence of carbon dioxide.
Clear limewater ✓

1.2.3 The acid that accumulates in the muscles of humans during continuous strenuous physical activity. Lactic acid ✓

1.2.4 The gas which is essential for the Krebs cycle to occur. Oxygen ✓

1.2.5 Folded structures found on the inner membrane of a mitochondria.
Cristae ✓

1.2.6 The stage of aerobic respiration that releases carbon dioxide.
Krebs cycle ✓

1.2.7 Genetic material found in the mitochondrial matrix.
Mitochondrial DNA ✓

1.2.8 The stage during aerobic respiration when water is released as a waste product.
Oxidative phosphorylation / electron transport system ✓

1.2.9 The type of anaerobic respiration that occurs in yeast cells.
(Alcoholic) fermentation ✓

1.2.10 The organelle in which respiration takes place. Mitochondria ✓

(10 × 1) = (10)

1.3 Indicate whether each of the descriptions in Column I applies to **A ONLY**, **B ONLY**, **BOTH A AND B** or **NONE** of the items in Column II. Write **A only**, **B only**, **both A and B** or **none** next to the question number.

Column I	Column II
1.3.1 The end product of anaerobic respiration in humans	A: lactic acid B: ethanol
1.3.2 A product of cellular respiration which supplies energy needed for metabolic reactions in cells	A: ATP B: oxygen
1.3.3 The fuel required for cellular respiration	A. glycogen B. glucagon
1.3.4 Molecule that stores energy	A: ADP B: ATP

(4 x 2) = (8)

1.3.1 **A only ✓✓**

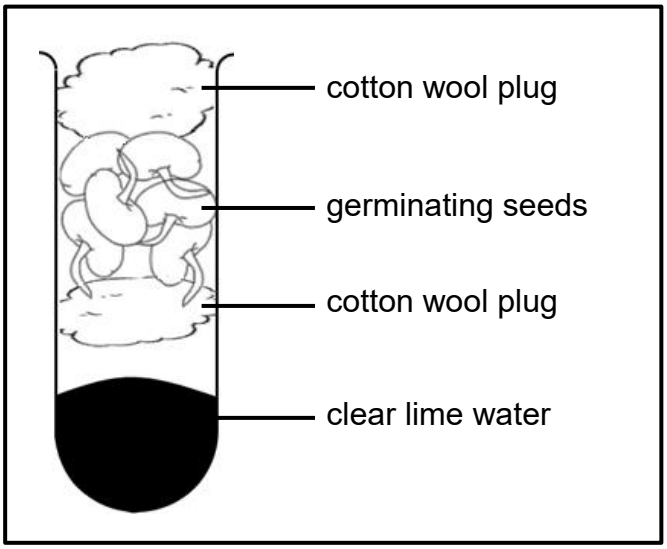
1.3.2 **A only ✓✓**

1.3.3 **none ✓✓**

1.3.4 **B only ✓✓**

1.4 The apparatus below was used to carry out an experiment on aerobic respiration. The experiment was set up as follows:

- 17 seeds of the same kind were used
- The seeds and the apparatus were sterilised before the investigation
- Once set up, the apparatus was placed in a dark cupboard at 35°C
- A control was also set up



1.4.1 What was the aim of the experiment? (2)

To determine if carbon dioxide is released ✓ during cellular respiration. ✓

1.4.2 What is the significance of sterilising the seeds before they are used? (1)

To ensure all micro-organisms are killed. ✓ / To eliminate any other organisms. / To ensure the carbon dioxide present is only produced by the germinating seeds.

1.4.3 Give one controlled variables in this investigation. (1)

Same kind of seeds. ✓
Constant temperature of 35°C ✓
Apparatus kept in the dark ✓ (mark first answer only)

1.4.4 Explain how you would set up a control for this investigation. (3)

The apparatus would be set up in the exact same way ✓
except by using no seeds ✓ / seeds that were boiled
To ensure that the changes observed in the investigation were

caused by the cellular respiration / germinating seeds ✓

1.4.5 Explain why germinating seeds were used in this investigation. (2)

Germinating seeds need a lot of energy for growth ✓
and the rate of cellular respiration will be high ✓
more carbon dioxide released ✓
achieving better results ✓ (any two correct answers)

(9)

1.5. Study the following extract and answer the questions which follow.

Many food and beverage industries are entirely dependent on the fermentation process to manufacture their products. Some of the products manufactured are being distributed and sold locally while the others are exported to foreign countries.

1.5.1 Name one food or beverage product which makes use of the fermentation process in its manufacture. (1)

Cheese, yoghurt, wine, beer, whisky, brandy. (any other relevant products) ✓ (mark first correct answer only)

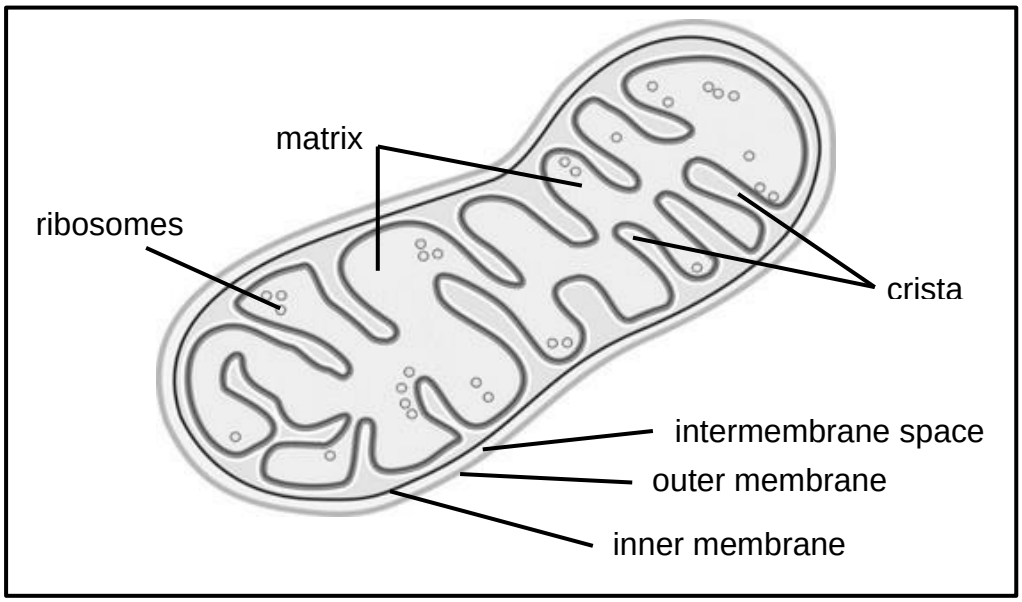
1.5.2 Explain one way in which the production of foods and beverages made by fermentation benefit the South African economy. (2)

- Products are exported ✓ and earns foreign exchange ✓
- Jobs are created ✓ and reduces unemployment ✓
- Company profit increases ✓ and government earns more revenue as taxes ✓ (any one answer × 2)

1.5.3 Describe how yeast cells benefit from the fermentation process? (2)

Derives energy ✓ for cellular activities ✓

1.5.4 Draw a labelled diagram of the organelle in which respiration takes place. (5)



Guidelines for assessing diagram:

Title	✓
Shape	✓
Any three correct labels	✓ × 3

(10)

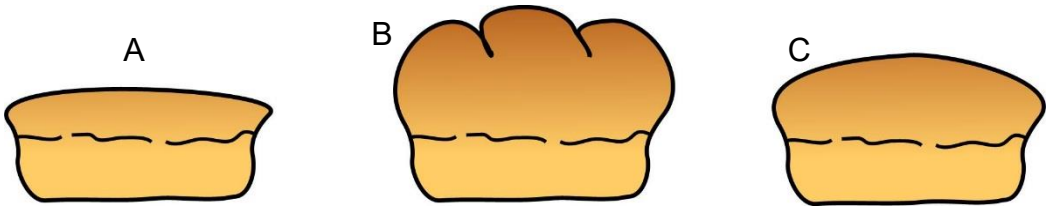
[45]

Section B

Question 2

2.1 A baker is testing a new recipe in order to bake the perfect loaf of bread. The two main ingredients in the bread dough are flour and yeast. She divides the dough into three equal parts and subjects the loaves to different treatments before baking.

- Loaf A: She immediately bakes the bread.
- Loaf B: She covers the dough with a damp cloth and leaves it in a warm area for an hour before baking it.
- Loaf C: She covers the dough with a damp cloth and leaves it in the fridge for an hour before baking it.
- After baking the three loaves she measured the height which each loaf rose. The results are shown below:



2.1.1 Formulate a hypothesis for this investigation. (2)

The bread dough ✓ will rise better in warm conditions than in cold conditions ✓ **OR**

Yeast cells respire more under warm conditions ✓ than cold conditions ✓.

2.1.2 Identify:

a) the dependent variable

How much the dough rises ✓.

b) the independent variable

Temperature ✓

c) one controlled variable (3)

Time allowed for the dough to rise ✓, amount of dough ✓, ingredients of the dough ✓ (any one correct answer)

2.1.3 Which loaf do you consider to be the control for this experiment? Give a reason for your answer. (2)

A ✓ because it was baked immediately ✓ all other factors were the same, except that there was no time allowed for the dough to rise.

2.1.4 One of the main ingredients is yeast.

a) Name the function of the yeast in this investigation. (1)

It respires which allows the dough to rise. ✓

b) Which biochemical process allows the yeast to perform its required function? (1)

Anaerobic respiration ✓

c) What is the yeast's source of glucose? (1)

Flour (starch) ✓

2.1.5 Why is the dough of loaves B and C covered with a damp cloth? (2)

To provide moist (optimum) conditions ✓ so that the yeast can respire and reproduce. ✓

2.1.6 What conclusions can be drawn from the resulting baked loaves? (4)

- Yeast cells respire optimally in warm, moist conditions. ✓
- Yeast cells respire slowly in cool conditions. ✓
- The yeast cells respire anaerobically, which produces carbon dioxide which is trapped in the dough and allows it to rise. ✓
- When the dough is placed in the oven, the high temperatures kill the yeast cells, because the proteins in the yeast denatures. ✓
- Dough does not rise when temperature is too high. ✓ (any four)

2.1.7 How can the baker improve the reliabilty of her experiment? (2)

- Repeat the investigation. ✓
- Use a thermometer to determine the exact temperature inside the dough as it rises. ✓ (18)

2.2 Read the information below and answer the questions that follow.

Traditional African Beer

Traditional beer forms a very important part of African culture. It is called *umqombothi* in isiXhosa and *iJuba* in isiZulu. The beer is mostly brewed from indigenous sorghum. The thick creamy African beer is very rich in vitamin B, it has a low alcohol content of less than 3% and it is inexpensive. The recipe for brewing beer is passed down through the generations.

The traditional method of testing to see if the brew is ready is to light a match close to the container of beer. If the flame dies quickly, the brew is ready. If the flames remain lit, the brew is not ready.

2.2.1 Name the biochemical process used to brew this African beer. (1)

Anaerobic respiration ✓

2.2.2 What causes the flame to die? (1)

Carbon dioxide ✓

2.2.3 Why would this test be an indication of whether the brew is ready or not? (2)

Anaerobic respiration uses oxygen and releases carbon dioxide. ✓

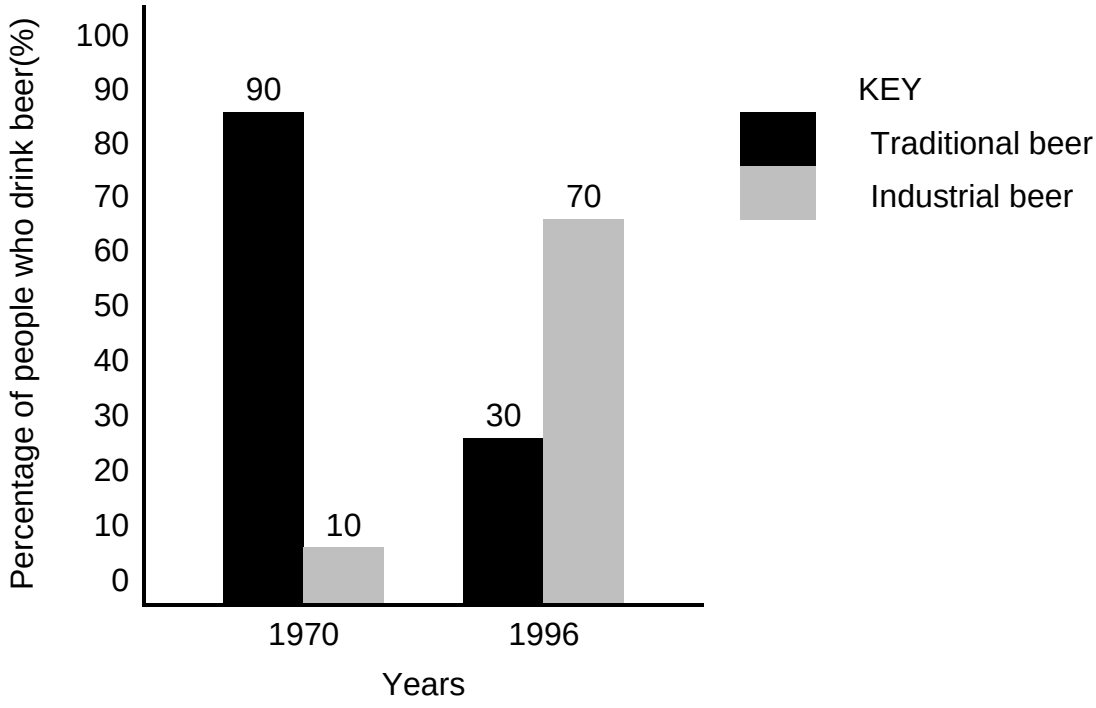
If the flame dies, carbon dioxide has been released which means that fermentation has occurred ✓ and the brew will be ready

A survey was done to determine the amount of people who drink industrially produced beer and traditional beer. The results for 1970 and then 1996 were as follows:

Type of beer	**Percentage of beer consumed**	
	1970	**1996**
Traditional beer	90%	30%
Industrially produced beer	10%	70%

2.2.4 Plot a bar graph to show the results of the survey. (6)

Percentage of people who drank industrially produced beer and traditional beer in 1970 and 1996



Guidelines for assessing graph:

Correct type of graph	✓
Title of graph	✓
Correct label for x-axis and Y-axis	✓
Appropriate scale for x-axis and y-axis	✓
Drawing of bars	✓: Drew 1-3 bars correctly ✓✓: Drew all bars correctly

NOTE: If wrong type of graph is drawn, marks will be lost for "correct type" and "drawing of bars".

2.2.5 Describe the trend shown by the graph. (2)

In 1970, more people drank traditional beer and less drank industrially produced beer. ✓

In 1996, more people drank industrially produced beer and less people drank traditional beer. ✓

(12)

Section B: [30]

Total marks: [75]

Cognitive level distribution

Question	Level 1	Level 2	Level 3	Level 4	Marks
1.1.1		✓			2
1.1.2				✓	2
1.1.3	✓				2
1.1.4	✓				2
	4	2		2	8
1.2.1	✓				1
1.2.2	✓				1
1.2.3	✓				1
1.2.4	✓				1
1.2.5	✓				1
1.2.6	✓				1
1.2.7	✓				1
1.2.8	✓				1
1.2.9	✓				1
1.2.10	✓				1
	10				10
1.3.1	✓				2
1.3.2	✓				2
1.3.3	✓				2
1.3.4	✓				2
	8				8
1.4.1		✓			2
1.4.2		✓			1
1.4.3			✓		1
1.4.4		✓			3
1.4.5		✓			2
		8	1		9
1.5.1	✓				1
1.5.2		✓			2
1.5.3		✓			2
1.5.4	✓		✓		5 (3+2)
	4	4	2		10

2.1.1			✓		2
2.1.2		✓			3
2.1.3		✓			2
2.1.4	✓				3
2.1.5			✓		2
2.1.6				✓	4
2.1.7			✓		2
	3	5	6	4	18
2.2.1		✓			1
2.2.2		✓			1
2.2.3			✓		2
2.2.4		✓			6
2.2.5			✓		2
		8	4		12
	29	27	13	6	75

CHAPTER 7: GASEOUS EXCHANGE

Overview

Time allocation: 2½ weeks (10 hours)

This chapter will consist of the following sections:

1. Introduction
2. Key concepts
3. Efficiency of gaseous exchange surfaces in living organisms
4. Relationship between respiratory structures and efficient gaseous exchange in different organisms
5. Human gaseous exchange
6. The mechanism of breathing
7. Measurement of the rate and depth of breathing
8. Composition of inhaled and exhaled air
9. Effect of exercise on breathing in humans
10. Internal and external gaseous exchange in humans
11. Homeostatic control of breathing
12. The effect of altitude on gaseous exchange
13. Diseases of the respiratory system
14. The effects of smoking on respiratory organs
15. Summary
16. End of topic exercises

Introduction

It is important to distinguish between breathing, gaseous exchange and cellular respiration.

- **Breathing** is a mechanical process of taking oxygen into the lungs. Why do we need to breathe? All organisms, from simple, unicellular to more advanced multicellular organisms need oxygen (O_2) to sustain cellular functions.

- **Cellular respiration** refers to a chemical process which takes place within cells in order to release energy. Plants and animals need cellular energy for survival.
- **Gaseous exchange** is a physical process which involves the exchange of gases between the air and the blood in the lungs. Organisms are adapted to ensure that the process of the exchange of gases is optimised. Mammals have a mechanism of breathing that ensures that gases enter their bodies, and this enables gaseous exchange and cellular respiration to occur as well as possible.

In studying aspects of gaseous exchange, the following should be kept in mind.

- **Structure to function**: how the organism is designed to carry out gaseous exchange
- **Regulation and control** of breathing in humans
- How the **amounts of gases** are kept at manageable levels in the blood
- **Disease** and certain **life choices** can impact negatively on effective gaseous exchange. Breathing can be impaired, and this affects the general health of an individual

Key concepts

- All living organisms need cellular respiration to obtain energy for cellular functions
- Important gases diffuse across surfaces in a process called gaseous exchange
- Air moves in and out of respiratory organs and this involves the mechanical process of breathing
- Effective gaseous exchange is dependent on the surface across which the gases diffuse as well as the external environment where the gases are found
- Plants and animals have gas exchange systems that are designed to suit their habitats (aquatic or terrestrial)
- Breathing in humans is regulated by a respiratory centre in the brain ensuring the balance of gases are correct in the blood
- Tuberculosis (TB) is a treatable bacterial disease that is highly prevalent in South Africa
- Bronchitis and pneumonia are bacterial infections that impact on the respiratory function
- Asthma, hay fever and lung cancer are disorders of the respiratory system and are on the increase in the world due to increased pollution
- Smoke from both cigarettes and marijuana is harmful to lung health

- Legislation in South Africa has changed with the aim of protecting children and non-smokers in public areas
- People in the workplace are encouraged to do First Aid courses and be proficient in cardiopulmonary resuscitation (CPR)
- Every adult South African should be encouraged to be able to perform artificial respiration
- High altitude training is encouraged for top athletes as the body undergoes physiological changes that benefit performance

Introductory teaching tool for Gaseous exchange chapter: Introduction to Human Respiratory System:
https://www.youtube.com/watch?v=CGVOWh20ufA&list=PL9jo2wQj1WCOM7JMqSBTzhrEWFe9-0QzQ

Key terminology

diffusion	the movement of molecules from a region of high concentration to a region of low concentration until equilibrium is reached; in gaseous exchange in living organisms we look at the movement of gases, O_2 and CO_2, into and out of cells
catabolism	breaking down
aerobic	in the presence of oxygen
anaerobic	in the absence of oxygen
cellular respiration	the breakdown of organic compounds (glucose / sugar) in the mitochondria of cells into inorganic products (CO_2 and H_2O) with the release of cellular energy (ATP); either aerobic or anaerobic

Efficiency of gaseous exchange surfaces in living organisms

As learners progress through the chapter they should continually remind themselves of the importance of effective structures in each organism they study.

- large respiratory surface
- thin and permeable respiratory surface
- moist respiratory surface
- well-ventilated respiratory surface
- protected respiratory surfaces
- vascular or transport system

Relationship between respiratory structures and efficient gaseous exchange in different organisms

Both terrestrial and aquatic plants and animals have gaseous exchange surfaces and respiratory structures that ensure effective exchange of gases (O_2 and CO_2). Learners should be able to briefly discuss how these requirements are met in dicotyledonous plants, earthworms, insects, bony fish and mammals. They should also be able to relate the gaseous exchange surfaces to their function in the different environments.

Learners can be reminded about some of the characteristics of mammals:

- warm blooded (endothermic)
- have mammary glands
- have 4 chambered hearts
- have hair or fur on the body
- have a diaphragm (sheet of muscle below the lungs)

Key terminology

terrestrial	(plants and animals) living on land
aquatic	(plants and animals) living in water
gaseous exchange	the exchange of O_2 and CO_2 at a respiratory surface occurs at **two** places in mammals: • at a gaseous exchange surface (lungs) and the blood • between the blood and the body cells at the tissue bed surface
breathing / ventilation	mechanical process of **inhalation** and **exhalation** through which air moves in and out of the respiratory organs enabling the uptake of oxygen and the removal of carbon dioxide.

Human gaseous exchange

Learners should be able to identify the air passages, lungs and structures involved in breathing and to discuss how each part is designed to carry out its function in the process of breathing or gaseous exchange.

They should be able to explain the appearance and texture of the lungs and how certain structures aid in protection and functioning of the lungs. With the aid of a sheep lung dissection, they should be able to identify the location of the lungs in relation to other main organs i.e. the heart.

They should also be able to explain the role of the ribs, intercostal and diaphragmatic muscles in the process of breathing.

A good teaching tool: Structure of lung for gaseous exchange: https://www.youtube.com/watch?v=aPUPfzsqDgs

The human gas exchange system consists of the following distinct sections:

- air passages
- lungs
- muscles involved in the mechanism of breathing (ventilation)

The system is well designed to carry out the function of gaseous exchange. Figures 1 and 2 in the learner text show parts of the respiratory system that are directly involved in breathing and gaseous exchange and Table 3 relates the structure to function of these parts.

The sheep lung dissection in Activity 1 will aid the learner in understanding the different structures and how they assist in the breathing.

Activity 1: Dissection of sheep lungs

When obtaining the sheep lungs from the butcher or abbatoir request that the whole trachea be included and if possible also the heart. It is also preferable to have the pleural membranes left on the lungs.

The following video is concise and detailed and is useful as a guide before carrying out the dissection.

Lung dissection in detail: https://www.youtube.com/watch?v=uDtZEM3FJnE

N.B. SAFETY GUIDELINES

- Ensure that you have the attention of every learner while giving safety demonstration
- Remind the learners that you are working with animal material and caution must be taken-no ingesting(eating) of any of the material
- Dissection tools are sharp and dangerous and should be handled with care
- Demonstrate the cutting action away from the hand and body
- No walking around the classroom/laboratory with any dissecting tools
- An inventory of dissecting tools must be taken before and after the session (one learner from each group can be responsible for this)

- Left over material must be correctly disposed of by the laboratory technician or by yourself as the teacher
- No material must leave the classroom with any learner
- Hands must be well washed with detergent (soap)

Aim: To **identify** the structure of the lungs and related structures and to **observe** the inflation of the lung.

End of dissection questions:

1. Describe the look, texture(feel) and colour of the lungs.
   Large and floppy looking. Spongy and soft feel. Deep / light red in colour
2. What structures keep the trachea open?
   C-shaped cartilage rings
3. Are the lungs hollow bags or spongy tissue?
   Spongy tissue
4. Name the two air passages that branch off the trachea and into each lung.
   The left and right bronchi
5. How does the diameter of these air passages compare to the diameter of the trachea?
   Slightly narrower in diameter
6. What happens to the piece of lung when you put it in water?
   It floats
7. When you inflated the lung what happened after you stopped blowing in?
   It started deflating (going down)

The mechanism of breathing

Learners should understand the mechanical processes of inhalation and exhalation.

Inhalation: Air is sucked in to the lungs due to air pressure and volume differences Intercostal and diaphragmatic muscles contract and the rib cage pushes out An active process

Exhalation: Air is forced out of the lungs due to pressure and volume differences Intercostal and diaphragmatic muscles relax and the rib cage collapses

This is a passive process

The learners should also be able to construct a model of the human breathing system, to identify weaknesses in the model, and to demonstrate how ‘breathing’ would happen in the model.

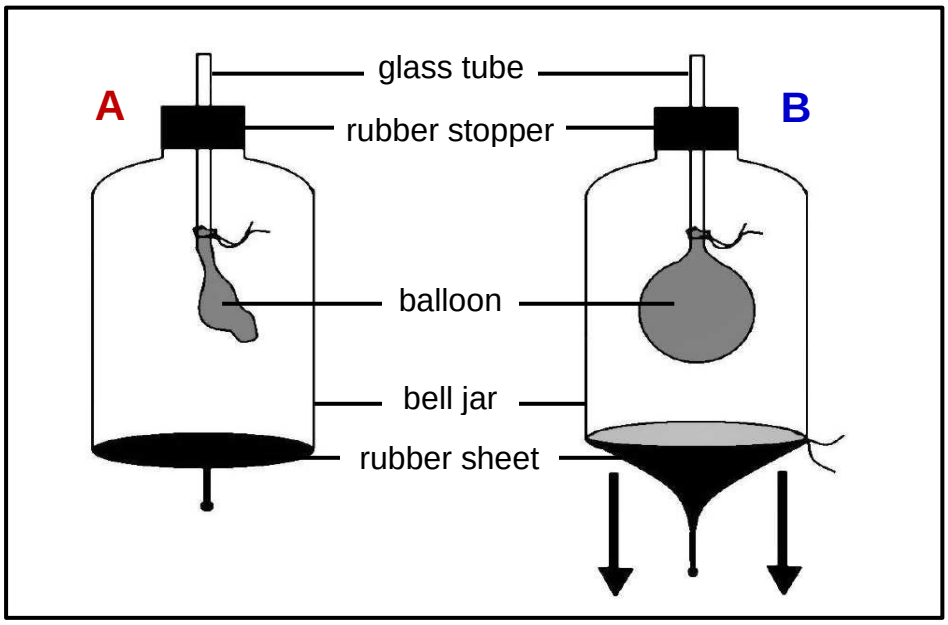
The process of breathing is a mechanical process. Air moves in and out of the lungs as a result of differences in atmospheric air pressure and the air pressure inside the lungs. It involves different muscles and volume and pressure changes in the thoracic cavity.

The table in the learner text has a diagrammatic representation of inhalation (Figure 3A) and exhalation (Figure 3B) as well as a brief explanation of the mechanism involved. The learners will need to understand how the muscles and ribcage behave in these two mechanical processes.

In Activity 2 the learners will look at a model of the lung showing the mechanism of breathing. The learners should be able to identify the parts that represent the real-life structure and to state what weaknesses their model has with respect to the human system.

Activity 2: Breathing

The following model can be used to demonstrate the mechanism of breathing.



Model of lung showing mechanism of breathing

1. For each of the model parts listed below, provide an appropriate name for the corresponding part in the human respiratory system (the model equivalent is shown in brackets):

   a) Glass tube trachea ✓ (1)

   b) Balloon lung ✓ (1)

   c) Bell jar chest (thoracic) cavity ✓ (1)

   d) Rubber sheet diaphragm ✓ (1)

2. Does B represent an active or passive process in the human mechanism of breathing? Active ✓ (1)
3. What happens to the air pressure in the bell jar at B? decreases ✓ (1)
4. What happens to the volume (size) of the space in the bell jar at B? (1)

   Increases ✓
5. What do you see as restrictions to the models when comparing them to the actual human body? Mention 2 possible **limitations** of the model. (2)

   The bell jar does not move but the lungs do ✓. Model demonstrates one lung where humans have 2 lungs ✓.

(9)

Measurement of the rate and depth of breathing

A **spirometer** is an instrument used to measure the volume of air that enters and leaves the human lungs during inhalation and exhalation.

Learners should be able to name the instrument used to measure the rate and depth of breathing, to identify a breathing graph (trace) showing inhalation and exhalation.

They should understand how the rate and depth of breathing would change when a person is exercising, and be able to interpret data on depth and rate of breathing and the heart rate at rest and when exercising.

Composition of inhaled and exhaled air

Learners should be able to name the main gases found in atmospheric air, explain the differences between the amount of each gas air in inhaled and exhaled air, and understand why exercise would alter these values

The air in the atmosphere is made up mainly of nitrogen, oxygen, carbon dioxide and water vapour and traces of inert gases. Inhaled air has the same composition as atmospheric air but different to exhaled air. Table 4 shows the difference in composition of the three main gases after exercise and while sleeping.

Table 4: The composition of inhaled and exhaled air

Gas	Inhaled air (%)	Exhaled air (%) from a sleeping person	Exhaled air (%) from a person exercising
Nitrogen (N_2)	78	78	78
Oxygen (O_2)	21	16	12

Carbon dioxide (CO_2)	0,04	4	9

Nitrogen is not used in the human breathing system. Oxygen is used by the cells in cellular respiration and carbon dioxide is a product of cellular respiration and needs to be removed from the cells.

By looking at the table above:

- What is the difference between the percentage of oxygen inhaled and that exhaled from a sleeping person? 21 – 16 = 5%
- What is the percentage oxygen used by the body in each inhalation of a person who is exercising? 21 – 12 = 9%

Effect of exercise on breathing and pulse rate in humans

Breathing is controlled by the respiratory centre in the medulla oblongata of the brain.

Activity 3: Breathing investigation

The table below shows results obtained from an experiment where 2 learners recorded their heart rates and breathing rates at rest, after walking up and down 2 sets of stairs and after running up and down two flights of stairs.

	Heart Rate (beats per minute)			**Breathing rate (breaths per minute)**		
	At rest	Walking	Running	At rest	Walking	Running
Learner 1	68	63	112	12	12	16
Learner 2	72	86	120	12	12	14

1. State the aim of the investigation. To determine the effect of exercise ✓ on the heart rate ✓ and breathing rate ✓ of 2 learners. (3)
2. What do you observe happened to the heart rate of both learners after running up the stairs? (1)

   Both their heart rates increased to over 100 bpm ✓
3. What do you observe happened to the breathing rate of both learners after running up the stairs? (1)

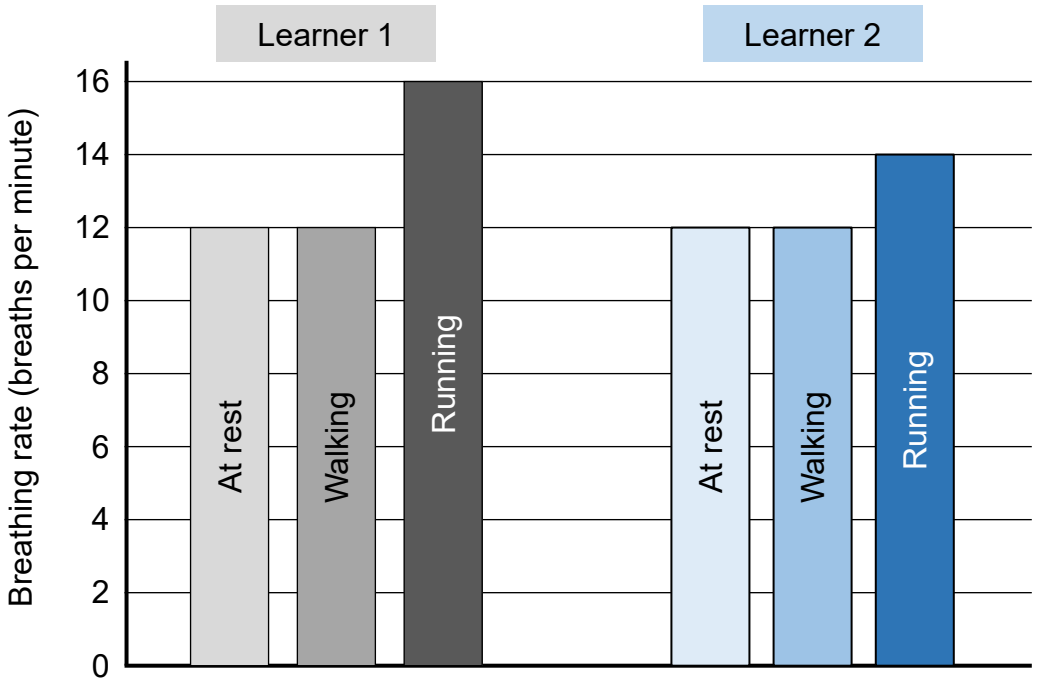
   Both learners breathing rates increased when running up the stairs ✓

4. Draw a histogram of the breathing rate of both learners at rest, after walking up and down 2 flights of stairs and after running up and down the 2 flights of stairs. (6)

Marking Guideline:

Appropriate title	✓
Correct type of graph	✓
Appropriate y-axis heading and scale	✓
Correct labelling of columns	✓✓
Key: learner 1 / learner 2	✓

Breathing rates of 2 learners at rest, walking and running up and down stairs



5. Write a conclusion that can be drawn from the above experiment. (3)

Learner's heart rates and breathing rates increased ✓ from rest to running up and down 2 flights of stairs ✓. Walking up the stairs did not result in a change of breathing rate ✓.

(14)

Internal and external gaseous exchange in humans

Learners should be able to identify the external and internal gaseous exchange surfaces and to discuss the structure of the alveoli surface in relation to its function.

They should understand the concept of the diffusion gradient at the alveoli surface and how this enables movement of gases.

They should be able to discuss the internal environment at the tissue bed surface and explain how the environment satisfies requirements for effective diffusion of gases, to name the pigment that carries most of the oxygen in the plasma, and to name the main form in which carbon dioxide is transported in the plasma

The exchange of gases occurs in two areas in the body. At the **alveoli** surface (**external gaseous exchange**) and at the **tissue bed** surface (**internal gaseous exchange**).

Transport of respiratory gases

Oxygen is transported mainly by the red blood cells. Most of the oxygen combines with haemoglobin present in the red blood cells (erythrocytes) to form oxyhaemoglobin. It is transported via the circulatory system to all body cells.

Most of the CO_2 is transported in the blood plasma in the form of bicarbonate ions.

Gaseous exchange between blood and tissues

Oxygenated blood arrives from the heart in the capillary network close to tissue cells (Figure 5 learner text). Oxygen will diffuse from the blood and into the neighbouring cells due to the concentration gradient.

The cells will have high carbon dioxide concentrations due to continuing cellular respiration. This carbon dioxide moves out of the cells and into the blood and is transported back to the heart and then to the lungs where it is exhaled.

The cells are also bathed in a tissue fluid which supplies the necessary moisture for gaseous exchange.

The exchange and transport of gases is simplified in Figure 6 of the learner text. Oxygen is continually entering the blood stream at the alveoli surface and is transported to the body cells. Carbon dioxide is transported from the cells to the alveoli where it is removed from the body.

Homeostatic control of breathing

The following video gives a comprehensive explanation of gaseous exchange, though it is almost 50 min long:

Gaseous exchange I: https://www.youtube.com/watch?v=z2rUEnztNcM

Feedback loops may be described as systems which are initiated when an internal alarm is set off and where the body responds. Negative feedback mechanisms stabilize a system and return it to its normal state.

Figure 7 in the learner text illustrates the regulation of carbon dioxide levels in the internal environment.

In homeostatic control:

- the heart rate increases – blood flow increases. Rapid transport of gases to and from the cells.
- Increased rate and depth of breathing – the intercostal muscles and the diaphragm contract and relax – more oxygen is inhaled, and more carbon dioxide is exhaled.

The effect of altitude on gaseous exchange

Altitude is a measure of the height of a place above sea level and is measured in metres. Altitude has an effect on the exchange of gases.
The greater the concentration gradient of oxygen between the outside air and inside the body, the greater will be the diffusion of oxygen into the blood since more oxygen can be absorbed by the red blood cells.

Activity 4: Effect of altitude

A study was carried out on eight swimmers (2 females and 6 males). They were all record holders and had participated in National championships and the Olympic games. These swimmers attended a 23 day camp which was at an altitude of 2300 metres above sea level. Before and after the camp their blood was tested for their red blood cell count and haemoglobin concentration. Their performance was also measured before and after the camp by looking at their times in races. Six out of the eight swimmers improved upon their performances after the camp.

The table below shows the average changes in the swimmer's blood before and after the high altitude training camp.

	Before camp	**After camp**
Red blood cells (millions/mm^3)	4,69	5,37
Haemoglobin (g/dL)	14,8	16,8

(adapted from Biol.Sport 2012: Athletic performance of swimmers after altitude training (2300M above sea level) in view of their blood morphology changes https://researchgate.net/)

1. Name two observations that could be made relating to the altitude training.
   The red blood cell count increases ✓ at altitude; the haemoglobin concentration increases ✓ at altitude (2)

2. Provide another name for red blood cells. erythrocytes ✓ (1)
3. What is the function of haemoglobin in the blood? transport of oxygen ✓ (1)
4. Which important element is found in haemoglobin? iron (Fe) ✓ (1)
5. Calculate the average increase in red blood cells of the swimmers after camp training. 5,37- 4,69 ✓ = 0,68÷4,69 × 100 ✓ = 14,5% ✓ (3)
6. Identify a dependent variable in the above table. RBC (mill/mm^3) **OR** Haemoglobin (g/dL) ✓ (1)
7. What would the advantage be for a swimmer to train at high altitudes before participating in an Olympic event? Their increased number of red blood cells and haemoglobin will enable them to carry more oxygen ✓ and thus improve their performance ✓ (2)
8. How can the reliability of the results obtained in the above experiment be improved?

   Increase the sample size ✓, repeat the experiment ✓ (2)

(13)

Diseases of the respiratory system

Pathogens (viruses and bacteria), environmental pollutants (pollen and smoke) and carcinogens (cancer causing substances) can negatively affect the human respiratory system.

Table 5 in the learner text gives a summary list of diseases of the respiratory system, their causes, symptoms, treatment and prevention.

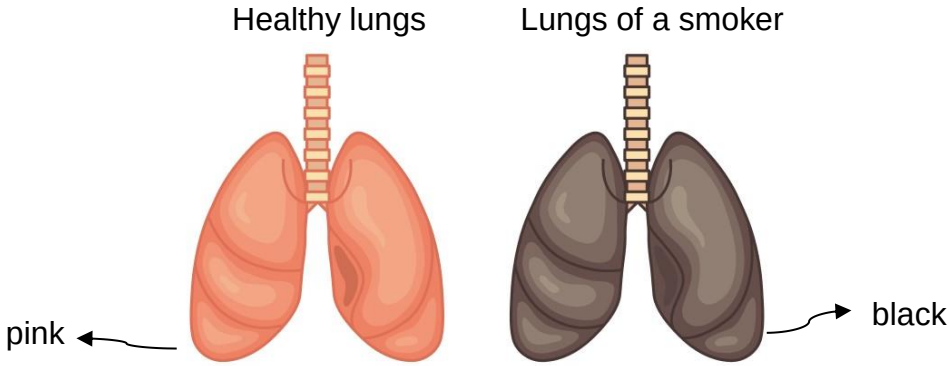
Extension: Tuberculosis is very prevalent in South Africa. A class discussion around the perceived ideas of why this is so would be an enlightening experience for some learners. The learners should all come away knowing that TB is a bacterial infection that can be prevented by immunisation and can be treated with long term medication. The link to HIV and AIDS with TB being an opportunistic infection (infecting due to the weakened immune system of an HIV patient) is topical and relevant. Lack of drug adherence has resulted in the two 'new' types of TB.

The effects of smoking on respiratory organs

Cigarette tobacco is known to cause a variety of **respiratory diseases**. Smoking of cigarettes has a link to diseases such as: lung cancer, heart disease, high blood pressure, emphysema and bronchitis. The three main ingredients, **carbon**

monoxide, tar and nicotine have adverse effects on the respiratory surfaces, and this can lead to reduced lung function.

South Africa has been pro-active in introducing strict tobacco restriction legislation. This together with cigarettes being an expensive habit there is hope that less people will take up smoking. It does start with the youth!



Artificial respiration and resuscitation (CPR)

Learners are to be encouraged to memorise the 3 important steps needed in emergency situations. Many lives have been saved by civilians or lay-people who have practiced the basic CPR on victims of accidents.

Summary

- In this chapter you have distinguished between the processes of diffusion, cellular respiration, gaseous exchange and breathing.
- For gaseous exchange to be efficient the surfaces must be designed to optimise this exchange.
- The surface to volume ratio in living organisms is important for allowing the maximum amount of gases to diffuse
- Living organisms are designed in a certain way to ensure that they are well adapted to their environment (terrestrial or aquatic) to ensure effective gaseous exchange i.e. dicotyledonous plants, earthworm, insects, fish and mammals
- You will have identified all the important parts of the human respiratory system for ventilation and gaseous exchange.
- These parts are well designed to perform the function of breathing and gaseous exchange
- The mechanism of breathing involves active inhalation and passive exhalation.
- The process of breathing involves muscles of the thoracic cavity and when exercising homeostatic control regulates this
- The medulla oblongata has the respiratory control centre
- Levels of carbon dioxide in the blood determine the depth and rate of breathing
- Gaseous exchange involves diffusion of gases at the alveoli surface and at the tissue bed

End of topic exercises

Section A

Question 1

1.1 Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A- D) next to the question number (1.1.1 – 1.1.5) on your answer sheet, for example 1.1.6 D

1.1.1 Cilia are found lining which of the following structures?

A larynx
B alveoli
C **trachea** ✓✓
D pleural membranes

1.1.2 Air breathed out is different from air breathed in because it…

A contains less carbon dioxide.
B is cooler.
C is drier.
D **contains less oxygen**. ✓✓

1.1.3 The lungs of a long-term smoker will have…

A **constricted bronchioles**. ✓✓
A thinner walls.
B a larger surface area.
C an increased capacity for gaseous exchange.

1.1.4 Which of the following does not occur during inhalation in a human?

A **Pressure within the thoracic cavity increases** ✓✓
B The lungs expand.
C The diaphragm contracts.
D Pressure in the abdominal cavity increases.

1.1.5 The rate of breathing is regulated by the medulla oblongata, mainly…

A under voluntary control.
B according to oxygen level of blood.
C according to the blood pressure.
D **according to carbon dioxide level of blood**. ✓✓

(5 × 2) = (10)

1.2 Give the correct **biological** term for each of the following descriptions. Write only the term next to the question number.

1.2.1 The double membrane that covers the outer surface of the lungs.
pleural membranes ✓

1.2.2 A chronic medical disorder of the lungs in which the air sacs are dilated or enlarged and lack flexibility. emphysema ✓

1.2.3 The cartilaginous structure that contains the vocal chords.
larynx ✓

1.2.4 Instrument that measures the rate and depth of breathing.
spirometer ✓

1.2.5 The liquid part of blood. plasma ✓

1.2.6 A measure of the height above sea level altitude ✓

1.2.7 Tiny air sacs at the end of each bronchiole. alveoli ✓

1.2.8 Dome-shaped muscle separating the thorax from the abdomen.
diaphragm ✓

1.2.9 Movement of air into the lungs. inhalation ✓

1.2.10 The main branches of the trachea that lead to the lungs.
bronchi ✓

(10 × 1) = (10)

1.3 Indicate whether each of the descriptions in Column I applies to **A ONLY**, **B ONLY**, **BOTH A AND B** or **NONE** of the items in Column II. Write **A only**, **B only**, **both A and B** or **none** next to the question number.

Column I	Column II
1.3.1 Mouth-to-mouth respiration	A: artificial respiration B: resuscitation
1.3.2 Breathing muscles	A: intercostal muscles B: diaphragm muscles
1.3.3 C-shaped cartilaginous rings	A: oesophagus B: bronchioles
1.3.4 The structure that prevents food particles entering the lungs	A: epiglottis B: glottis
1.3.5 Transport of carbon dioxide in the blood	A: calcium carbonate B: bicarbonate ions

(5 × 2) = (10)

1.3.1 **Both A and B** ✓✓

1.3.2 **Both A and B** ✓✓

1.3.3 **None** ✓✓

1.3.4 **A only** ✓✓

1.3.5 **B only** ✓✓

1.4 Read the extract below and answer the questions that follow:

Miss SA talks about her battle with TB, launches new campaign

Miss SA for 2018, Tamaryn Green, was diagnosed with TB in 2015. She has launched Tamaryn's #BreakTheStigma campaign and hopes to highlight the TB epidemic. She had the following to say: "My campaign is based around breaking the stigma with regards to TB. It's about raising awareness that TB is curable, but it's still killing so many people, so action needs to be taken. … I'm going to be the voice behind TB". One of the side effects she suffered from the treatment to fight the disease was drug-induced hepatitis (inflamma-tion of the liver). As part of her campaign she plans to create short educa-tional videos that will teach people about the signs and symptoms of the disease, testing for the disease and the treatment of the disease.

https://www.channel24.co.za/The-Juice/News/miss-sa-talks-about-her-battle-with-tb-launches-new-campaign-20180830-2

1.4.1 Which pathogenic organism causes TB? (1)

Mycobacterium tuberculosis ✓

1.4.2 Tamaryn suffered with side-effects while on treatment for her TB. What is the recognised treatment for the disease? (1)

Antibiotics ✓

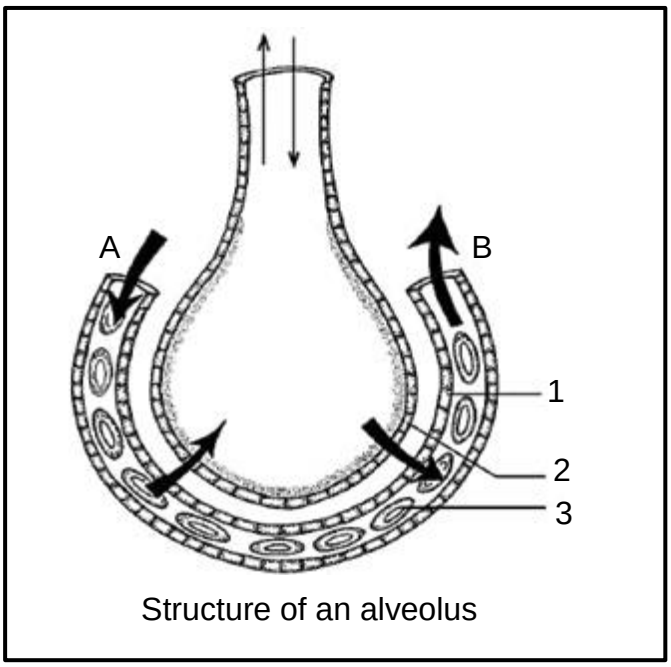
1.4.3 Give 3 symptoms that a TB sufferer might experience. (3)

Chronic cough, night sweats, fever, fatigue, anorexia, weight loss, coughing up blood, chest pain (✓ – for any 3)

1.4.4 What viral disease has caused TB infection to rise in the South African population? HIV ✓ (1)

(6)

1.5 The diagram below represents a section through an alveolus and a surrounding blood capillary in the human body.



Structure of an alveolus

1.5.1 Name the type of epithelial tissue numbered 1 and 2. (2)
1 – endothelium ✓, 2 – squamous epithelium ✓

1.5.2 Identify the blood cell labelled 3. (1)
erythrocyte / red blood cell ✓

1.5.3 What pigment is found in the cell mentioned in question 1.5.2? (1)
haemoglobin ✓

1.5.4 Which type of blood:

a) enters the blood capillary at A? (1)
deoxygenated blood ✓

b) leaves the blood capillary at B? (1)
oxygenated blood ✓

1.5.5 In which form is most oxygen carried in the blood? (1)
oxyhaemoglobin ✓

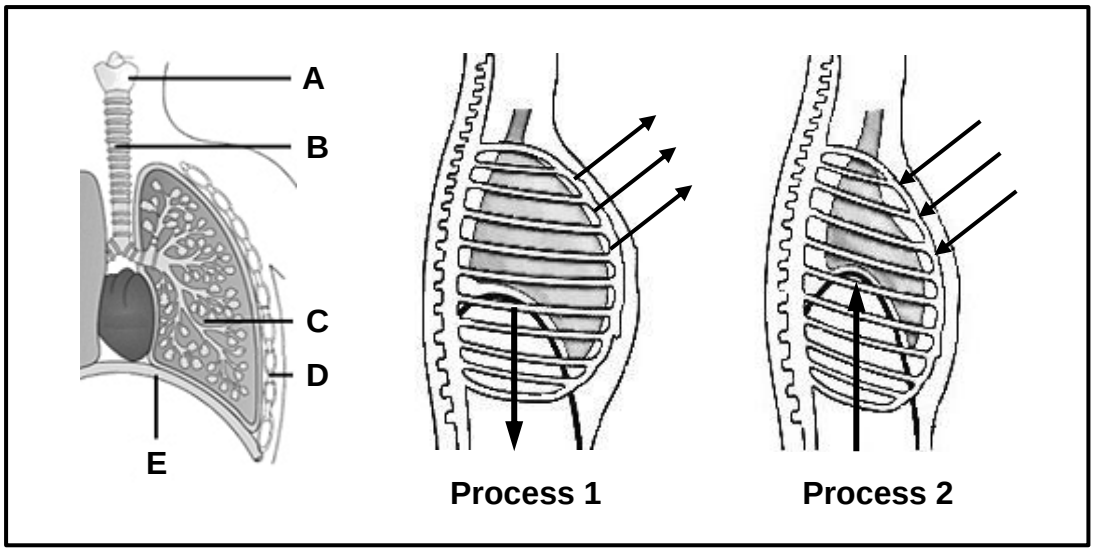
1.5.6 Supply two structural adaptations of the alveoli which make them well suitable for gaseous exchange. (4)
Many alveoli provide large surface area for gaseous exchange.✓
The inner surface is kept moist by film of moisture, to facilitate diffusion of oxygen and carbon dioxide in dissolved states. ✓
The lining of the alveolus is thin; only one cell layer thick for rapid diffusion of gases. ✓
Are in close contact with blood capillaries; blood contains haemoglobin which acts as an oxygen carrier. ✓
(any two correct answers)

(9)

Section A: [45]

Section B: Question 2

2.1 Study the diagrams below showing some parts of the human respiratory system. Answer the questions that follow.



2.1.1 Identify parts A, B and C. (3)

A – larynx ✓, B – trachea ✓, C – bronchioles ✓

2.1.2 Which process in the above diagram illustrates inhalation (Process 1 or Process 2)? (1)

Process 1 ✓

2.1.3 Give three reasons from the diagrams to support your answer to question 2.1.2. (3)

Ribs are lifted / chest cavity expands / moves outwards ✓

Thoracic cavity enlarges / lungs are larger ✓

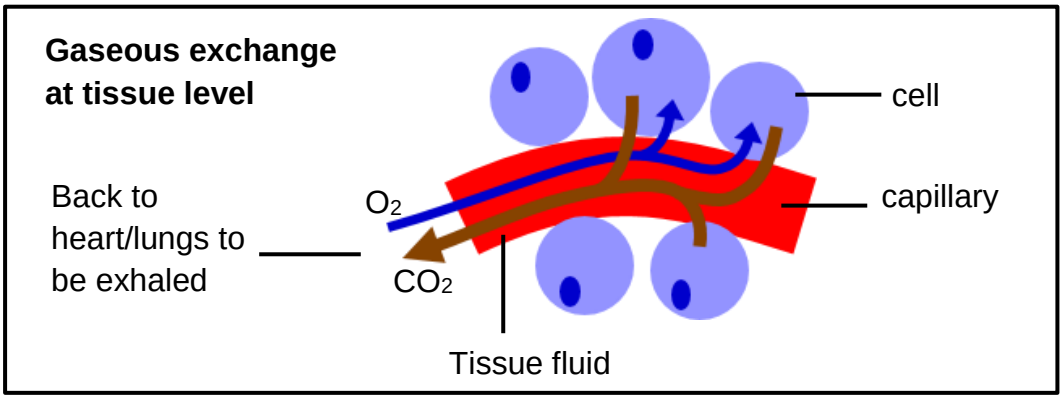
Diaphragm contracts / flattens / moves downwards ✓

2.1.4 Give the letters and the names of the muscles shown in the diagram that are involved in inhalation. (4)

D ✓ – intercostal muscles ✓

E ✓ – diaphragm ✓

2.1.5 Draw and label a diagram showing gaseous exchange at the tissue level. Use arrows to show the direction of the gas movement. (5)



Guidelines for marking diagram:

Correct diagram	✓
Correct caption / heading / title	✓
Oxygen diffuses into cells	✓
Carbon dioxide diffuses into blood	✓
Any other correct label	✓

2.1.6 When one makes use of a heater to warm a room, one is advised to place a small bowl of water next to the heater. Explain the purpose of this practice. (4)

Increases the amount of moisture in the air ✓ because water evaporates ✓

Prevents drying out of inner surface of lung ✓ which would prevent gaseous exchange ✓ / gases can only diffuse through a solution

2.1.7 A person's thoracic wall is punctured in an accident. Explain how this injury will affect the breathing process. (2)

Cannot breathe / inhale / exhale / lungs collapse ✓

No pressure difference between exterior and thoracic cavity ✓

(22)

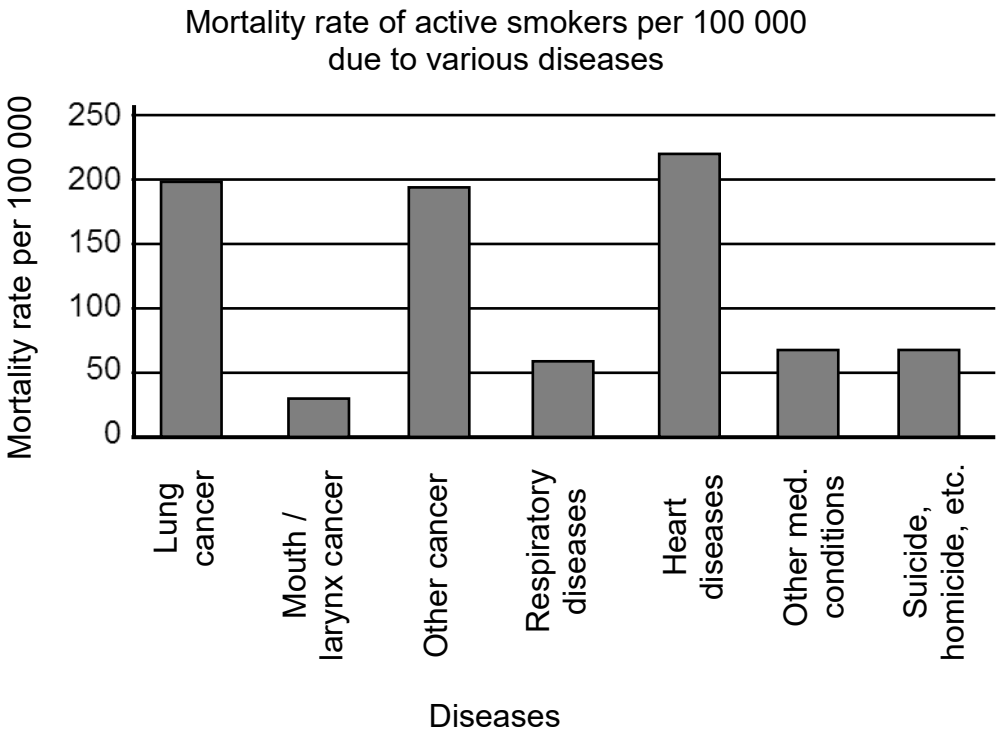
2.2 An investigation was conducted to determine the effect of smoking on the prevalence of other diseases. Study the table below and answer the questions that follow.

	Mortality rate per 100 000		
Diseases	**Active-smoker**	**Passive smoker**	**Non-smoker**
Lung cancer	200	190	11
Cancer of the mouth or larynx	30	20	6
Other cancers	195	80	105
Respiratory diseases	60	56	12
Heart diseases	220	138	80
Other medical conditions	70	40	35
Suicide, homicide, accidents	70	75	20

2.2.1 State the dependent variable for this investigation. (1)

Mortality rate ✓ per 100 000

2.2.2 Draw a bar graph representing the above information for active smokers. (6)



Guidelines for marking:

Title	✓
Correct type of graph	✓
x-axis: correct label and scale	✓
y-axis: correct label and scale	✓
Bars drawn correctly	1 – 5 drawn correctly : ✓ 6 – 7 drawn correctly: ✓

2.2.3 State how many smokers per 100 000 die of heart disease. (1)

358 ✓ (220 + 138)

2.2.4 Indicate the ratio between active smokers, passive smokers and non-smokers that die of respiratory disorders. (2)

60 : 56 : 12 **OR** 15 : 14 : 3 ✓✓

2.2.5 Suggest two controlled variables that can improve this investigation. (2)

Same gender individuals ✓, same age group ✓

2.2.6 What is the effect that smoking has on the prevalence of cancer? Use the information in the table to explain your answer. (1)

Smoking increases the risk of cancer ✓

2.2.7 Discuss the effect of smoking on the bronchioles and alveoli of the lungs. (3)

Smoke gets trapped in the alveoli ✓ causing inflammation ✓.This inflammation activates enzymes ✓ that destroys the lung tissue ✓.

2.2.8 Suggest why South Africa has strict laws that control smoking in public places. (2)

Passive smokers can inhale enough smoke to cause lung damage. ✓ In public places people must smoke outside a building to prevent smoke in the air conditioning system. ✓ Smoking in a car with a child younger than 12 is against the law as it causes serious lung damage to the child's lungs. ✓ (any 2)

(18)

2.3 Jane is training for a race by running 20 km every day. Describe how carbon dioxide produced in her body during training is controlled to maintain normal levels. (5)

- Because of the exercise the carbon dioxide levels in the blood will increase. ✓
- The medulla oblongata will be stimulated ✓
- to send messages to the heart ✓ and
- breathing muscles ✓
- the heart beats faster ✓
- blood with carbon dioxide is pumped to the lungs faster to be exhaled ✓
- the breathing muscles contract faster ✓
- and the rate and depth of breathing increases ✓
- more carbon dioxide is removed out of the body ✓
- the carbon dioxide levels decrease back to normal ✓

(any five correct answers)

Section B: [45]

Total marks: [90]

Cognitive level distribution

Question	Level 1	Level 2	Level 3	Level 4	Marks
1.1.1	✓				2
1.1.2	✓				2
1.1.3	✓				2
1.1.4	✓				2
1.1.5	✓				2
	10				10
1.2.1	✓				1
1.2.2	✓				1
1.2.3	✓				1
1.2.4	✓				1
1.2.5	✓				1
1.2.6	✓				1
1.2.7	✓				1
1.2.8	✓				1
1.2.9	✓				1
1.2.10	✓				1
	10				10
1.3.1	✓				2
1.3.2	✓				2
1.3.3	✓				2
1.3.4	✓				2
1.3.5	✓				2
	10				10
1.4.1	✓				1
1.4.2	✓				1
1.4.3		✓			3
1.4.4		✓			1
	2	4			6
1.5.1		✓			2
1.5.2		✓			1

1.5.3		✓			1
1.5.4 a – b		✓			2
1.5.5	✓				1
1.5.6		✓			2
	1	8			9
2.1.1	✓				3
2.1.2	✓				1
2.1.3			✓		3
2.1.4		✓			4
2.1.5				✓	5
2.1.6		✓	✓		4
2.1.7				✓	2
	4	6	5	7	22
2.2.1		✓			1
2.2.2			✓		6
2.2.3			✓		1
2.2.4			✓		2
2.2.5				✓	2
2.2.6		✓			1
2.2.7			✓		3
2.2.8			✓		2
		2	14	2	18
2.3		✓			5
		5			5
Total	37	25	19	9	90

CHAPTER 8: EXCRETION IN HUMANS

Overview

Time allocation: 2½ weeks (10 hours)

This chapter consists of the following sections:

1. Introduction
2. Key concepts
3. Excretory organs
4. The urinary system
5. The structure of the kidney
6. The structural and functional unit of the kidney
7. Kidney functions performed by the nephron
8. Homeostatic regulation by the kidneys
9. Kidney diseases
10. Dialysis
11. Kidney transplants
12. Summary
13. End of topic exercises

Introduction

All living organisms ‘respire’ or breathe. Plants produce their own organic food in the process of photosynthesis. The waste from this process is live-giving oxygen. Animals use this in cellular respiration when they produce cellular energy. Carbon dioxide is released as waste from this process.

An accumulation of waste is dangerous to the cells, tissues, organs, systems and the body as a whole. Animal bodies, and thus the human body too, are designed to effectively remove or excrete the waste.

This chapter will look in detail at the urinary system and the functioning of the human kidneys. It is these organs that filter the blood, regulate water and salt levels and play an important role in the control of blood pH levels. Kidney functioning can be impaired by diseases, lifestyle choices and accidental injuries. Renal or kidney

failure can be effectively treated with dialysis. Kidney transplants are successfully carried out in many hospitals in South Africa.

Key concepts

- The main waste products (metabolites) from cellular metabolism include carbon dioxide, urea, bile pigments, mineral salts and water
- Excretory organs that removal this waste are the lungs, skin, liver, large intestine and the kidneys
- The urinary system is made up of the kidneys, ureters, the bladder and the urethra
- The kidneys are the main organs of excretion
- The kidneys filter the blood and produce urine that carries metabolic waste
- The functional unit of the kidney is the nephron
- The nephrons are designed to perform 3 important processes: ultrafiltration, reabsorption and tubular excretion
- The levels of water and sodium in body fluids is under homeostatic regulation (negative feedback)
- The nephrons are targeted by hormones in this mechanism and they ensure that a stable internal environment is maintained
- Mechanical injuries, dehydration, infections, alcohol and drug abuse and diabetes are some situations that can negatively affect the kidney functioning
- Treatment options in severe cases of renal failure is dialysis and kidney transplants

Key terminology

excretion	the removal or elimination of metabolic waste from an organism
secretion	the release of a useful substance (enzymes, saliva) from cells or glands
egestion	the removal of undigested food solid waste from the digestive tract in the form of faeces = defaecation
metabolism	chemical reactions that take place within every cell of the body. these can be building up (anabolic) or breaking down (catabolic) reactions
renal	relates to the kidney
deamination	removal of an amino group from amino acids

Excretory organs

Learners should be able to distinguish between secretion, egestion and excretion. They should be able to name the main excretory waste products and the excretory organs that are involved in their production and final excretion. Learners should have a basic understanding of the waste production process.

In human digestion the carbohydrates, proteins, fats and vitamins are broken down into their simplest form and enter the blood stream to be utilized where they are needed.

Excretory waste products include CO_2, H_2O, bile pigments, urea and mineral salts.

Table 1 in the learner text summarises how they are produced, the organs involved in their excretion and the final products of excretion.

The urinary system

The following video gives a comprehensive look at the urinary system and can be used as a teaching tool.

The human urinary system: https://www.youtube.com/watch?v=H2VkW9L5QSU

The 2 kidneys, 2 ureters, bladder and urethra form the urinary system. The renal blood supply, including an extensive network of blood capillaries, ensures that a steady flow of blood reaches and leaves the kidneys.

The kidney performs the following four **main functions** of the urinary system. The other components work together towards achieving these (see Figure 1 in learner text).

- **Osmoregulation** – regulation of levels of H_2O in body fluids
- **Excretion** – removal of nitrogenous waste e.g. urea
- **Regulation of pH** of body fluids
- **Regulation of salt** concentration of body fluids

The structure of the kidney

The kidneys are bean shaped structures (Figure 2 in learner text) that are found half down the back just under the ribcage. They weigh between 115 and 170 grams each depending on the age and gender of the person and are about 11cm long.

They are macroscopic structures. They are protected with adipose (fat) tissue and each kidney is covered by a renal capsule which protects the kidney and its internal

structures from infection. The aorta branches into the renal artery which brings oxygenated blood to the kidneys. The blood is filtered by the kidney and 'clean' blood leaves the kidney in the renal vein.

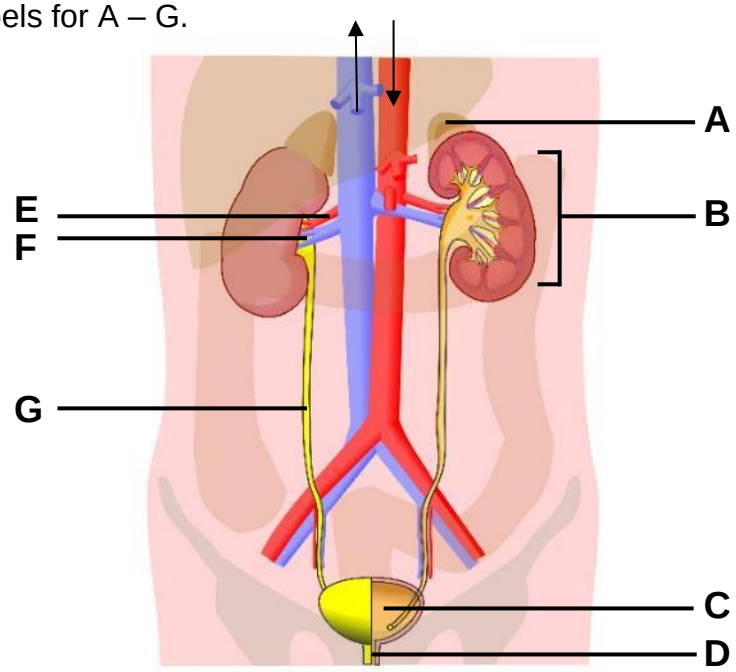
Learners should be able to identify the external and internal structures and features of the kidney. This includes the blood vessels entering and leaving the kidney, the different regions of the internal structure of the kidney, their appearance and texture and how certain structures aid in the protection and functioning of the kidney.

Activity 1: Excretory organs

1. Supply a caption for the diagram below. (1)

   The human urinary system with associated structures ✓

2. Supply labels for A – G. (7)



   A – adrenal gland ✓ B – kidney ✓ C – bladder ✓ D – urethra ✓

   E – renal artery ✓ F – renal vein ✓ G – ureter ✓

3. What type of blood does E bring to the kidney? (1)

   Deoxygenated, unfiltered blood ✓

4. What is the function of the part labelled C? Stores urine ✓ (1)

5. Name 4 important functions of the part labelled B. (4)

   Removal of waste ✓. Regulation of water levels in blood/body fluids ✓. Regulation of salt levels in the blood/body fluids ✓. pH regulation ✓

6. What two substances does the part D carry in adult males? (2)

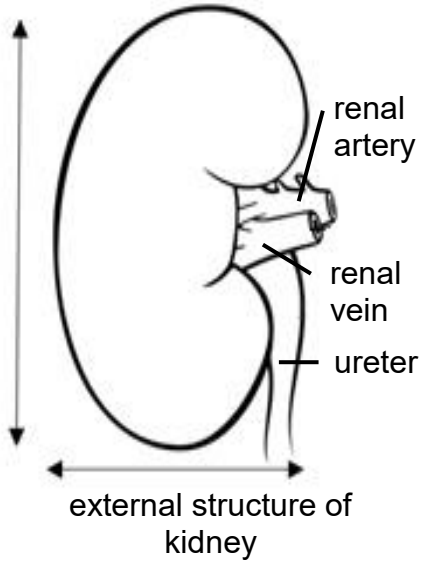
   Urine ✓ and semen ✓

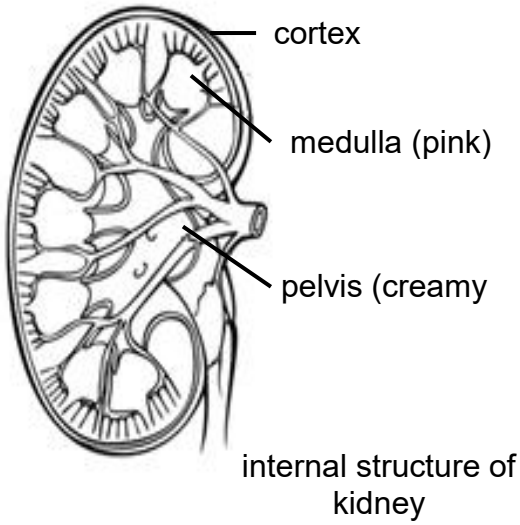
(16)

Activity 2: Sheep kidney dissection

Sheep kidney anatomy: https://www.youtube.com/watch?v=nPhzYkq5YWE

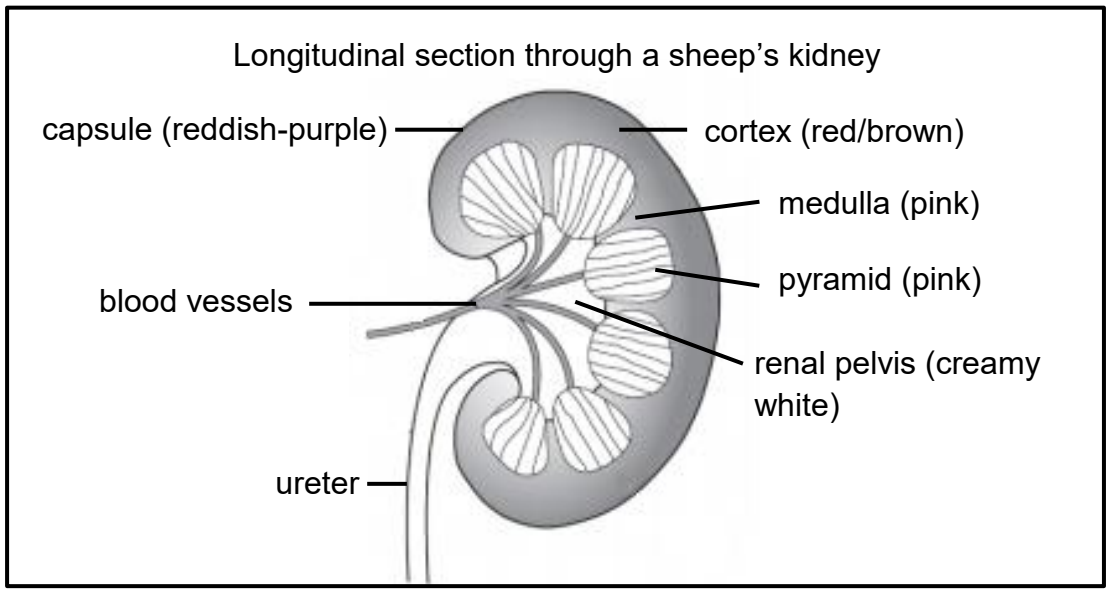
See the learner text for instructions regarding the dissection. The main external and internal structures of the kidney are indicated in the diagram below.





Questions:

1. Drawing of longitudinal section through kidney.



Marking guidelines:

Correct diagram ✓

Caption / title ✓

Labels: capsule, cortex, medulla, renal pelvis, ureter ✓✓✓✓ (any 4)

2. State the function of the (a) fat around the kidney?

It provides protection to the kidney in the region of the back ✓

(b) renal capsule around the kidney? (2)

It protects the kidney from infection ✓

3. Explain why it is an advantage to have two kidneys instead of one. (2)

Increased kidney functioning ✓. Double the volume of blood can be filtered ✓

4. Name the artery that transports blood to the kidney. (1)

renal artery ✓

5. Where does the ureter lead to and what is its function? (2)

To the bladder ✓which stores urine until urination ✓

(13)

The structural and functional unit of the kidney

The kidneys are highly complex filtration organs. Once in the kidney the renal artery branches into narrower blood vessels until they are in contact with the core functional unit of the kidney, **the nephron** (Figures 3 and 4 in learner text).

Nephrons are **microscopic,** coiled and convoluted structures made up of tubes, arterioles, capillaries and ducts. Each human kidney has about 1 million nephrons. Their main function is to filter the blood, regulate the waste, water and other important substances as the body needs.

The nephron can be divided into 2 separate sections – the **Malpighian body** (Figure 5 in learner text) and the **renal tubule**.

Learners should understand the importance of the nephron in kidney functioning. They must be able to draw, identify and label the 2 distinct sections of the nephron and relate the various structures to their function.

Kidney functions performed by the nephron

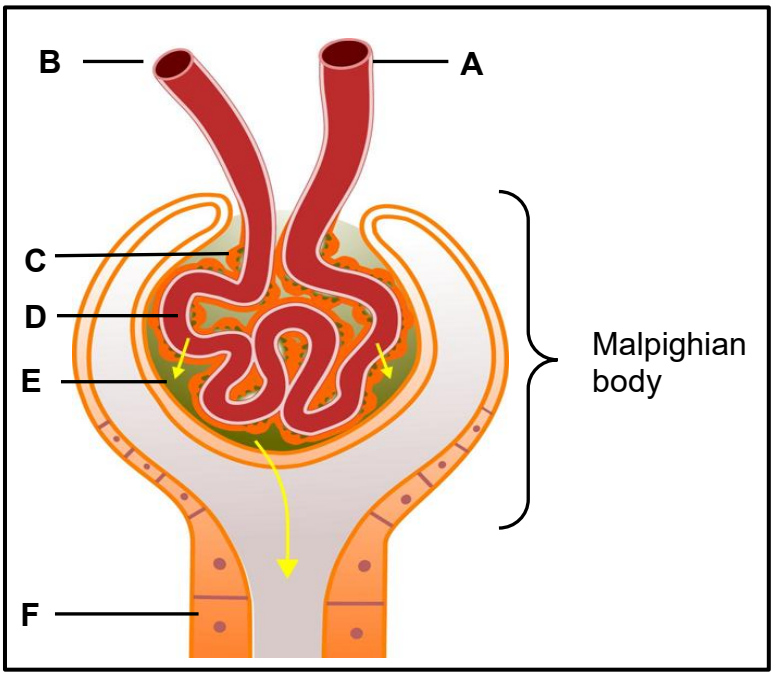
The nephron is the structural and functional unit of the kidney and performs 4 vital processes. The formation of urine involves the following (Figure 6 in learner text):

- Glomerular filtration or ultrafiltration
- Tubular re-absorption
- Tubular secretion
- Excretion

Discuss in detail with the learners the four main processes that take place along the length of the nephron. Relate the structure to its function where applicable in relation to the excretory function. Also discuss the role and importance of the distal convoluted tubule in pH regulation of the blood.

Activity 3: Nephron-Malpighian body

1. Structure and function of Malphighian body.



1.1 Supply labels for A – F. (6)

A - afferent arteriole ✓ B - efferent arteriole ✓ C - podocyte ✓

D - blood capillary ✓ E - glomerular filtrate ✓ F - renal tubule ✓

1.2 What two structures make up the Malpighian body? (2)

Glomerulus ✓ and Bowman's capsule ✓

1.3 What cell types line the structures D and F? (2)

D – squamous epithelium ✓ F – cuboidal epithelium ✓

1.4 What difference do you notice between structures A and B? (1)

A has a wider diameter than B ✓

1.5 C has features that assist in the filtration function of the Malpighian body. Name these 2 features. (2)

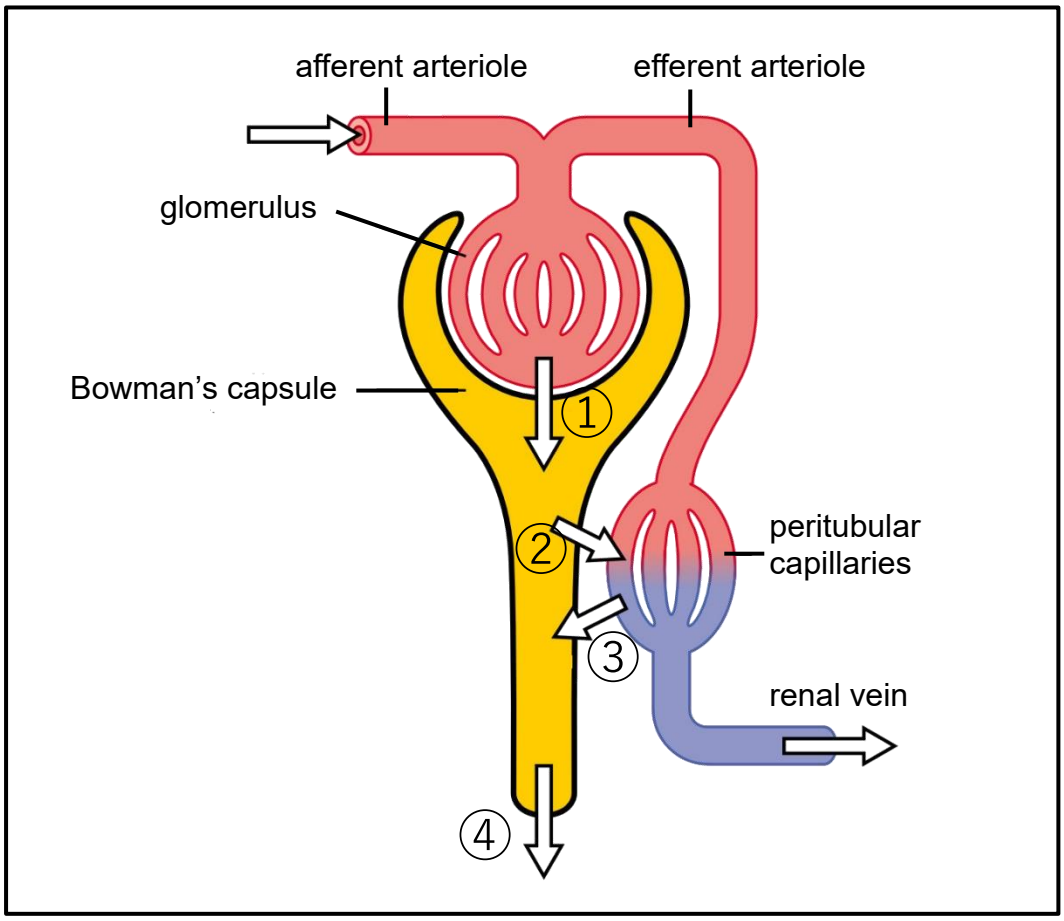
Podocytes with finger like extensions ✓; filtration slits (gaps) ✓

1.6 Name four substances found in structure E. (4)

Water, glucose, amino acids, vitamins, fatty acids (✓ for any 4)

(17)

2. Functions of the nephron:



2.1 Name the processes shown at 1, 2, 3 and 4. (4)

1 – glomerular ultrafiltration ✓ 2 – tubular re-absorption ✓

3 – tubular secretion ✓ 4 – excretion ✓

2.2 Mention 3 substances that move back into the blood at process 2. (3)

Glucose, amino acids, vitamins, water (any 3 ✓✓✓)

2.3 Process 3 helps in homeostasis. What does it control? (1)

pH levels in the blood ✓

2.4 What would you expect to be present in urine in a healthy person? (3)

Water ✓, excess salts ✓, urea ✓

2.5 Explain why a person who regularly smokes marijuana will test positive for the drug with a urine test? (2)

Drugs are actively secreted into the distal convoluted tubule ✓ and passed into the urine ✓

2.6 Suggest two ways in which the nephrons of a desert mammal would differ from human nephrons. (2)

Nephrons would have a longer Loop of Henle (the Loop of Henle conserves water) ✓; there would be many more nephrons in each kidney (prevents loss of water and dehydration) ✓ (15)

Homeostatic regulation by the kidneys

The human body has the ability to maintain a stable internal environment. It is important that body temperature is kept within a narrow range of 37°C. The pH of the body fluids needs to be regulated and the composition of these fluids need to be kept within certain limits for effective metabolism.

The kidney is involved in 3 homeostatic mechanisms:

- the regulation of **pH** of the blood
- the regulation of **water** levels (osmoregulation)
- the regulation of **salt** levels in the blood

Table 2 and Figure 10 explain osmoregulation by the kidney and related control centres.

Table 3 and Figure 11 explain the regulation of salts in the blood.

Learners should be able to name the main homeostatic mechanisms performed by the kidney and identify the role-players in these mechanisms, e.g. the pituitary gland, collecting ducts. They should be able to explain how the kidney plays a role in these homeostatic mechanisms and describe how each mechanism works.

Kidney diseases

Kidney diseases (Table 4 in learner text) can be life-threatening and require different treatment regimes. Ineffective kidney function would result in an imbalance of salts, water and pH in the blood. Levels of substances can reach toxic levels.

Kidney failure can happen over a period of time due to a chronic condition e.g. diabetes. An sudden injury, kidney infection or severe dehydration can lead to acute kidney failure. Severe cases of kidney failure require dialysis or even a kidney transplant.

Analgesic nephropathy (Abuse of medication and illegal drugs): certain over-the-counter (OTC) drugs can cause damage to the kidneys. Overuse of **painkillers** like paracetamol and asprin as well as certain anti-inflammatories can cause damage over time. Long-term use of illegal drugs like **heroin and cocaine** can cause irreversible kidney damage.

Bilharzia infection: this disease is common in Africa, South America and Asia. It is caused by a **parasitic flatworm,** *Schistosoma***,** which is found in rivers and dams. The worm larvae which are hosted by snails in the water attach to the skin of a human. They travel in the blood stream and then release their eggs. These eggs damage the **kidneys, ureters and the bladder**. The infected person will pass blood in the urine, have a fever and rashes, will be tired and often anaemic. Bilharzia can be prevented by avoiding infected water and treatment to ease the symptoms are available.

Dialysis

Kidney dialysis: https://www.youtube.com/watch?v=lNX65X2iQCA

A dialysis machine is sometimes called an artificial kidney machine. Dialysis (Figure 12 in learner text) involves a process where a patient's blood is passed through a filtration system and returned to the body. Certain hospitals in South Africa have dialysis centres and patients have to book a time because of the demand for these machines. Dialysis is an expensive treatment and is scarce in the public health hospitals.

Steps in dialysis (see Figure 12 in learner text)

- blood from the artery is pumped through a dialyser which has dialysis fluid in it.
- The dialysis fluid has the same concentration of useful substances e.g. glucose, amino acids, as the blood.
- Useful substances are not lost

- The dialysis fluid has no waste e.g. urea
- The dialysis tubing is semi-permeable (allows substances through selectively)
- Waste substances are constantly drained from the waste drain
- Cleaned, filtered blood returns into the patient's vein

Kidney transplants

Kidney transplant (animation of surgical steps):
https://www.youtube.com/watch?v=Or2pcS2a0Ow

Summary

- In this chapter we looked at the main organs of excretion, their excretory products and the source of their waste
- The urinary system is the main excretory system and includes structures that enable it to function optimally
- The kidneys perform a number of very important functions in the human
- They remove waste, regulate the water and salt levels in the body fluids as well as the pH of the body fluids
- The functional unit of the kidney is the nephron
- The nephron is microscopic, and each human kidney has about 1 million of them
- Each nephron has a Malpighian body, made up of the Bowman's capsule and the glomerulus, and the renal tubule which extends through the medulla and cortex of the kidney
- The nephron carries our 4 specific processes along its length
- Glomerular filtration in the Malpighian body results in the formation of the glomerular filtrate which has many dissolved substances in it, both useful and waste.
- Structural adaptations in the capsule (podocytes) and the capillaries (squamous epithelium) result in efficient functioning

- Water is reabsorbed back into the blood shortly after leaving the Malpighian body. Glucose and other important substances are actively reabsorbed in the proximal convoluted tubule
- The loop of Henle is important in regulation of water levels in the blood
- The loop controls this with movement of Na^+ and Cl^- ions into the medulla of the kidney
- Lack of permeability of the ascending limb to water, ensures that the water moves back into the blood where it is needed in the region of the distal convoluted tubule
- Substances are secreted back into the tubule from the blood in the distal region. This includes H^+, nitrogenous waste and certain drugs
- The pH of the blood is regulated in this region by control of the secretion of the H^+
- The 2 hormones ADH and aldosterone play a role in homeostasis in the body
- ADH prevents excessive loss of water in the urine and this is important osmoregulation function is controlled in the nephron
- Aldosterone helps the body maintain its levels of Na^+ and this hormone is released from the adrenal glands
- The functioning of kidneys can be impaired by chronic disease or in acute situations
- Ultrasound is used to break down kidney stones, dialysis is an effective treatment for impaired functioning, but it is expensive and inaccessible to most South Africans. A transplant is a good option but there are risks involved in the procedure

End of topic exercises

Section A

Question 1

1.1 Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A – D) next to the question number (1.1.1 – 1.1.5) on your answer sheet, for example 1.1.6 D

1.1.1 Which of the following is the correct sequence of activities that occurs during kidney functioning?

A pressure filtration→ excretion → re-absorption
B re-absorption → pressure filtration → excretion
C excretion → pressure filtration → re-absorption
D **pressure filtration → re-absorption → excretion ✓✓**

1.1.2 Which of the following is part of the circulatory system of blood?

A **Glomerulus ✓✓**
B Convoluted tubules
C Loop of Henle
D Bowman's capsule

1.1.3 Which of the following will cause the kidneys to reabsorb more sodium ions?

A **A decrease in blood pressure**. **✓✓**
B An increase in the volume of blood.
C Constriction of the afferent arterioles.
D A decrease in the amount of ADH secreted.

1.1.4 If a drop in pH of the blood occurs, the kidneys will…

A increase the absorption of urea.
B decrease the absorption of sodium ions.
C decrease the secretion of hydrogen ions.
D **increase the re-absorption of bicarbonate ions**. **✓✓**

1.1.5 Which one of the following is a direct cause of kidney damage?

A High cholesterol
B To little physical exercise.
C Drinking hot tea
D **High blood pressure**. ✓✓

(5 x 2) = (10)

1.2 Give the correct **biological** term for each of the following descriptions. Write only the term next to the question number.

1.2.1 The process of filtering the accumulated waste products of metabolism from the blood of a patient whose kidneys are not functioning properly.
Dialysis ✓

1.2.2 The functional and structural unit of the human kidney.
Nephron ✓

1.2.3 The control of water content and salt balances in the blood and tissue fluid.
Osmoregulation ✓

1.2.4 Specialised cells with filtration slits found lining Bowman's capsule.
Podocytes ✓

1.2.5 A network of capillary blood vessels inside Bowman's capsule.
Glomerulus ✓

1.2.6 Blood vessel that carries purified deoxygenated blood away from the kidney.
Renal vein ✓

1.2.7 Outer fibrous membrane that protects the kidney against infection.
Renal capsule ✓

1.2.8 Tube that transports urine from the bladder to outside the body.
Urethra ✓

1.2.9 The blood vessel that carries oxygenated blood filled with waste to the kidney.
Renal artery ✓

1.2.10 Part of the kidney where the Malpighian bodies are found.
Renal cortex ✓

(10 x 1) = (10)

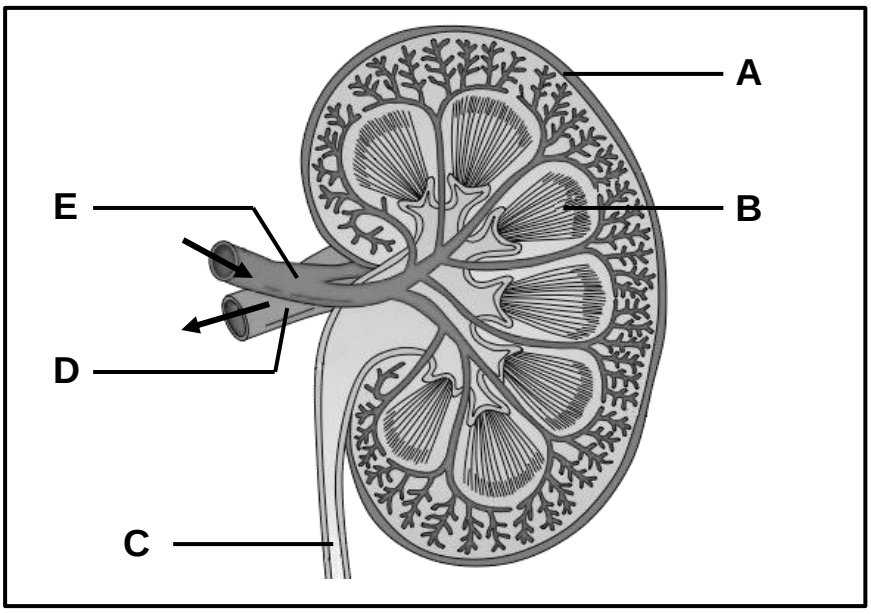
1.3 Indicate whether each of the descriptions in Column I applies to **A ONLY**, **B ONLY**, **BOTH A AND B** or **NONE** of the items in Column II. Write **A only**, **B only**, **both A and B** or **none** next to the question number.

Column I	Column II
1.3.1 Blood leaving the kidney contains more of this substance than the blood entering the kidney	A: amino acids B: carbon dioxide
1.3.2 Affected by bilharzia	A: kidneys B: lungs
1.3.3 Osmoregulation	A: ADH B: TSH
1.3.4 Tube that carries urine from the kidney to the bladder.	A: ureter B: urethra
1.3.5 The hormone(s) secreted by the adrenal gland to regulate the salt concentration of the blood.	A: ADH B: aldosterone

(5 x 2) = (10)

1.3.1 **B only ✓✓**
1.3.2 **A only ✓✓**
1.3.3 **A only ✓✓**
1.3.4 **B only ✓✓**
1.3.5 **A only ✓✓**

1.4 Study the longitudinal section through the human kidney and answer the questions that follow.



1.4.1 Label parts **A**, **B** and **C**. (3)

A – Renal capsule ✓

B – Collecting tubules / ducts ✓

C – Ureter ✓

1.4.2 Which labelled part becomes a site of obstruction to the flow of urine when a pellet of renal stone is dislodged. (1)

C / Ureter ✓

1.4.3 Mention two ways in which kidney stones can be prevented. (2)

Drinking a lot of water ✓

Limit salt intake in the diet ✓

1.4.4 Mention ONE way in which kidney stones can be treated. (1)

Ultrasound / shock waves ✓

Lasers ✓

Medication / Surgery ✓ (any one x 1)

1.4.5 State the name and letter of the blood vessel that contains a higher percentage of waste products. (2)

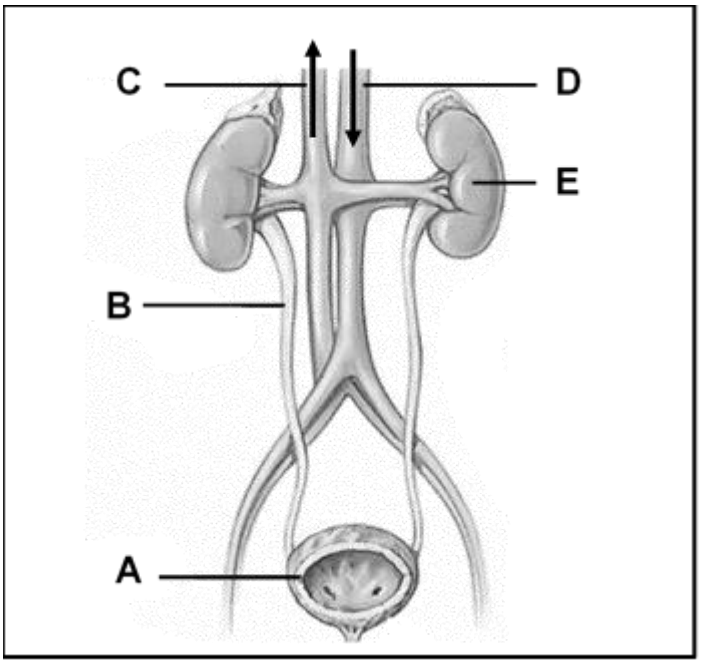
Renal artery ✓ - E✓

1.4.6 Which one of the labelled blood vessels has the lowest blood pressure? (1)

E / renal vein✓

(10)

1.5 The diagram below shows the structure of the human urinary system.



1.5.1 Give labels for the following parts:

a) ureter✓

b) Kidney✓

c) (Urinary) bladder✓

1.5.2 Mention one difference between the composition of the blood in **C** and **D**. (2)

The blood in **C** contains less waste products ✓ than the blood **D**. ✓

The blood in **C** contains less oxygen ✓ than the blood in **D**. ✓

The blood in **C** contains more carbon dioxide ✓ than the blood in **D**. ✓

(any one x 2)

1.5.3 Although bilharzia it is not a notifiable disease in South Africa, but in 2015 approximately 2 million children were infected with it. More than 200 million people worldwide have bilharzia. There is no vaccine for the disease, but treatment can reduce its impact on the body.

a) Name the parasite that causes bilharzia. (1)

Schistosoma ✓

b) The kidneys, ureters and bladder are affected by the parasite. Name 3 symptoms of the disease. (3)

Blood in urine, back pain, fever, rashes, anaemia, tiredness ✓✓✓

(any 3)

c) What should you avoid doing if you are in an infected area in South Africa? (1)

Do not walk in(avoid) lakes or rivers where there is a possibility the parasite might be ✓

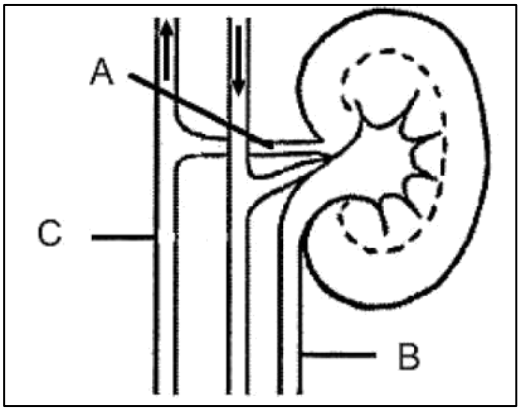
(10)

Section A: [50]

Section B

Question 2

2.1 The diagram shows part of the excretory system of the human body.



2.1.1 Identify the labels marked **A**, **B** and **C**. (3)

A – renal vein ✓, B – ureter ✓, C – inferior vena cava ✓

The table below shows the composition of fluid in **Structure A** and **Structure B** of the diagram.

	Structure A	**Structure B**
Component	**Concentration (%)**	**Concentration (%)**
Urea	3	200
Glucose	10	0
Amino acids	5	0
Salts	72	150
Proteins	800	0

2.1.2 By comparing the contents of structures, **A** or **B**, what conclusion can be drawn regarding the functions of the kidney? (1)

The kidney has the important function to remove nitrogenous wastes or excess salts from the blood. ✓

2.1.3 Would you consider that the person with the medical report shown above suffers from diabetes mellitus? Explain your answer. (4)

No ✓(* compulsory mark)

- If the person suffers from diabetes, there would be a certain percentage of glucose in the content of structure B. ✓
- A diabetic will have an abnormal glucose content in the blood ✓
- because his insulin secretion is abnormal. ✓
- Therefore, glucose is not converted to glycogen ✓
- hence the glucose is excreted through urine. ✓

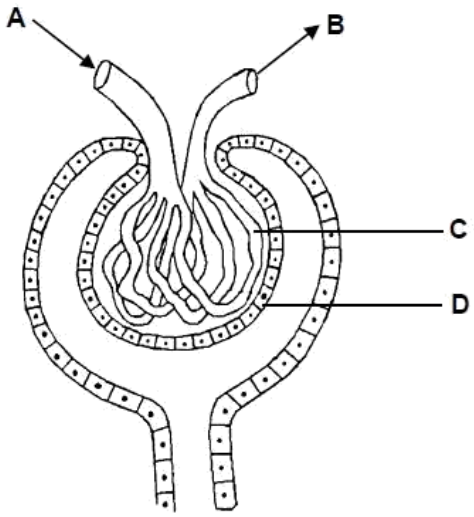
(1 compulsory mark + any 3)

2.1.4 Which organic substances in the table are considered to be useful? Give a reason for your answer. (4)

Glucose, ✓ amino acids ✓ and proteins ✓ as they get reabsorbed into the blood and do not end up in B to be excreted. ✓

(12)

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



2.2.1 In which region of the kidney would you find this structure? (1)

In the cortex ✓

2.2.2 Name the process in urine formation that occurs in this structure. (1)

Diffusion or Glomerular / Ultra- / Pressure filtration ✓

2.2.3 Identify the part **C**. (1)

Glomerulus / Blood capillary ✓

2.2.4 Describe two structural adaptations of part **C** for the process in question 2.2.3 above. (4)

- Walls are made of a single / thin layer ✓ to facilitate diffusion ✓ of substances.
- Many tiny pores ✓ act as microfilters, restricting large substances such as proteins / blood corpuscles. ✓
- Lots of capillaries ✓ to ensure large surface area. ✓

(any 2 x 2)

2.2.5 Part **A** is wider than part **B**. What is the importance of this? (2)

To create a high pressure ✓ in **C** for filtration. ✓

2.2.6 Name the hormone secreted when there is a storage of water in **A.** (1)

ADH ✓

2.2.7 Describe how the hormone named in question 2.2.6 plays its role under such conditions. (3)

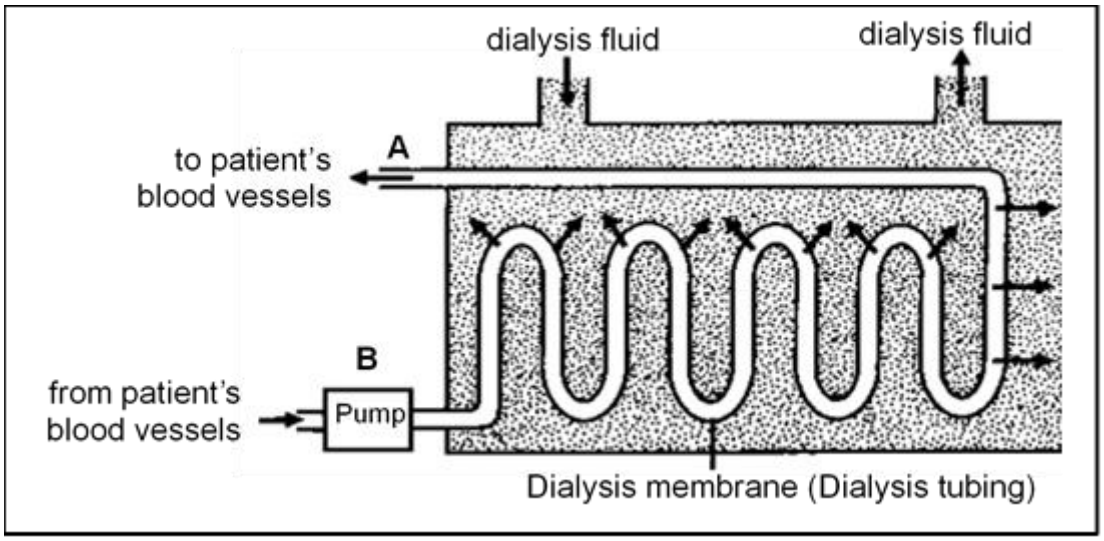
- Makes collecting duct✓ / distal convoluted tubule
- more permeable to water✓
- allowing more water to be reabsorbed into the blood steam. ✓

(13)

[25]

Question 3

3.1 An extract on renal failure and its treatment is given below (the diagram below represents a dialysis machine, used to treat patients with renal failure).



Extract:
Kidneys can become so damaged that they no longer function properly, and we say that the person has renal failure. People with severe renal failure can be treated by dialysis, using a dialysis machine, to purify the blood. Dialysis is the separation of molecules by size, the smaller molecules diffusing through a dialysis tubing (selectively permeable membrane). The process takes between three and six hours and needs to be done two or three times a week.

3.1.1 Describe what *renal failure* is. (2)
When kidneys become so damaged ✓ they no longer function properly ✓

3.1.2 Which process is illustrated in the diagram above? (1)
Dialysis ✓

3.1.3 At what point in the diagram (**A** or **B**) would you expect the highest concentration of urea. (1)
B ✓

3.1.4 Describe how blood is purified in the dialysis machine. (2)

- The waste products move out of the dialysis tubing / blood ✓
- where there is a high waste product concentration ✓
- into the dialysis fluid ✓
- where there is a low waste product concentration ✓
- through the process of diffusion ✓

- concentration gradient is maintained because dialysis fluid is being pumped ✓ (any two x 1)

3.1.5 Explain why dialysis tubing needs to be selectively permeable. (2)

It removes only the waste products ✓and not the products still required by the body. ✓

3.1.6 Renal failure affects the osmoregulatory function of the kidney, so that it no longer excretes water efficiently. Explain the effect of renal failure on the patient's blood pressure. (3)

- More water will remain in the bloodstream. ✓
- Blood volume will increase, ✓
- therefore, the blood pressure will increase ✓

(11)

3.2 Study the following table that shows the flow rate and concentration of certain substances taken at regions **A**, **B**, **C** and **D** of the nephron in the human kidney.

Part of nephron	**Flow rate (cm^3/min)**	**Solute concentrations (g/100 cm^3)**				
		Proteins	**Glucose**	**Sodium ions**	**Ammonium salts**	**Urea**
A	4	0	0	0,6	0,04	1,80
B	200	0	0,10	0,72	0	0,05
C	4	0	0	0,3	0	0,15
D	2000	7	0,10	0,72	0	0,05

3.2.1 State, with a reason, which of the following parts (**A**, **B**, **C** or **D**) of the nephron represents the following:

a) Afferent arteriole (2)

D ✓ contains proteins / highest flow rate ✓

b) Bowman's capsule (Capsular space) (2)

B ✓ - high concentration of glucose, but no proteins ✓

c) Loop of Henle (2)

C ✓ – no glucose and sodium ions and the urea is lower in concentration than in D ✓

d) Collecting duct/ Duct of Bellini (2)

A ✓ - has the highest concentration of urea ✓

3.2.2 Explain the difference in the flow rate between **B** and **D.** (4)

- High flow rate in D because of the heart beat / arterial blood. ✓
- Flow rate decreased in glomerulus ✓ because of smaller diameter of capillaries / flow divided into many capillaries. ✓
- Flow rate is decreased as the fluid passes through membranes✓ hence low flow rate when fluid enters capsule where pressure of heartbeat is absent. ✓
- Large volume comes in via the afferent arteriole and has to travel through the narrower efferent arteriole which therefore slows the flow rate down✓

(any 4)

3.2.3 State two functions of the kidneys, other than pH regulation, that can be supported by the data given. (2)

- Excretion of urea, sodium ions and ammonium ions ✓
- Reabsorption / regulation of glucose ✓
- Osmoregulation ✓

(any 2)

(14)

[25]

Section B: [50]

Total marks: [100]

Cognitive level distribution

Question	Level 1	Level 2	Level 3	Level 4	Marks
1.1.1		✓			2
1.1.2		✓			2
1.1.3		✓			2
1.1.4		✓			2
1.1.5		✓			2
		10			10
1.2.1	✓				1
1.2.2	✓				1
1.2.3	✓				1
1.2.4	✓				1
1.2.5	✓				1
1.2.6	✓				1
1.2.7	✓				1
1.2.8	✓				1
1.2.9	✓				1
1.2.10	✓				1
	10				10
1.3.1	✓				2
1.3.2	✓				2
1.3.3	✓				2
1.3.4	✓				2
1.3.5	✓				2
	10				10
1.4.1	✓				3
1.4.2		✓			1
1.4.3			✓		2
1.4.4			✓		1
1.4.5		✓			2
1.4.6		✓			1
	3	4	3		10
1.5.1	✓				3
1.5.2			✓		2
1.5.3	✓	✓	✓		5 (1+3+1)
	4	3	3		10
2.1.1	✓				3

2.1.2			✓		1
2.1.3				✓	4
2.1.4				✓	4
	3		1	8	12
2.2.1		✓			1
2.2.2		✓			1
2.2.3		✓			1
2.2.4			✓		4
2.2.5			✓		2
2.2.6		✓			1
2.2.7			✓		3
		4	9		13
3.1.1		✓			2
3.1.2	✓				1
3.1.3				✓	1
3.1.4			✓		2
3.1.5				✓	2
3.1.6			✓		3
	1	2	5	3	11
3.2.1		✓			8
3.2.2				✓	4
3.2.3		✓			2
		10		4	14
TOTAL	31	33	21	15	100

CHAPTER 9: POPULATION ECOLOGY

Overview

Time allocation: 4 weeks (24 hours)

This chapter consists of the following sections:

1. Introduction
2. Key concepts
3. Population size
4. Interactions in the environment
5. Social organisation
6. Community change over time
7. Human population
8. Summary
9. End of topic exercises

Introduction

This chapter expands on learner's knowledge of environmental studies through population ecology. Learners should already have a fundamental understanding of basic concepts in ecology that have been learnt during their grade 10 year. If necessary, a baseline assessment should be done to assess their understanding of terminologies (e.g. ecology, species, population, community, ecosystem, abiotic factors, biotic factors, food chains, etc.) and other processes that will be re-visited in this chapter.

It will be of paramount importance that learners are exposed to many examples, more than what is in the textbook, of counting natural populations, the symbiotic relationships of different species, predation and population growth curves and human age-gender growth pyramids. Whilst it is possible to use pseudo examples to illustrate the above content, it is highly recommended that you choose local, South African, based examples that are contextually correct to the real-world. This will help not to distort the content of the syllabus and keep it relevant.

Key Concepts

- Populations grow in number through natality and immigration and they decrease in number through mortality and emigration.
- We can measure population sizes through either using direct or indirect methods.
- Depending on the type of organism, different growth curves are found in nature. They are the geometric J-shaped and logistic S-shaped curves.
- Organisms display various relationships amongst each other including predation, competition, three types of symbioses, herding/swarming, packs for hunting and dominance hierarchies.
- Through social interactions amongst individuals of the same species and between different species, trends that increase survivability in the environment are possible.
- The emergence of a community over time is evident in a pioneer species being replaced by a latter until a stable climax community is reached.
- Because of the agricultural, industrial and medical revolutions, man has been able to transcend past initial inhibitors of human population growth.
- Depending on the development or underdevelopment within a country, different population pyramids can be used to represent growth forms.

Population size

This topic is covered under three sub-topics, namely:

- Factors influencing population size
- Counting populations
- Population growth forms

Factors influencing population size

Learners are exposed to the reasons why populations are considered dynamic and in constant flux. Important terms such as: natality, immigration, mortality and emigration are to be discussed in detail. Contemporary examples of African wildlife should be drawn up, e.g. the migration of wildebeest in SA and the Serengeti. Reasons why natural populations immigrate and/or emigrate can also assist in learners content enrichment.

Causes of fluctuations in populations are also to be discussed. These causes must be directly linked to carrying capacity, density dependent factors and density independent factors. It is necessary that you acquaint yourself with these terms and can illustrate these concepts with different examples. Class discussions with linkage to animals your students know, e.g. cows, goats and other livestock etc. could help bridge these concepts in a practical manner.

Counting populations

Learners learn of the two major population counting methodologies and their constituents. Emphasis is to be placed on direct methods as counting exact population number and indirect methods as estimating population number.

Of each method, learners should be able to practically use the method in an experimental set-up. It is recommended that experimental set-ups are created using available resources at your disposal.

For quadrats:

Create a 1 x 1 m^2 quadrat and conduct an investigation on the number of common weeds on the playground field. Allow learners to measure the field with a tape measure or roughly by walking in metered-steps. Guide learners with questions such as why the quadrat method is used? For which animals can we use this method? How can we increase the validity and reliability of our results etc.

For mark-recapture:

Create data sets in which learners have to estimate population size after each recapture event. Show learners how the reliability of population estimate can be increased through more sampling events. Use the practical in the textbook as a guide or as an SBA task.

Population growth forms

The introduction of two distinct growth forms of natural populations is done in this unit. Learners need to identify various growth phases from either the geometric or logistic growth curves. More than identification of the phases, learners have to state general characteristics of each respective phase. They also need to give an account of why the graph takes on this shape at this moment in time. Learners need to link

concepts that were taught previously, such as carrying capacity and environmental resistance and their influence(s) on the growth curve.

Activity 1: Populations

1. Distinguish between the terms species, population and community. (6)

   - A species is a group of living organisms consisting of similar individuals ✓ that are capable of exchanging genes ✓.
   - A population is a part of a particular species ✓ that occupies the same habitat at the same time ✓.
   - A community is formed by different species ✓ that interact with each other in a specific habitat ✓.

2. Explain how the density of a population affects its growth rate. (4)

   Density dependent factors exert an effect on a population in proportion to its size ✓. The greater the population number✓, the greater influence density dependent factors will have ✓. Density independent factors will have an influence on a population irrespective of its size. ✓

3. Define the term carrying capacity. (2)

   Carrying capacity refers to the largest number of individuals of a biological species ✓ that an ecosystem can support over an indefinite time ✓

4. Name two environmental conditions which could result in a positive population growth. (2)

   Enough food and water ✓, space ✓

(14)

Activity 2: Determining population size

1.a) Phumzi and Rebecca both agree that the quadrat method would work best. Explain why you would agree with them and not choose to use the mark and recapture method. (3)

The quadrat method is an indirect method used to estimate organisms which are sessile and are fixed to one location ✓. The mark-recapture method is used in assessing more mobile organism ✓. Through quadrats an estimate can be generated of the number of individuals per quadrat and this can be divided into the number of quadrats that could fit over the entire geographic area (size) ✓.

b) The quadrat that they will be using is 2,5 m^2 and they choose to throw the quadrat six times at random at different locations along the 32 m^2 rock pool. The results are recorded in the table below. Using these results, calculate the population size of the mussels. (4)

Throw no.	Number of mussels in quadrat
1	25
2	13
3	31
4	19
5	22
6	26
Total	25+13+31+19+22+26 = 136 ✓
Average / quadrat	136 / 6 = 22,667 ✓
× Area / quadrat size	22,667 × (32 / 2,5) = 290,13 ✓
Population size	290 mussels ✓

c) How has (i) validity and (ii) reliability been assured? (2)

(i) Validity has been ensured through using the same sized quadrant through-out the investigation ✓.

(ii) Reliability has been ensured through repeating throws, six times, and then creating an average estimate of the population size ✓.

2. Describe any four precautions that must be considered when working with the mark and recapture method. (4)

- The first sample is taken must be large enough to be a true representation of the population. ✓
- The mark used on the organism must remain for the entire period of the procedure. ✓
- The mark must be suitable to the type of organism. The mark must not harm or impair the movements and behaviour of the organism in its environment. ✓
- When the marked organisms are released back into the environment, they must be given enough time to mix with the existing population. ✓

(13)

Activity 3: Growth forms

1. Tabulate two major differences between logistic and geometric growth forms. Include an example of a species representing each growth form. (6)

Geometric growth	**Logistic growth**
Three phases	Five phases
Micro-organisms (typically)	Higher order animals

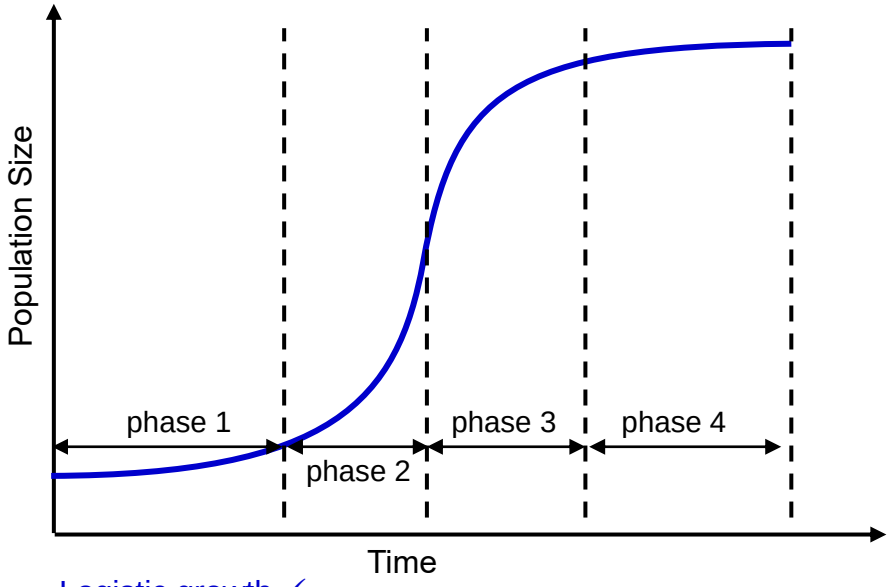
Overshoots carrying capacity	Typically equalizes with carrying capacity
Example: bacteria	Example: mammals Elephant

Table: ✓

Example per growth form: ✓

Any 2 comparisons: ✓✓ per correct comparison – mark only first two.

2. Identify the growth form in the following graph. (1)



Logistic growth ✓

3. Identify the phases 1 to 4 in the above graph. (4)

Phase 1: lag phase ✓; phase 2: exponential phase ✓; phase 3: decelerating phase ✓, phase 4: equilibrium phase ✓

(11)

Interactions in the environment

This topic is covered under four sub-topics, namely:

- Predation
- Competition
- Resulting specialisations because of competition
- Symbiotic relationships

Predation

The definition of predation, explanations of the predator-prey graph(s), how predators are adapted for their ecological niche as well as two examples of predators

are discussed in this topic. Class discussions could be used to establish a basic definition of a predator, their adaptations and ecological niche(s) that they fulfill. Learners already know examples of predators and the teacher should explore these examples in a learner centered approach: (i) why are they predators; (ii) how are they adapted to being predators; (iii) do they serve a regulatory function in their environment? How?

A good understanding of the predator-prey graph is essential. When using the predator-prey graph, focus must be on how the two linear relationships are dependent on each other (e.g. when the prey population rises, the predator population will rise later). Use questions to establish reasons for the shape of the graph and to build understanding.

Competition

Learners are exposed to two contrasting definitions of competition, namely interspecific and intraspecific competition. Whilst all forms of competition negatively affect participants and result in injury etc., emphasis should be placed on how many species are involved e.g., between two or more species (interspecific) or within the same species (intraspecific). An elaboration can be made of these concepts in respect to humans vs other natural species' populations in nature (interspecific) and humans vs. humans in the acquisition of food, shelter, jobs etc. Gause's law of competitive exclusion whereby one species outcompetes another is also important.

Resulting specialisations because of competition

Two forms of specialisations are discussed in this topic namely (i) Character displacement in Darwin's finches and (ii) Resource partitioning amongst herbivores and carnivores in the African savannah.

The concept of organism's specialisation is more abstract for learners to grasp. A recommendation to overcome this challenge will first be to discuss what specialisations refer to and what do they mean in humans and career fields.

> Specialisation has many definitions but let's over-simplify it through saying that it makes you an expert in your field of work or discipline of study.

Now we can relate this to animal populations. Different animals have developed unique morphological features (character displacement) that have allowed them to become 'specialists' in the way they acquire their food, e.g. long neck for the eating of leaves on trees, big and thick powerful beaks for the crushing of seeds (a finch species) etc. Through character displacement, the resulting morphological trait, allows an organism to occupy a unique niche.

Niche partitioning shows how different organisms can co-exist in the same environment and limit their interspecific competition. The learner's book illustrates this using different cat species, herbivores and the plants in the forest biome.

Symbiotic relationships

Symbiosis refers to the close relationship shared between two organisms of different species. Definitions of all three symbiotic relationships are important in this topic. Simple discussions of win-win (mutualism), win-loose (parasitism) and win-neutral relationships can set the tone for these topics. The key ideas to be made clear in this section are: (i) what type of relationship it is, and (ii) how are the organisms in the relationship affected.

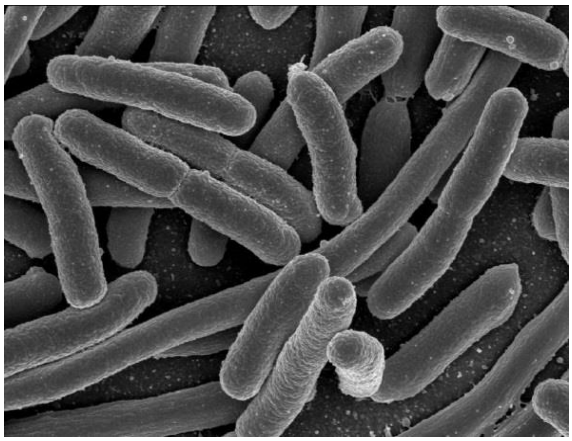
Activity 4: Symbiotic relationships

Identify the types of symbiotic relationships depicted in A – D below. (4)

A – mosquito

B – Bird's nest in a tree

C – lichen



D – E.coli in the gut

A – parasitism ✓; B – commensalism ✓; C – mutualistic ✓; D – mutualistic ✓

Social Organisation

This topic is covered under four sub-topics, namely:

- Herding as a protective strategy
- Packs as a hunting strategy
- Dominance as a protective and reproductive strategy
- Division of tasks (castes)

Herding as a protective strategy

The definitions of herding / swarming and their role as a protective feature are discussed under this topic. Herding should be explored in an African context under the light of the many-eyed hypothesis and how it increases the survivability of members of the herd.

Packs as a hunting strategy

Use African examples to illustrate how packs offer benefits in co-operative hunting. The auditory signals that packs use to co-ordinate behaviour and how they attack prey species should be highlighted. The question of solitary hunting vs. pack hunting can be explored in class discussion and through a multimedia presentation.

Dominance as a protective and reproductive strategy

Through dominance, groups of animals establish social hierarchies, a pecking order. In these social hierarchies, breeding pairs may form because of traits which make them dominant. These dominant traits can be illustrated as ensuring reproductive success and are the traits that will be passed down. The dominant male and/or female, being the strongest, will also demarcate and protect his/her area and group.

Division of tasks (castes)

This topic can be explored in ants, termites and bees most notably. One can draw on learner's knowledge with respect to what they have physically seen, e.g. an ant colony. The point of hierarchy and position is not as important as the function that each caste plays in the colony. All castes must be shown as inter-dependent and reliant on their shared interactions for the survival of the colonial species'.

Community change over time

This topic is covered under one sub-topic, namely:

- Primary and secondary succession in ecosystems

Primary and secondary succession in ecosystems

The differentiation between primary and secondary succession are focal in this topic. In differentiation, the presence or complete absence of soil layers should be the starting point. In primary succession focus on the ABSENCE of soil layers and how pioneers are adapted to living in these adverse conditions (whilst this is not assessable, it brings wholeness to the concept). The definition of a pioneer plant species should also be elaborated as the first to move in and change the physical and chemical composition of the environment. It can then be further elaborated that through changes from one generation to another succession takes place until a climax community is reached. Characteristics of climax communities as well as organisms that one would expect to inhabit them should be mentioned.

Learners should also be able to note several differences between primary and secondary succession. For secondary succession, the speed that it occurs at, why it occurs at this speed and when it occurs are all important facets.

Human Population

This topic is covered under three sub-topics, namely:

- A brief history
- Age-gender population pyramids
- The South African population

A brief history

In this topic learners are introduced to human population studies. Reasons for why early human populations were low must be discussed in detail. These reasons can include: (i) Higher infant mortality rates because of childhood diseases; (ii) Higher predation and injury rates due to being hunter-gatherers and (iii) overall low standard of living, starvation, diseases and general low education levels. How humans overcame these early challenges through revolutions in medicine, agriculture and technological innovation should be highlighted as causes of our exponential growth.

Age-gender population pyramids

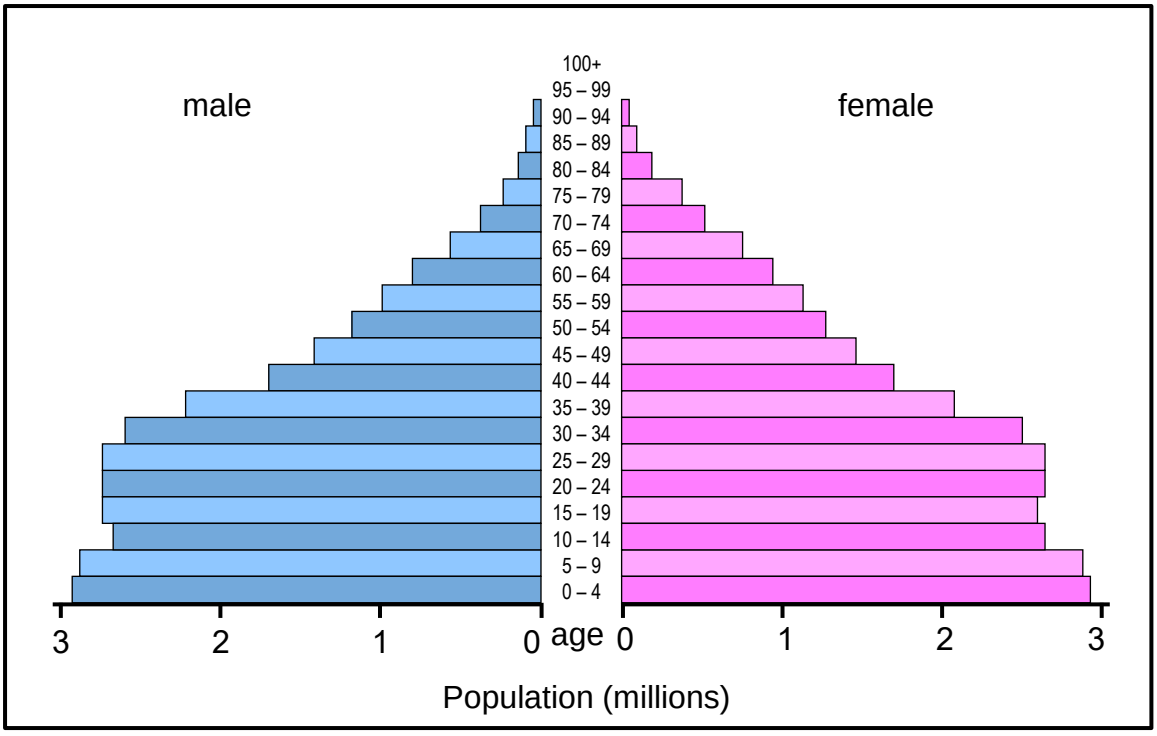
Learners need to know how to identify each of the three population pyramids based on their visible characteristics. Chiefly, distinctions should be made on the number of pre-reproductive to reproductive and post-reproductive groups and their number of individuals per cohort group. Countries that represent each form of population pyramid should be noted, as well as discrepancies in their natality rates, standards of living, general education levels and social advancement.

The South African population

In this topic, learners are exposed to the age-gender pyramid of the South African population. Being able to identify our population growth pyramid as transitionary in nature, to becoming a stable population growth pyramid is essential. In must also be noted how the SA fertility rate and societal developments have caused this. Major changes to be shown are the steady, but definite, decrease in fertility rates and how this has influenced our stabilizing population growth pyramid.

Activity 5: Population pyramids

Study the following population pyramid before answering the questions that follow:



1. Which age-gender population growth curve is displayed in the above population pyramid? Stable growth ✓ (1)

2. Give three reasons for your answer in question 1. (3)

Pre-reproductive members of the population are more-or-less the same number as the reproductive members ✓.

Natality is consistent year-on-year ✓.

Many individuals reach old age ✓.

Lower mortality rates amongst individuals ✓ (any 3).

3. What type of country is this population pyramid representative of? List any two characteristics of such a country. (3)

USA / CHINA ✓

Life expectancy is high because of an increased standard of living ✓.

Education levels amongst the population are high ✓.

Countries are well developed ✓. (Country plus any 2)

Summary

- A population is defined as a group of individuals of the same species that occupies the same habitat at the same time.
- Population size increases through natality and immigration and decreases through mortality and emigration. Population size is never fixed and is always fluctuating.
- Reasons for population fluctuations include seasonal availability of scarce resources (food, water, space etc.), unfavourable abiotic conditions, the spread of disease, predation, environmental carrying-capacity etc.
- Limiting factors on population size include density-dependent (directly related to population size and distribution) and density-independent (unrelated to population size and distribution) factors.
- Depending on the species of animal, two possible growth curves exist. The geometric J-shaped curve demonstrates an exponential growth because of favourable conditions and recedes during periods of environmental disturbance. The logistic S-shaped curve initially represents the J-shaped curve, but, due to environmental resistance, the population becomes stable. It may collapse if the carrying capacity falls due to environmental degradation.
- In a logistic graph, 5 phases can be observed. Each phase has its own unique characteristics. These phases are the lag, exponential growth rate, decelerating, stabilising and death phases.

- Animals demonstrate various social interactions. Examples of these social interactions include predation; intra and interspecific competition; three types of symbiotic relationships (mutualism; parasitism and commensalism); herding; division of labour and packs as a hunting strategy.
- Plant communities show enormous change over time. Pioneer plant species alter the physical and chemical composition of a new piece of land or disturbed land allowing later climax species to take root.
- The human population has increased dramatically because of revolutionary events in agriculture, medicine and technology.
- Human population growth can be represented in three types of age-gender distribution pyramids. The pyramids differ per how well developed a country is and can be classified as either, positive, negative or stable.
- When analysing a growth pyramid, we can clearly see the male to female ratio; how many young individuals to older individuals we have and the total population number. We can infer what has caused this and predict what the future population may be.

End of topic exercises

Section A

Question 1

1.1 Various options are provided as possible answers to the following questions. Choose the answer and write only the letter (A to D) next to the question Number (1.1.1 to 1.1.5) in your ANSWER BOOK, for example 1.1.6 D.

1.1.1 Which of the following will cause a decrease in the size of a population?

(i) emigration
(ii) immigration
(iii) natality
(iv) predation

A (i) and (iii)
B (ii) and (iv)
C **(i) and (iv)** ✓✓
D (iii) and (iv)

1.1.2 The net increase of a population can be determined by ...

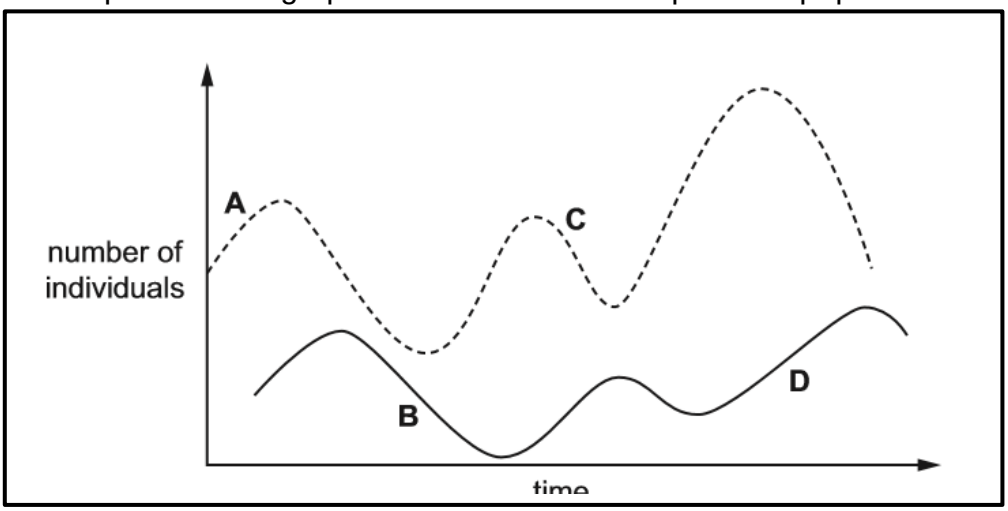
A adding births and deaths and subtracting emigrations and immigrations.
B adding births and emigrations and subtracting deaths and immigrations.
C **adding births and immigrations and subtracting deaths and emigrations.** ✓✓
D adding deaths and immigrations and subtracting births and emigrations.

1.1.3 The following limitations on population size are all considered density dependent factors, except for…

A Predation
B Competition
C **Wild fires** ✓✓
D Spread of disease

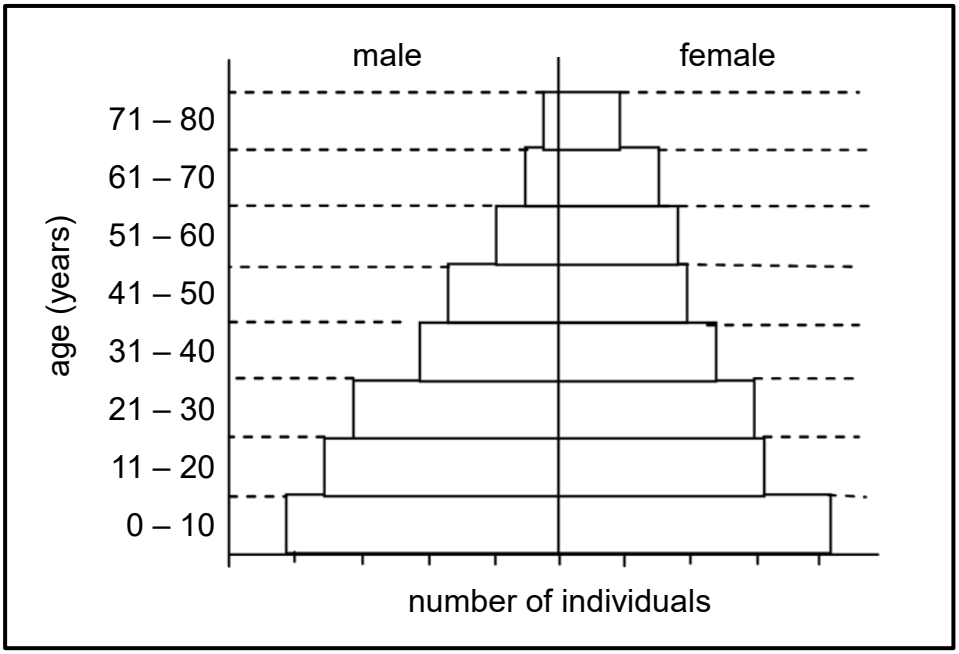
1.1.4 The graph shows the changes in the populations of predator and prey over a period of time.

Which point on the graph shows a decrease in predator population?



Answer: **B** ✓✓

1.1.5 Study the population pyramid below:



Which of the following is a CORRECT interpretation of the population above?

A **Rapidly growing population; characteristic of a developing country** ✓✓

B Declining population; characteristic of a developing country

C Stable population; characteristic of a developed country

D Declining population; characteristic of a developed country

(5 x 2) = (10)

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

1.2.1 The relationship between two species that live in close contact with each other for part or all of their lives symbiosis ✓

1.2.2 A community made up of living organisms and non-living components such as air, water, and mineral soil ecosystem ✓

1.2.3 The phase during population growth where animals adapt to their new environment lag phase ✓

1.2.4 The maximum number of organisms of a particular kind that can be supported by resources in the environment carrying capacity ✓

1.2.5 The movement of individuals of a population out of a habitat emigration ✓

1.2.6 A pattern of animal behaviour of an organism or a group of similar organisms in defending an area for such purposes as mating, nesting, roosting, or feeding territoriality ✓

1.2.7 A common term for limiting factors that prevent a population from increasing environmental resistance ✓

1.2.8 The total count of all individuals in a population census ✓

1.2.9 Development of a community over time where species in one stage are replaced by other species ecological succession ✓

1.2.10 A square frame used to determine population size over an area. quadrat ✓

(10 × 1) = (10)

1.3 Indicate whether each of the statements in Column I applies to **A ONLY**, **B ONLY**, **BOTH A AND B** or **NONE** of the items in Column II. Write **A only**, **B only**, **both A and B**, or **none** next to the question number (1.3.1 to 1.3.5).

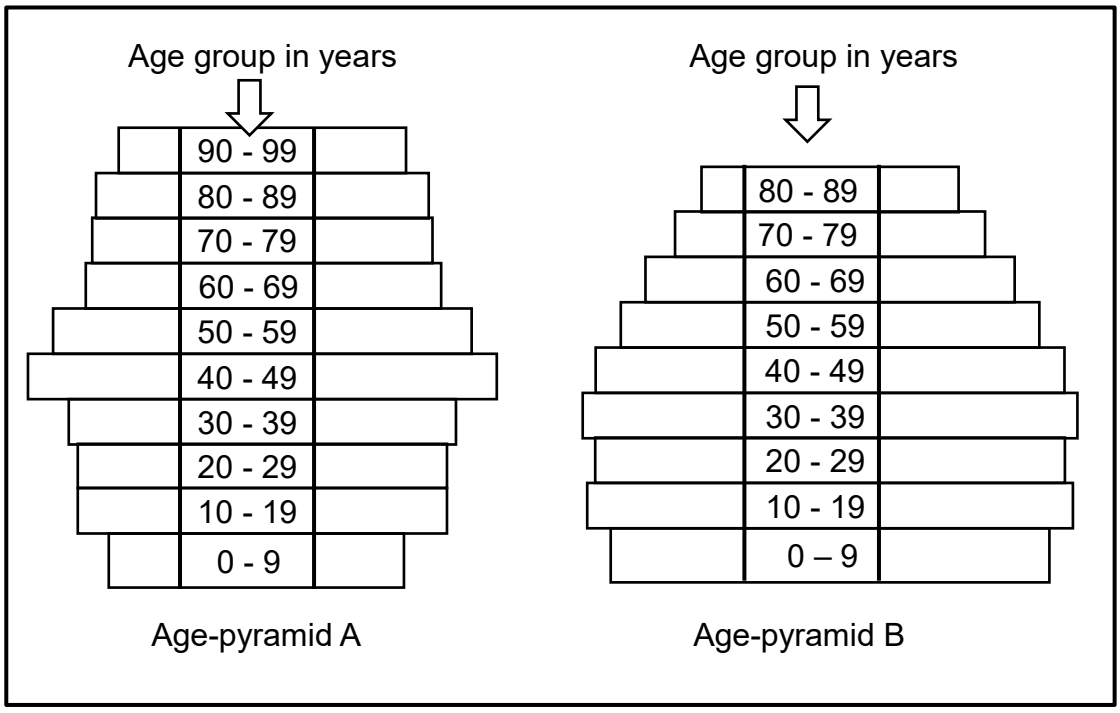
	Column I	**Column II**
1.3.1	Kittens competing for their mother's milk	A: interspecific competition B: intraspecific competition
1.3.2	A pine forest is burnt to the ground over a 10 km^2 area when lightning strikes a tree. In spring, a few seedlings begin to sprout.	A: primary succession B: secondary succession
1.3.3	One of the species benefits and the other is unaffected	A: commensalism B: mutualism

1.3.4	Organisms have overlapping niches and compete for the same resources but they coexist because they use the resources slightly differently	A: resource partitioning. B: temporal partitioning
1.3.5	Example of social organisation that increases the chances of survival	A: division of labour in bees B: a herd of zebras

(5 x 2) = (10)

1.3.1 **A only** ✓✓
1.3.2 **B only** ✓✓
1.3.3 **A only** ✓✓
1.3.4 **A only** ✓✓
1.3.5 **Both A and B** ✓✓

1.4 Study the age-gender pyramids below representing a developing country and a developed country. Both pyramids have been drawn to the same scale.



1.4.1 Which pyramid represents the population distribution of a developed country? Pyramid A ✓ (1)

1.4.2 Give two reasons for your choice in question 1.4.1. (2)
Low birth rate/ low natality rate ✓
Low death rate/ low mortality rate/ Higher life expectancy ✓

1.4.3 Which group (male or female) has the larger percentage reaching old age in Pyramid B? Female ✓ (1)

1.4.4 Which two age groups has exactly the same percentage of male and female population in Pyramid A? (10-19) ✓ and (20-29) ✓ (2)

1.4.5 Give four reasons why it is important for a country to know the age and gender structure of its population. (4)

The population size and structure of a country is used for several things:

- taxation ✓
- the building of public buildings i.e. schools' hospitals etc. ✓
- housing development ✓
- future employment and where the deficits would be ✓
- prevention of an economical slump ✓
- infrastructure of a country i.e. roads bridges, dam, reservoirs public transport. ✓
- the population of a country indirectly impacts on immigration from other countries. ✓ (Any 4)

(10)

1.5 Read the article below on elephant culling.

TOO HUNGRY, TOO DESTRUCTIVE, TOO MANY: SOUTH AFRICA TO BEGIN ELEPHANT CULL

An elephant herd at the Kruger National Park has 20 000 elephants, 5 000 more than is sustainable. Ecologists say the animals' huge appetites and fondness for 'habitat re-engineering' – reducing forests to flatland by uprooting trees and trampling plants – is the main problem.

Culling of the excess elephants is seen as an advantage in that it generates revenue for the communities from the sale of ivory and other elephant products. It will also provide meat to the local communities. Alternatives to culling include contraception and relocation of entire elephant families. The removal of fences between the Kruger National Park and parks in neighbouring Mozambique will eventually help with migration into less congested areas.

The 1998 figure of 8 000 elephant increased to 20 000 in 2008 and it is expected to reach 34 000 by 2020.

1.5.1 Give the main reason mentioned above in support of the culling of elephants. Damage to the environment ✓ (1)

1.5.2 Name three alternatives to culling proposed above. (3)

contraception ✓
relocation of elephant families ✓
removing fences to allow migration ✓

1.5.3 Predict the likely elephant population number by 2036 if the population is allowed to keep growing at the same rate? (2)

50 000 ✓✓

1.5.4 Determine the carrying capacity, for elephants, in the Kruger National Park: 15 000 ✓✓ (2)

1.5.5 Suggest how the community can benefit from the culling of elephants. (2)

Culling generates revenue for the communities from:

- the sale of ivory and other elephant products, ✓

- as well as providing meat to the local communities. ✓

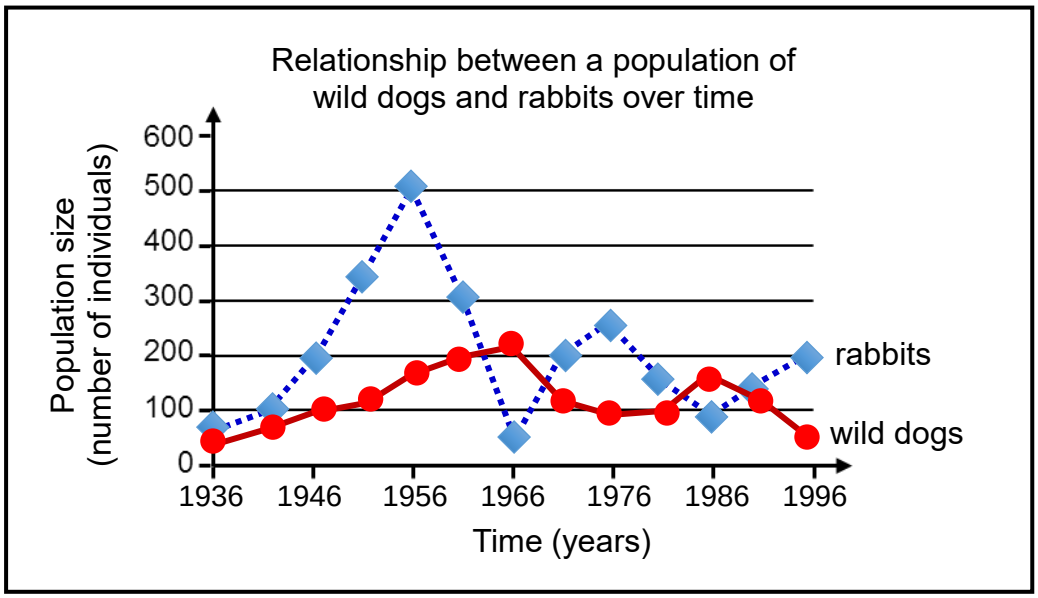
(10)

Section A: [50]

Section B

Question 2

2.1 Study the graph below and answer the questions that follow.



2.1.1 Which population-regulating factor is illustrated by this graph? (1)

Predation / predator-prey ✓

2.1.2 Is this regulating factor in question 2.2.1 a density dependent or a density-independent factor? Give a reason for your answer. (2)

density-dependent ✓ - the number of prey depends on the number of predators ✓

2.1.3 How many of the following were there in 1966?

(a) Rabbits 50 ✓

(b) Wild dogs 200 - 220 ✓ (2)

2.1.4 What is the maximum number of rabbits that have ever survived in this environment? 500 ✓ (1)

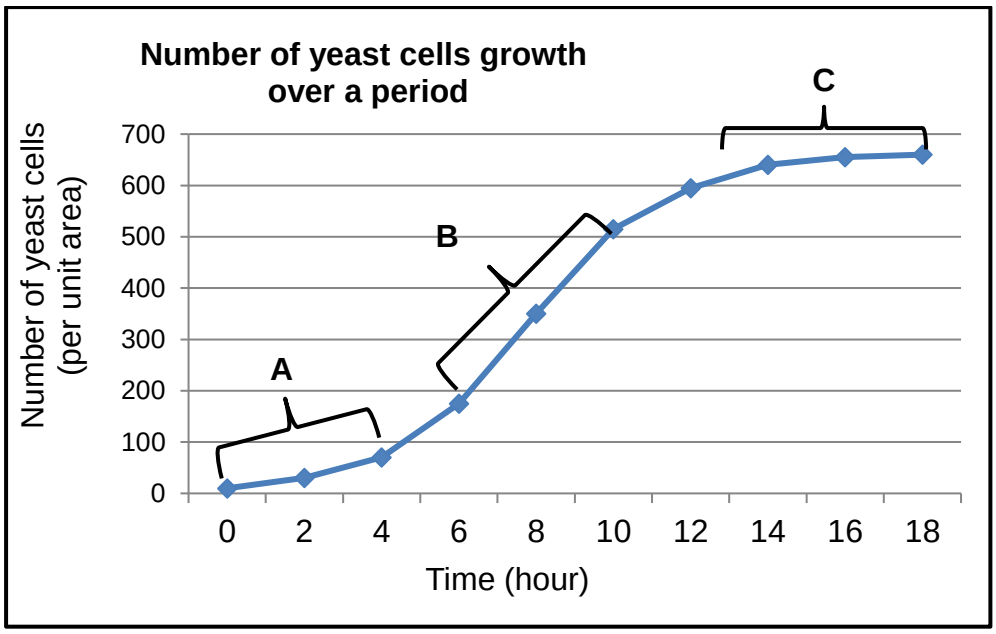
2.1.5 Will the rabbit population increase or decrease when there is a small number of wild dogs? Explain your answer. (2)

increase ✓- because there are less wild dogs to prey on the rabbits ✓ (8)

2.2 In an experiment, yeast cells were grown in a glucose solution in a test tube and kept at a temperature of 30 °C. Every two hours, a drop was taken from the mixture and examined under a microscope. The number of cells per unit area was counted. The results of the experiment are shown in the table.

Time	Number of yeast cells (per unit area)
0	10
2	30
4	70
6	175
8	350
10	515
12	595
14	640
16	655
18	660

2.2.1 Draw a line graph to illustrate these results. (6)



Guidelines for assessing the graph:

Correct type of graph	✓
Title of graph (2 variables indicated)	✓
Correct label, unit and scale for X-axis	✓
Correct label, unit and scale for Y-axis	✓
Drawing of line graphs	✓: 1 to 9 points plotted correctly ✓: All 10 points plotted correctly

2.2.2. On your graph, indicate the various phase. (3)

Indicated on the graph:

A - lag phase ✓

B - the exponential growth phase (or log phase) ✓

C - stable phase. ✓

2.2.3 Identify the growth form indicated by the graph (1)

S-shaped/Logistic growth ✓

2.2.4 During which time period did the greatest increase in the number of yeast cells occur? 6 to 10 hour ✓✓ (2)

2.2.5 After six hours, there are 175 yeast cells per unit area. How long does it take to double this number? 2 hours ✓ (1)

2.2.6 Give two reasons why the growth rate of the population might have slowed down. (2)

because of limited space ✓, nutrients in the test tube ✓

(15)

2.3 A population of mice in a field of mealies was studied for one week. The population parameters (per thousand mice) were calculated for that week. Six months later the investigation was repeated. The results are recorded in a table.

.**Population parameter (per 1000)**	**First survey**	**Second survey**
Birth rate	110	270
Immigration	10	30
Death rate	145	200
Emigration	10	70

The rate of change of a population can be calculated by the following formula:

Rate of change = (birth rate + immigration rate)
– (death rate + emigration rate)

2.3.1 Calculate the rate of change for the first survey. (4)

Rate of change = (birth rate + immigration rate) – (death rate + emigration rate)

= (110 + 10) ✓ – (145 + 10) ✓

= 120 – 155 ✓

= – 35 ✓

2.3.2 What was happening to the size of the population in the first survey? Give a reason for your answer. (2)

decreased ✓; the rate of change is negative. ✓

2.3.3 Calculate the rate of change for the second survey. (4)

Rate of change = (birth rate + immigration rate) – (death rate + emigration rate)

= (270 + 30) ✓– (200 + 70) ✓

= 300 – 270 ✓

= 30 ✓

2.3.4 What was happening to the size of the population in the second survey? increased ✓ (1)

2.3.5 The difference in the rate of change between the two investigations is a result of which possible factors? (2)

Decrease in predation and disease ✓

Decrease in competition for food, space, and mates ✓

2.3.6 Distinguish between the concepts: population size and population density (4)

- Population size ✓– refers to the total number of individuals in a population ✓
- Population density ✓– refers to the number of individuals of a population per unit area ✓

(17)

Section B: [40]

Total marks: [90]

Cognitive level distribution

Question	Level 1	Level 2	Level 3	Level 4	Marks
1.1.1	✓				2
1.1.2	✓				2
1.1.3		✓			2
1.1.4		✓			2
1.1.5	✓				2
	6	4			10
1.2.1	✓				1
1.2.2	✓				1
1.2.3	✓				1
1.2.4	✓				1
1.2.5	✓				1
1.2.6	✓				1
1.2.7	✓				1
1.2.8	✓				1
1.2.9	✓				1
1.2.10	✓				1
	10				10
1.3.1		✓			2
1.3.2		✓			2
1.3.3		✓			2
1.3.4		✓			2
1.3.5		✓			2
		10			10
1.4.1		✓			1
1.4.2			✓		2
1.4.3		✓			1
1.4.4		✓			2
1.4.5				✓	4
		4	2	4	10
1.5.1	✓				1
1.5.2	✓				3
1.5.3				✓	2
1.5.4		✓			2
1.5.5	✓				2
	6	2		2	10

2.1.1	✓				1
2.1.2		✓			2
2.1.3 a – b	✓				2
2.1.4	✓				1
2.1.5	✓				2
	6	2			8
2.2.1	✓	✓	✓		6 (2+2+2)
2.2.2	✓		✓		3 (2+1)
2.2.3	✓				1
2.2.4	✓				2
2.2.5	✓				1
2.2.6			✓		2
	8	2	5		15
2.3.1		✓			4
2.3.2	✓				2
2.3.3		✓			4
2.3.4	✓				1
2.3.5			✓		2
2.3.6	✓				4
	7	8	2		17
	43	32	9	6	90

CHAPTER 10: HUMAN IMPACT ON THE ENVIROMENT

Overview

Time allocation: 7 weeks (28 hours)

This chapter consists of the following sections:

1. Introduction
2. The atmosphere and climate change
3. Water availability
4. Water quality
5. Food security
6. Loss of biodiversity
7. Solid waste disposal
8. End of topic exercises

Introduction

This chapter on the 'Human Impact on the Environment' must be completed in Grade 11, though the topic is examined in both the Grade 11 final examinations, and in the final matric exams at the end of Grade 12.

The chapter covers a significant amount of material and educators are generally pushed to complete the chapter in the allocated 7 weeks. In practice, educators often have far fewer than 7 weeks to teach all the material to their learners.

In teaching this chapter, it is important to emphasise the interrelatedness and the interdependence of human activities and the environment.

Human activities are causing extreme crises in our natural environment given that our increasing human populations and technological growth are out of balance with the limited natural resources available to us worldwide.

It is a good idea to introduce this chapter to learners by watch one of two movies that may be hired from DVD rental stores. These are: **An Inconvenient Truth**, and **An Inconvenient Sequel**.

Watch trailers to these at:

An Inconvenient Truth: https://www.youtube.com/watch?v=8wkR-PSIu4A and
An Inconvenient Sequel: https://www.youtube.com/watch?v=huX1bmfdkyA

The atmosphere and climate change

- **Climate** refers to the average weather conditions (temperature, rainfall and air pressure) of a large area over a long period of time.
- **Climate change** refers to any change or disturbance to an established climate pattern. This has happened in the past and is occurring now.

It is important to carefully distinguish between **climate** – as average weather conditions over a long period of time, and **anthropogenic climate change** (climate change caused by human beings). Earth has always experienced changes in climate as part of Earth's natural process, but the current human-induced climate changes are unprecedented.

Composition of the atmosphere

- Discuss the composition of the atmosphere and the sources of greenhouse gases which lead to the greenhouse effect.

Sources of CO_2 and CH_4 emissions – greenhouse gases

- Greenhouse gasses include carbon dioxide, methane, nitrous oxide, ozone and CFC**.**

The greenhouse effect and its importance for life on Earth

- Emphasize the difference between the 'greenhouse effect' and the 'enhanced greenhouse effect' and the importance of the greenhouse effect.
- The following videos provide enrichment with regards to the greenhouse effect:

  https://climatechangeconnection.org/science/climate_causes/greenhouse-effect
  https://youtu.be/nlu21CNd3

The effects of global warming

- Explain how an increase in greenhouse gases (enhanced greenhouse effect) leads to global warming.
- Two videos showing what has been done in Africa to combat global warming:

  Africa's green wall: https://www.youtube.com/watch?v=4xls7K_xFBQ

  Rwanda: https://www.youtube.com/watch?v=O9dXtW8VjfM

- Consider greenhouse gas mitigation strategies for South Africa, a document produced for the Department of Environmental Affairs published in 2018. The link:
  https://www.environment.gov.za/sites/default/files/docs/mitigationpathways_finaldraft_report_greenhousegas.pdf

Deforestation and its influence on the CO_2 concentration in the atmosphere

- Define the term deforestation and discuss the causes and effects of deforestation and ways to reduce deforestation.
- Watch this short video of Professor Maathai and deforestation in Kenya: https://www.youtube.com/watch?v=GFvv9f9u-vY

Carbon footprint

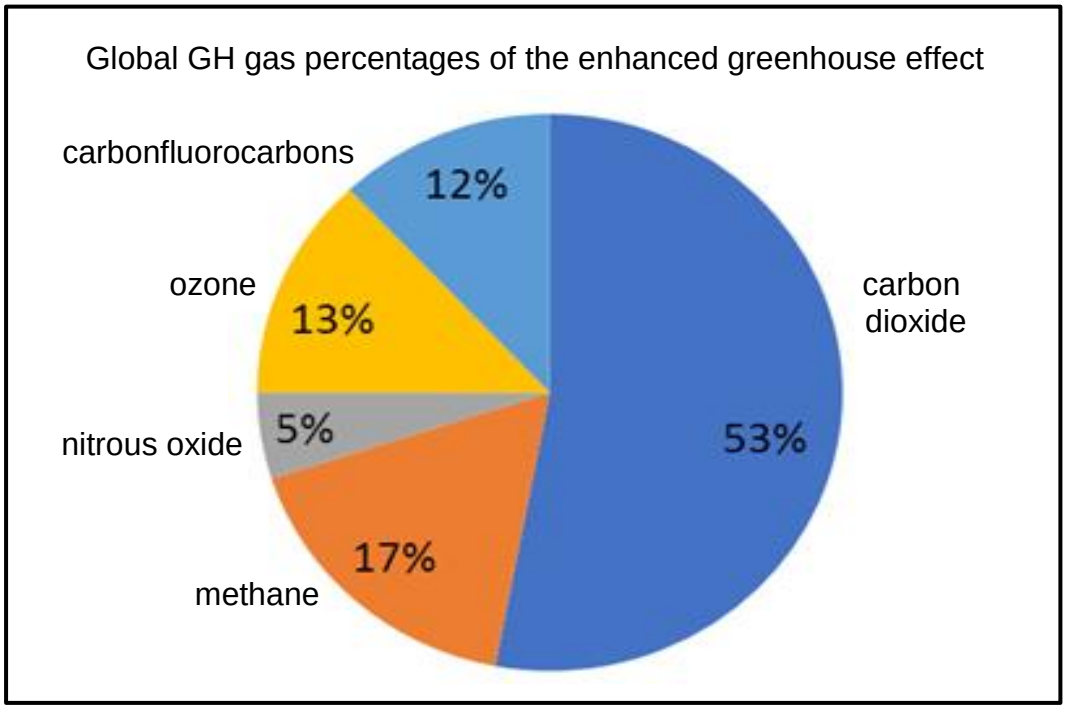
- Focus on what is meant by *carbon footprint* and how we calculate a carbon footprint as well as ways in which we can reduce our 'carbon footprint' to decrease global warming.
- Watch this video on how we can reduce our carbon footprint: https://www.youtube.com/watch?v=YseZXKfT_yY

Ozone depletion

- Ozone as both a protective atmospheric gas and a greenhouse pollutant gas. Focus on:
  - the causes of ozone depletion
  - the consequences of ozone depletion
  - ways in which we can decrease ozone depletion
  - international strategies and solutions to ozone depletion.

Activity 1: The greenhouse effect

Study the pie chart and fill in the missing information on the table below. (6)



Greenhouse Gas	Sources of emissions	%
Carbon dioxide	respiration, fires, fossil fuel burning, decomposition	53
Methane (name 3 more)	gas leaks, agriculture ✓, waste dumps ✓, sewerage works ✓	17
Nitrous oxide	fertilisers, organic decomposition, fires, deforestation	5 ✓
Ozone ✓	industrial processes, chemical reactions to sunlight	13 ✓
Carbonfluorocarbons	refrigerants, aerosols, cleaning solvents	12

Water availability

- Access to clean drinking water is a basic human right. Watch this video about the human right to water in South Africa: https://www.youtube.com/watch?v=cjWUw2rOQlo
- The following factors influence the availability of water in South Africa
    - The construction of dams
    - The destruction of natural wetlands
    - Water wastage
    - The cost of water
    - Poor farming practices
    - Droughts and floods
    - Boreholes and their effects on aquifers

Water quality

- Explain what is meant by the term 'water quality'.
- Explain why water quality is important for the well-being of people and animals, and indeed of all life on Earth.
- Factors reducing water quality include:
    - Eutrophication and algae bloom
    - Domestic, industrial and agricultural use
    - Mining operations
    - Thermal pollution
    - Alien invasive plants

Role of water purification in improving the quality of water

- Discuss the future of water quality in South Africa and South African law and water quality. Explore ways in which water pollution may be prevented.

Water purification

- Focus on how water quality may be increased through water purification at purification plants and privately with different filters.

Recycling water improves the quality (and availability) of water

- Discuss how water availability and quality may be increased through the recycling of water including:
    - ground water
    - construction artificial wetlands
    - methods of desalination

Note: there are numerous short videos on YouTube that demonstrate aspects of water availability and water quality. Here are a few samples:

Human impact on water: https://www.youtube.com/watch?v=VdRfB9X_pyQ

The water crisis in South Africa: https://www.youtube.com/watch?v=Z6UxTTrdsZo

Acid mine drainage: https://www.youtube.com/watch?v=jz4A6al_ceO

Toilet water treatment explained: https://www.youtube.com/watch?v=pXaXjzbccPo

Activity 2: Water availability

Western Cape water consumption data was calculated to be the following in 2018:

Consumers	Water consumption in Mm^3
City of Cape Town	360
Agricultural sector	180
Other municipalities (Overberg, Boland, West Coast and Swartland)	40

1. Identify …

    a) the independent variable consumers ✓ (1)

    b) the dependent variable (1)
    water consumption in Mm^3 (millions of cubic metres) ✓

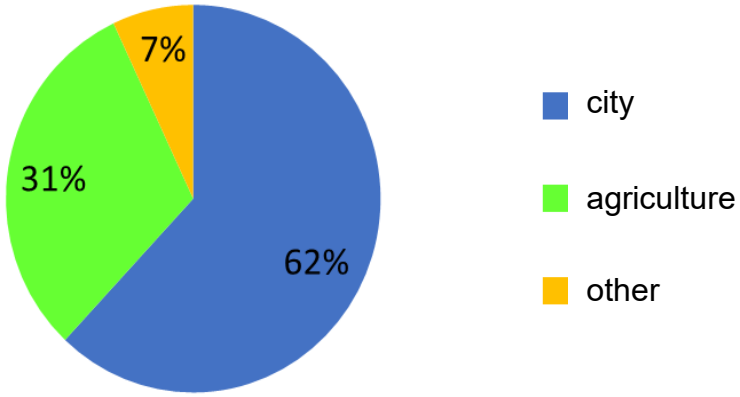
2. Can this data be used to accurately predict the water consumption for the year 2019? Give a reason for your answer. (2)

    No ✓. Consumption depends on water usage restrictions each year and these depend on the amount of rain that falls. ✓

3. Draw a pie chart (with labels) to show the data in the table expressed in percentages. Show workings in table format, round to whole numbers. (6)

Consumers	Water in Mm^3	Working out percentages	Proportion (degrees)
City	360	360/580 × 100 = 62	62/100 × 360 = 223
Agriculture	180	180/580 × 100 = 31	31/100 × 360 = 112
Other	40	40/580 × 100 = 7	7/100 × 360 = 25
Total	580	= 100	= 360

Western Cape: Percentage water consumption in 2018



Marking guideline:

Correct type of diagram	✓
Correct percentages	✓✓✓
Workings (percentages, degrees)	✓✓

4. Can one predict future water consumption for the Western Cape? Give a reason for your answer. (2)

No ✓. Population growth is increasing and climate change is unpredictable ✓

5. Research waterless composting toilets and determine whether they should be installed as an alternative to septic tanks, pit latrines or bucket toilets. (4)

Here is a video link to a one type of waterless composting toilet.

https://www.youtube.com/watch?v=4LrUc0C7vW0

A sample answer might be:
Yes, they should be installed if possible and economically feasible ✓.
Waterless composting toilets will save water ✓,
prevent ground water pollution ✓
and create safe bio-fertilisers from waste which can be used to grow plants ✓

(16)

Food security

Food security “exists when all people, at all times, have physical and economic access to sufficient, safe, nutritious food that meets their dietary needs and food preferences for an active, healthy life.”

By contrast, for **food insecurity** exists where there is evidence of malnutrition and starvation.

The following factors influence food security (positively or negatively):

- human exponential population growth
- drought and floods (particularly because of climate change)
- alien plants and the reduction of agricultural land
- the loss of wild varieties of plants
- food wastage
- genetically engineered foods
- poor farming practices such as:
    - monoculture
    - overgrazing and the loss of topsoil
    - the use of fertilisers
    - the use of pesticides

Some You Tube videos dealing with food security:

Monoculture vs biodiversity: https://www.youtube.com/watch?v=6w-uqFokEh0

Food waste: How much food do supermarkets throw away?
https://www.youtube.com/watch?v=QLqkVBcP4xs
Waste to Food, 2014 SEED South Africa Winner:
https://www.youtube.com/watch?v=1eCcHdmh7bM

One third of the food produced in SA goes to waste (World Wildlife Fund):
https://www.youtube.com/watch?v=to_AEBQtVnk

Activity 3: Food security

Read the following and then answer the questions below.

The multinational companies controlling agricultural economics:

- impoverish farmers who are forced to buy seed, pesticides, fertilisers and even farming equipment from them at high costs.
- do not allow independent research, in order to protect their profits.
- control most GMO seed rights with patents. Farmers who traditionally saved their seed for replanting or exchanging with other farmers are no longer allowed to do so. The control and ownership of seeds - in the case of GM maize, GM soya and GM cotton in South Africa - passes entirely to multinational corporations that hold the patents, such as Monsanto (German and American) and Syngenta (American and Chinese). This undermines farmers' rights, and places control outside the country.
- the costs of genetic modification increase food prices which negatively impacts food security.
- Most South Africans are unaware that some of their staple foods are genetically modified.

Redacted from: March Against Syngenta: Monsanto's Swiss Twin Unmasked by MultiWatch, Schwabe AG, 2016

Figure 52: European famers and public protest against Monsanto and Syngenta controlling food seeds

1. Describe what is meant by the following terms: (4)

   a) Genetically modified organism (GMO)

      GMO: an organism that has its DNA altered ✓ for a specific purpose ✓

   b) food security

      when people have enough food ✓ to live a good, healthy life ✓

2. Name three genetically modified crops grown in South Africa. (3)

   GM maize □, GM soya ✓ and GM cotton ✓

3. Discuss three ways in which genetically modified seed companies negatively impact on impoverished farmers. (3)

   Farmers are forced to buy seeds, pesticides and fertilisers at high cost.✓
   Ownership and rights to the GMO seeds belongs to the companies and not to the farmers.✓
   Farmers using GMO seeds cannot do independent research to improve their crops.✓

   Profits go out of the country to enrich other wealthy countries ✓ (any three)

4. The extract above describes only the negative impacts of genetically modified crops. Describe how food security is positively affected by genetic modification of crops. (3)

   Benefits of GMO: higher yields ✓, pest and disease resistant ✓, can be grown in places where conditions where previously unsuitable ✓, they provide extra nutrients ✓ .. (any three)

5. How do GM seeds affect the gene pool and biodiversity? (2)

   GM could reduce the gene pool with the loss of variety ✓
   This will negatively affect or reduce biodiversity ✓

(15)

Loss of biodiversity

Biodiversity refers to the variety of all living organisms on Earth. Loss of biodiversity is the most damaging impact humans have on the environment.

Help learners understand the concept of biodiversity and define it for themselves. Then discuss the importance of maintaining biodiversity.

Biodiversity is important because it maintains the provision of …

- good quality fresh water and air quality
- climate stabilisation
- healthy quality soil formation
- pollination and natural seed dispersal
- natural fuel and food from the environment
- natural pest control with predators
- healthcare from medicinal plants and microbes
- ecotourism and recreation in nature

The following factors contribute to reducing biodiversity:

- Habitat destruction through:
    - farming methods
    - golf estates
    - mining
    - urbanization
    - deforestation
    - loss of wetlands and grasslands
- Poaching (e.g. rhino horn, ivory, 'bush meat')
- Alien plant invasions

The following You Tube videos may be used by way of enrichment:

Mass extinctions, climate change and habitat destruction:
https://www.youtube.com/watch?v=z9gHuAwxwAs

South African alien invasive plants and biodiversity (excellent videos): https://www.youtube.com/watch?v=CiYJRNRcBWB

Rhinos and biodiversity: https://www.youtube.com/watch?v=yDGAswalOVw

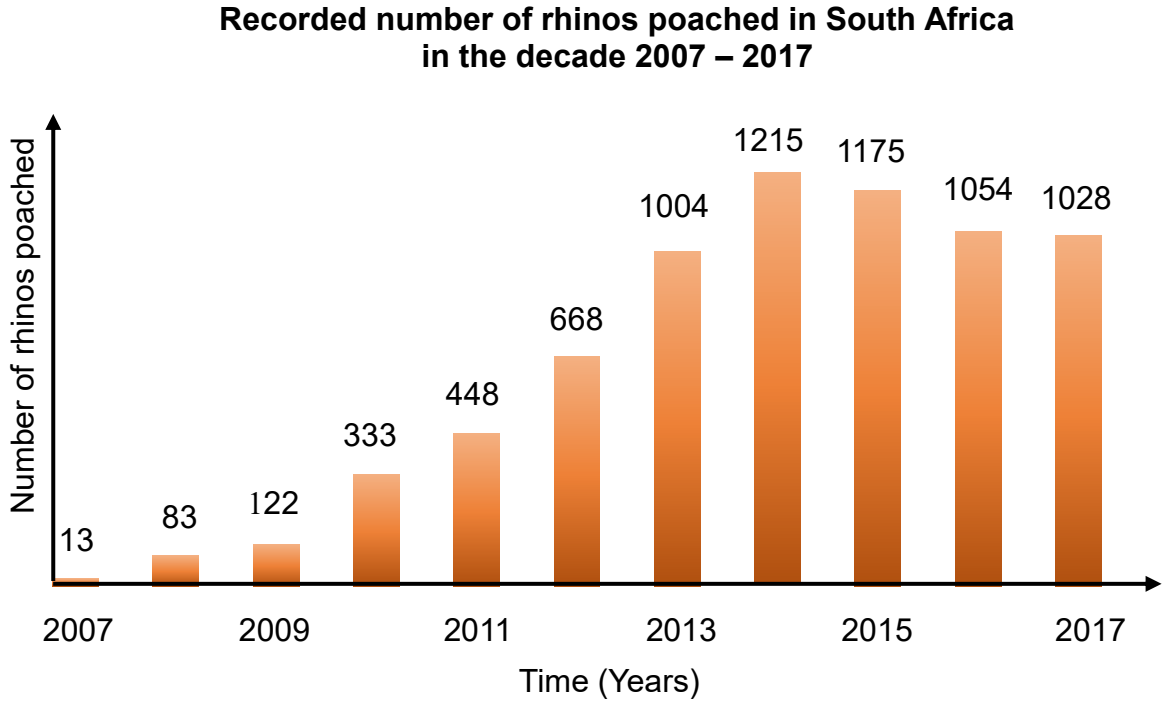
Rooibos and biodiversity: https://www.youtube.com/watch?v=jQMdEOuBtqA

Traditional knowledge: https://www.youtube.com/watch?v=GHsJF-n-rnA

Fynbos, fire and birds: https://www.youtube.com/watch?v=6OcJfH2aQGI

Activity 4: Biodiversity

In the early 1800s there were more than a million wild rhinos worldwide. In 2018 there were less than 20 000 rhinos in the wild.



1. a) How many rhinos have been lost worldwide over the years from the early 1800s until 2018? Show your calculations. (2)

   1 000 000 – 20 000 ✓ = 980 000 ✓

   b) Calculate the average number of rhinos lost per year over the 10-year period from 2007 to 2016. Show your calculations. (3)

   13 + 83 + 122 + 333 + 448 + 668 + 1004 + 1215 +1175 + 1054 = 6115 ✓

   6115 / 10 ✓ = 611,5 rhinos per year ✓

c) If rhinos continue to be killed at the same rate as calculated in 1.b), how long will it be (in years more or less) before they are extinct. Show your calculations. (3)

20 000 / 611,5 ✓✓ = 37,7 years (or 38 years)

2. Explain why it is important to protect rhinos from extinction. (2)

Rhinos form part of the food chain ✓ and the natural biodiversity on Earth ✓

3. Give two suggestions of what can be done to prevent rhino poaching? (2)

Education, dehorning rhino, dyeing or poisoning horn, armed anti-poaching task teams can patrol game reserves, stricter laws with jail sentence penalties instead of fines … ✓ for any two

(12)

Solid waste disposal

Focus on the need to reduce solid waste and ways to manage solid waste.

Discuss the following aspects of solid-waste disposal:

- Ways in which dumpsites can be managed for rehabilitation and prevention of soil and water pollution.
- The use of methane from dumpsites for domestic use, such as heating and lighting
- The need for recycling
- The need for safe disposal of nuclear waste.

You Tube videos for enrichment:

South Africa's landfills pose health risks to thousands:
https://www.youtube.com/watch?v=lXpt-mlcono

Discussion of SA landfills reaching almost full:
https://www.youtube.com/watch?v=4FNluqedsZI

Future of Waste Management in South Africa:
https://www.youtube.com/watch?v=cvy_QsLdEyU

How waste recycling helps our planet - Zero to Landfill:
https://www.youtube.com/watch?v=e2FfssgMk4g

Virtual tour of a recycling facility: https://www.youtube.com/watch?v=Nv7s68OtlhM

Activity 5: Solid waste disposal

1. Name any three problems that can occur when dumpsites are not managed properly. (3)

   decomposing or burning waste adds to air pollution ✓

   methane can explode or burn causing dangerous fires and adding to air pollution ✓

   odour and dust pollution lowers the value of neighbouring properties ✓

   surface or ground water bodies are contaminated by toxic chemicals ✓

   soil pollution makes the land unusable for agriculture or building ✓

   pests, such as rats, mice and flies spread diseases ✓ (any three)

2. In well managed landfills what prevents toxic leachate from polluting ground water? (1)

   Properly managed landfills are lined to isolate the dumped waste from ground water supplies so that toxic leachate does not cause contamination ✓

3. Name three things you can do to reduce your solid waste? (3)

   Any of the Rs: refuse, reduce, reuse, recover, recycle, repair ✓ - any three

4. How can solid waste landfills be used to provide energy? (6)

   Methane gas can be collected from landfills ✓.

   In the waste-to-energy process anaerobic bacteria decompose waste and produce methane which stays trapped in the fill ✓.

   Wells are then sunk into the landfill to tap off the methane in pipes ✓.

   This is then extracted and burned to generate electricity ✓.

   Burning methane does not emit toxins so it is green energy ✓.

   The electricity generated can be fed into local power stations ✓.

(13)

Summary

Atmosphere and climate change

The following topics are dealt with:

- The composition of the atmosphere, including greenhouse gases (GHGs) and how human activities are enhancing the Greenhouse Effect.
- Sources and sinks of carbon dioxide (CO_2) as a greenhouse gas, and how humans have increased CO_2 emissions by using fossil fuels as energy sources; ways of reducing carbon dioxide emissions.
- Methane emissions (CH_4) coming from mostly organic, anaerobic decomposition; how these emissions are increasing at an alarming rate, as well as natural ways of controlling CH_4.
- Nitrous oxide (NO_2) as another source of greenhouse gases; how we can reduce the impact of NO_2 as well as other synthetic greenhouse gases by changing farming practices and transport methods to cleaner options.
- Ozone as a layer of gas in the atmosphere which protects from harmful UV radiation; the depletion of the ozone layer by reactive chemicals and its restoration by international agreements to stop the use of harmful pollutants.
- Causes and effects of deforestation globally and in South Africa; how forests are the biggest carbon sinks on land, soaking up excess CO_2 and helping manage other greenhouse gases.
- The consequences of climate change due to global warming and deforestation leading to global desertification.
- The responses to climate change being a global and well as local issue; the proposals to limit and control further climate change by the United Nations with all countries commitment to the international Kyoto Protocol.

Water availability

The following is dealt with:

- The amount of natural fresh water on Earth in surface and groundwater supplies decreasing as the population increases.
- Natural factors limiting water availability and water use in South Africa, and how our surface and groundwater supplies are being affected by climate change, with increasing droughts and floods.
- Human impacts on water availability in South Africa with the construction of dams, destruction of natural wetlands, poor farming and irrigation practices.

- Mines and boreholes depleting aquifers, as well as exotic plantations and invasive alien plants (IAPs) affecting large volumes of water.

Water quality

The following topics are dealt with:

- The concept of water quality.
- Factors reducing water quality: human activities, like industry, mining and agriculture, as well as poor settlement infrastructures, affecting surface waterbodies causing eutrophication and waterborne diseases.
- Municipal landfills, mining, and lack of sanitation in informal settlements reducing the ground water quality of our aquifers.
- Aquatic alien invasive plants (AIPs) degrading surface water quality and being costly and difficult to eradicate.
- Water purification and recycling, and the future of water quality in South Africa

Food security

The following topics are dealt with:

- Food security means having access to healthy food that is produced.
- Although food production has increased, exponential human population growth has resulted in a decrease in food availability per person, particularly in the developing countries.
- Threats to food security - poor farming practices in developing countries, and monoculture practices in developed countries, poor or toxic pest control methods and a need for fertilisers, overgrazing and the loss of topsoil.
- Alien invasive plants(AIPs) cause a loss of available agricultural land in South Africa, as they outcompete with indigenous species.
- Domestic crops and livestock have weakened due to selective breeding and will need to be bred with wild varieties to improve genetic diversity; however, many wild species are threatened or extinct because of habitat loss.
- Genetically engineered food may help to improve food security, through modifying livestock and crop farming now, and in the future, but the positive and negative effects are still being assessed.
- Food wastage is much greater in developed than in developing countries; solutions are possible to reduce waste and ensure greater food security across the world.

Loss of biodiversity

The following topics are dealt with:

- Biodiversity is all about maintaining the natural balance in Earth's ecosystems, and the loss of biodiversity is the most damaging impact humans have had on the environment.
- Habitat destruction has impacted negatively on biodiversity through monoculture crop farming, livestock farming, mining and increasing urbanisation, e.g. the development of golf estates.
- Habitat destruction as a result of deforestation and the loss of wetland and grassland habitats are an ongoing threat to biodiversity
- Biodiversity loss is continuing through the overexploitation of natural resources: e.g. rhino, elephant and abalone poaching, as well as the bushmeat hunting crisis in Africa
- The alien plant invasion, and the loss of useful indigenous plants, also affects biodiversity negatively. Traditional knowledge systems identified useful indigenous plants such as Rooibos, Devil's claw, African potato and *Hoodia gordonii*, which are all being overexploited and therefore impacting on the biodiversity of their habitats.

Solid waste disposal

These topics are dealt with:

- Solid waste refers to general household and industrial waste as well as hazardous chemical waste.
- Landfills are large excavated dump-sites where solid waste gets trucked to be buried. More than 90% of our solid waste in South Africa goes to landfill sites.
- Positive management of landfill sites can happen by constant monitoring of soil air and water quality surrounding landfills
- Waste from landfills can also be used to generate energy, especially methane, as a supplement to our power stations. This Waste-to-Energy process will address the greenhouse gas problem as well as the current crisis of fossil fuel supplies running short.
- Hazardous waste is still a problem in South Africa as it is being sent to landfills together with general waste instead of being disposed of separately, with anti-contamination safety measures.
- Nuclear waste is extremely hazardous as it can emit dangerous radioactivity for millions of years and causes serious and deadly health issues.

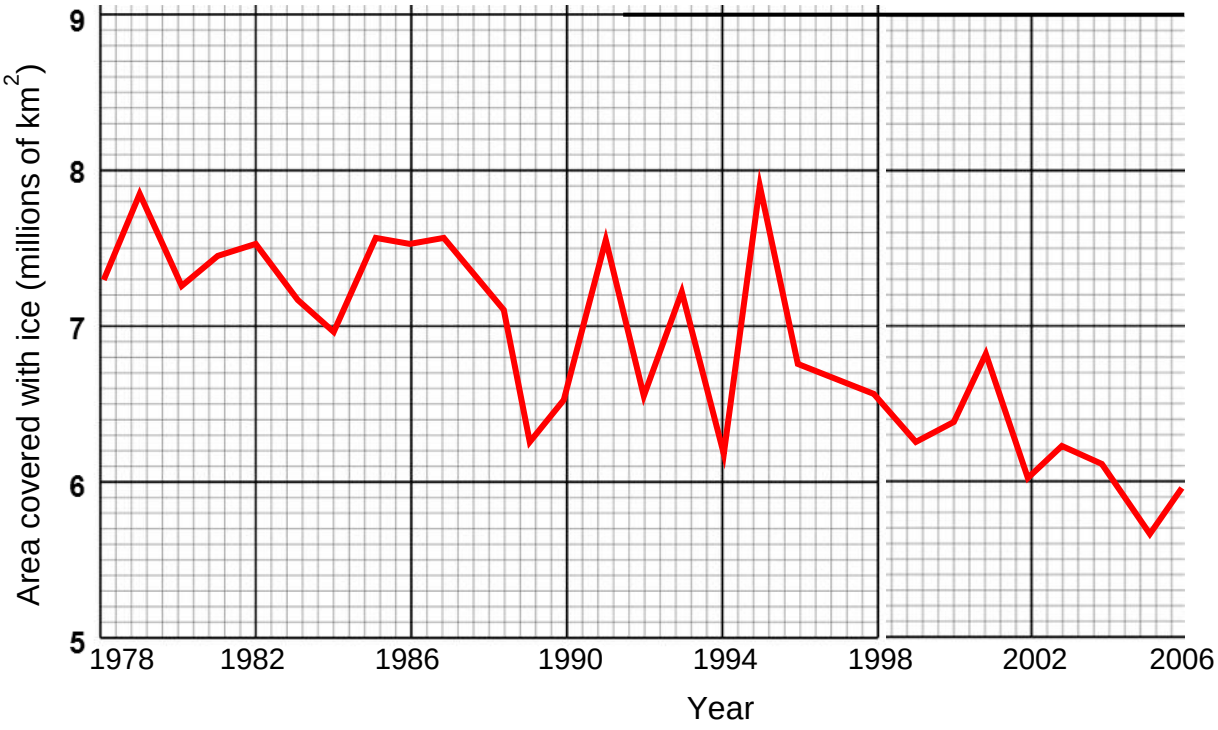
End of topic exercises

Section A
Question 1

1.1 Various possible answers are provided to the following questions. Choose the correct answer and write only the letter next to the question number.

1.1.1 Rising temperatures on Earth have led to the melting of ice in glaciers. The graph shows the measured changes in the size of an area covered with ice in the Arctic region between 1978 and 2006.

Size of Arctic area covered with ice between 1978 and 2006



What is the difference between the size of the area covered with ice in 1978 and the size of the area covered with ice in 1998?

A 1,3
B 7,2
C **0,7 ✓✓**
D 5,9

1.1.2 Which of the following is a source of CO_2?

A Process of photosynthesis
B Refrigeration
C **Process of respiration ✓✓**
D Aerosol

1.1.3 Which of the following represents one advantage and one disadvantage of genetic engineering in developing desirable products?

	Advantage	Disadvantage
A ✓✓	**Increased rate of production**	**Cost of development is high**
B	Cost of development is high	Possible release of GMO into the environment
C	Increased range of products	Increased rate of production
D	Increased rate of production	Increased range of products

1.1.4 The sector that uses the most water in South Africa is?

A **Agriculture and forestry ✓✓**
B Mining
C Domestic
D Industry

1.1.5 Nuclear waste is...

A disposed of in desert dumpsites
B **radioactive and hazardous ✓✓**
C used to generate methane gas
D destroyed by salt water

(5 × 2) = (10)

1.2 Give the correct **term** for each of the following descriptions.

1.2.1 The average weather conditions of a large area over a long period of time climate ✓

1.2.2 The overall increase in temperature worldwide due to the Enhanced Greenhouse effect? global warming ✓

1.2.3 An ecological body or natural system which absorbs carbon dioxide from the atmosphere. carbon sink ✓

1.2.4 Treaty signed at the first International conference to formulate strategies to manage risk and effects of climate change.
Kyoto protocol ✓

1.2.5 Chemically corrosive and contaminated waste water from mining.
AMD (Acid mine drainage)

1.2.6 Pollution that is the result of warm or very hot water waste pumped into water bodies. thermal pollution ✓

1.2.7 Algal bloom due to increase of nitrates and phosphates in water bodies. eutrophication ✓

1.2.8 Waste water and excrement. sewage ✓

1.2.9 The variety of all living organisms on Earth. biodiversity ✓

(9 × 1) = (9)

1.3 Indicate whether each of the statements in Column I applies to **A ONLY**, **B ONLY, BOTH A AND B or NONE** of the items in Column II. Write **A only**, **B only**, **both A and B,** or **none** next to the question number (1.3.1 to 1.3.6).

Column I	Column II
1.3.1 Methane	A: Decomposition in landfill sites B: Global warming potential higher than CO_2
1.3.2 Ozone depletion	A: Loss of ozone from the troposphere B: Loss of ozone from car engines
1.3.3 Climate change in SA	A: Desertification B: More frequent and severe veldfires

(3 × 2) = (6)

1.3.1 **A only** ✓✓

1.3.2 **A only** ✓✓

1.3.3 **Both A and B** ✓✓

1.4 Study the image of maize cobs and answer the questions that follow:

1.4.1 What does GMO stand for? (2)

Genetically ✓ modified organism ✓

1.4.2 Describe the process of genetic engineering. (3)

Genetic engineering starts with the identification and isolation of the desire genes. ✓

These genes are transferred to the cells of the organism to be modified ✓

This leads to the cloning of organisms with desired traits. ✓

1.4.3 Give two possible advantages of GMO maize. (2)

More nutritious ✓, better yield ✓, more resistant to disease and pests ✓ (any two)

1.4.4 Name three possible disadvantages of genetic engineering. (3)

Loss of biodiversity ✓, genetic pollution ✓, allergic reactions ✓

(10)

1.5 1.5.1 Define the term ‘ozone’. (1)

Ozone is a gas consisting of three oxygen molecules (O_3) ✓

1.5.2 Where is the ozone layer found? (1)

It is found in the earth’s higher atmosphere / stratosphere ✓

1.5.3 Distinguish between good ozone and harmful ozone. (1)

Ozone at ground level is considered a harmful pollutant. Ozone in the higher atmosphere is useful. ✓

1.5.4 How is good ozone useful? (1)

Good ozone traps UV radiation ✓

1.5.5 What is ozone depletion and how does it occur? (3)

Ozone depletion is the thinning or disappearance of ozone in the stratosphere ✓. It occurs because ozone reacts with various chemicals ✓ and pollutants such as CFC’s, bromine and carbon tetrachloride ✓.

1.5.6 Distinguish between the terms **climate** and **climate change**. (2)

The climate can be described as the average weather over a period of time ✓. Climate change refers to the change in climate patterns as a result of human activities. ✓

1.5.7 What is meant by the term ‘global warming’? (1)

Global warming is the long-term rise in the average temperature of the Earth. ✓

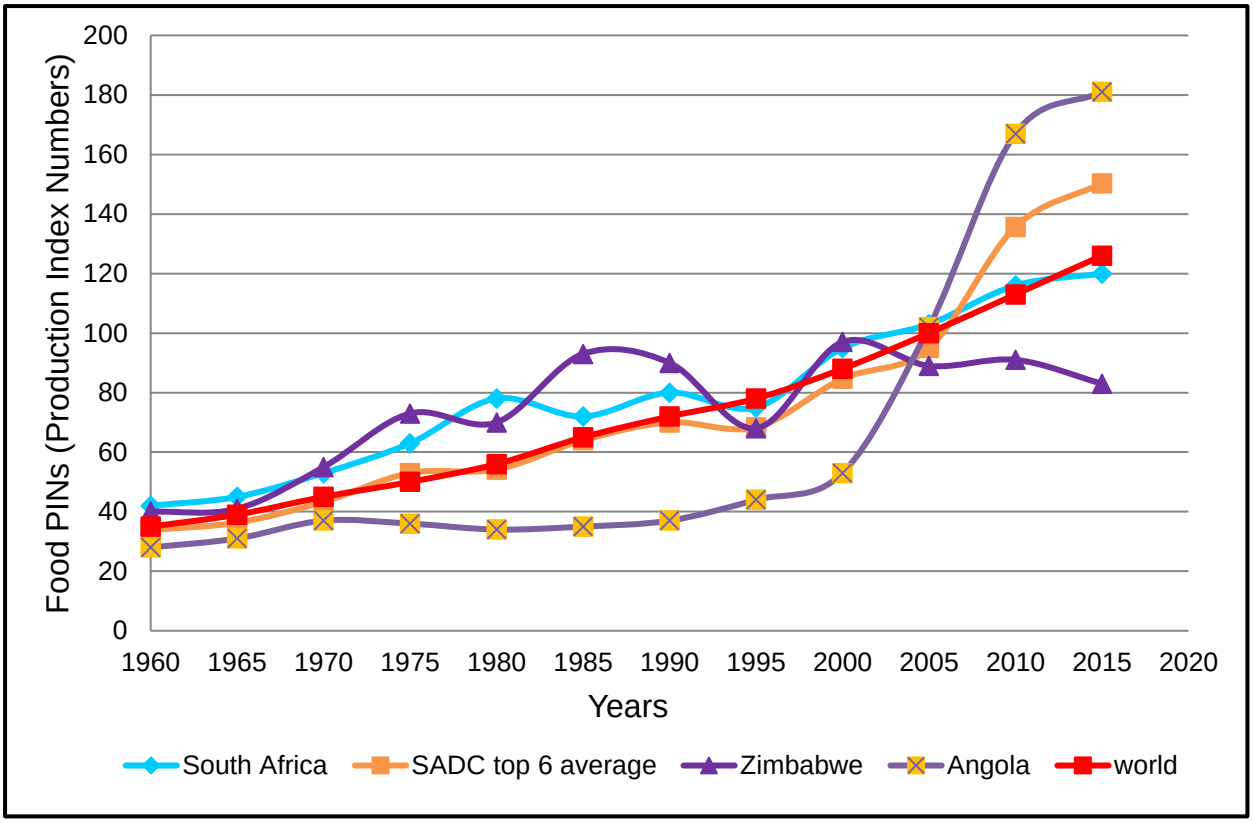
(10)

Section A: [45]

Section B

Question 2

2.1 The graph on the next page is a graph of food production averages from 1960 to 2015, in South Africa, some SADC countries and in the world as a whole. Study the graph and answer the questions that follow.



(Adapted from Food and Agriculture Data from the FAO of the UN: http://www.fao.org/faostat/)

2.1.1 Identify the following for this graph (2)

a) The independent variable Years ✓

b) The dependent variable

Food production index numbers ✓

2.1.2 Which country had the lowest food production in 1985? (1)

Angola

2.1.3 Which country had the highest food production in 2015? (1)

Angola

2.1.4 Give a possible reason for this change. (1)

Improved farming techniques, end of civil war, people working together for a common goal, political liberation ✓ - any one

2.1.5 Discuss exponential human population growth as one of the main factors causing food insecurity and compare the human growth rate with the graph above showing food production growth rate. (5)

The human population growth rate has increased exponentially ✓ over the last two centuries due to improving agriculture, healthcare, hygiene and advancements in power generation. ✓

Overpopulation will eventually exceed the carrying capacity and the

earth may not be able to provide us with enough resources to sustain life. ✓

By 2030 the expected human population is 9 billion! ✓

Food growth rate is linear compared to the exponential growth rate of the human population. ✓

(10)

2.2 2.2.1 Explain why current human activities are causing extreme crises in our natural environments? (5)

The rapidly increasing needs of the human population are becoming greater than the natural resources available to us. ✓

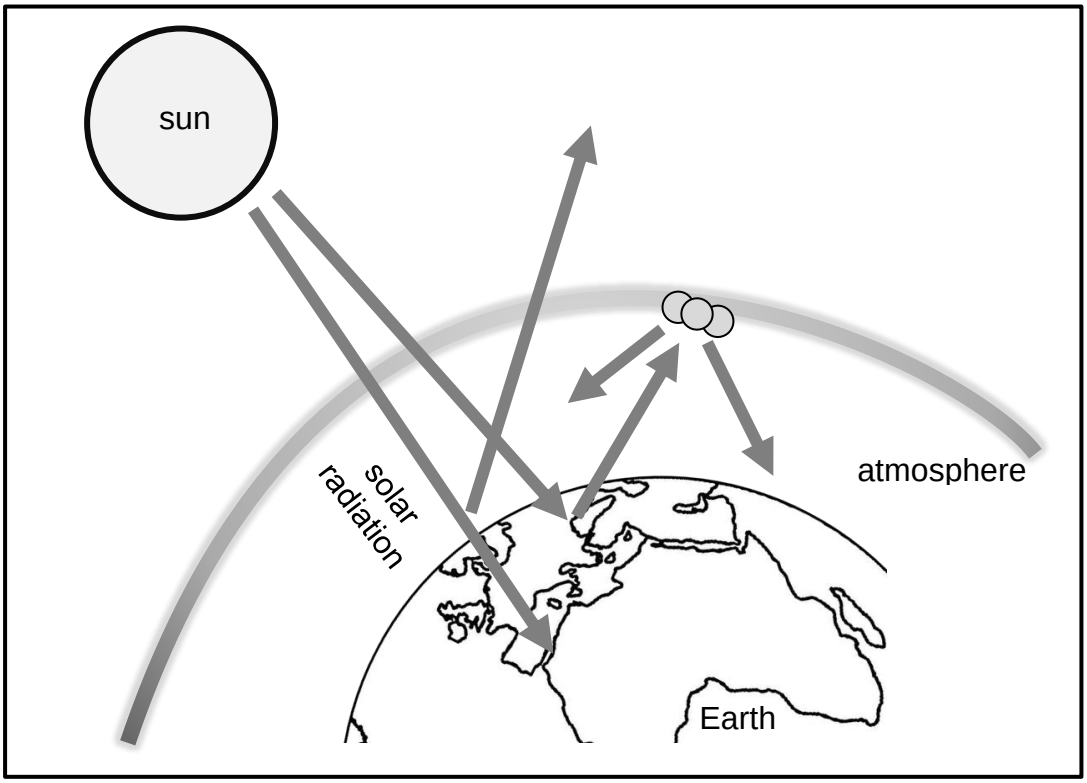
The earth cannot adapt fast enough to environment changes and demands caused by human activities and so thousands of organisms are going extinct. ✓

Humans produce more waste than our ecosystems can cope with. ✓

Human activities are causing global warming and the quality of all life on earth is negatively affected. ✓

Environmental equilibrium is disturbed, climate change is causing an increase in extreme weather conditions, e.g. storm, droughts and floods. ✓

2.2.2 Use the figure below and explain why Earth's average temperatures are rising because of the rampant enhanced greenhouse effect. (5)



Human activities have increased emissions of greenhouse gases, ✓ disturbing the stable ratio of nature greenhouse gases. ✓

As radiation from the sun is reflected back by the Earth, some is trapped in the atmosphere by the greenhouse gases. ✓ This warms the atmosphere and is reflected back to the earth's surface. ✓

Because less heat escapes into space, there is a rise in average temperatures across the earth – this is global warming. ✓

(10)
[20]

Question 3

3.1 Read the passage below about food wastage around the world.

> Every year a third of all food for human consumption, about 1,3 billion tons, is wasted in the world. The UN Food and Agriculture Organisation (FAO) estimated that the carbon footprint of wasted food was equivalent to 3,3 billion tons of carbon dioxide a year. The FAO suggests that more efficient use of food could contribute to global efforts to cut greenhouse gases to limit global warming. In the industrialised world, much of the waste comes from consumers buying too much and throwing away what they do not eat. In developing countries, it is mainly the result of inefficient farming and a lack of proper storage facilities.
>
> *(adapted from Reuters Daily News, September 2013)*

3.1.1 What is meant by the following terms carbon footprint and food security? (4)

Carbon footprint is a measure of the total amount of greenhouse gas emissions ✓ of an individual / population/ company per year ✓

Food security refers to the availability and access ✓ to adequate, safe and nutritious food to people at all times ✓

3.1.2 Explain how wastage of food contributes to loss of energy and global warming. (4)

Energy used to produce and transport wasted food is lost ✓

Fossil fuels used to produce and transport that food leads to increasing greenhouse gases ✓

Decomposition of wasted food releases greenhouse gases ✓

These factors contribute to the enhanced greenhouse effect which eventually leads to global warming ✓

3.1.3 Use the information in the passage to suggest two ways in which food wastage could be reduced. (2)

Buy only what is needed in sufficient quantities ✓

Give to others what is not used instead of throwing away ✓

Educate about efficient farming methods ✓

Educate about ways to preserve food ✓

Improve storage facilities ✓

Improve the shelf-life of food ✓ (any two)

(10)

3.2 Many parts of South Africa are facing a water crisis.

3.2.1 Write a brief summary of the water crisis facing South Africa? (4)

Rainfall very restricted and unpredictable in certain areas in our country. ✓

Global Warming and climate change have increased desertification as the arid or semi-arid areas grow larger ✓

There are not enough perennial rivers to fill dams ✓

Dams are often situated far from cities in areas that are becoming more arid. ✓

Too much pollution from mining' industries and agriculture is putting strain on our already limited water resources ✓

There is massive water wastage and poor service delivery of water ✓

Population growth demands will exceed water resources and may not be sustainable in the near future (beyond 2030). ✓ (any 4)

3.2.2 How do poor farming practices affect water availability? (4)

Monocultures ✓

Open ditch or overhead irrigation ✓

Over fertilisation ✓

Slash and burn clearing ✓

Overgrazing ✓

Incorrect ploughing ✓

(any of the above which lead to erosion or evaporation) (any 4)

3.2.1 Which two overall factors influence water quality on Earth? (2)

Natural factors ✓

Human activities ✓

(10)

3.3 Read the extract 'Hunting Wildlife for Food' given below:

> An organisation, Trade Records Analysis of Fauna and Flora in Commerce (TRAFFIC), did an investigation to find out about the extent of the illegal killing of wildlife for use as bushmeat (meat from wildlife) and the influence of this on the environment.
>
> The organisation reported that the illegal killing of wildlife, both for trade and consumption, had been on the increase in many African countries during the past two years. It also reported that some species, such as impala, were preferred to other species of wildlife.
>
> One of the organisation's recommendations was that the hunting of wildlife should be legalised. This would enable governments in these countries to control the number of animals being hunted and also to restrict the age of animals that may be hunted. It also recommended that only those animals that were very old and weak in a population should be hunted.
>
> (adapted from an article "Wildlife Under Siege', Endangered Wildlife, 2000)

3.3.1 What is the illegal hunting and killing of animals called? (1)

Poaching ✓

3.3.2 State one way in which humans destroy wildlife habitats. (1)

Deforestation, mining, urbanisation, golf estates, agriculture, veldfires, pollution, invasive alien species ✓ any one

3.3.3 Give two reasons for the increase in the illegal killing of wildlife. (2)

Increasing human population with increasing demand ✓
Increasing unemployment / poverty ✓
Lack of awareness and education about the value of wildlife ✓
Increased prices of bushmeat ✓
Poor protection of wildlife ✓ any two

3.3.4 Explain how the increase in the killing of wildlife will influence the environment. (3)

Disturbs the ecosystems ✓
Food chains are affected ✓
Dependent plants and animals are negatively affected ✓
Leads to the extinction of some species in the ecosystem ✓
Leads to an eventual decrease in biodiversity ✓ any 3

3.3.5 Discuss why TRAFFIC recommended that only very old and weak animals in a population should be killed if hunting is legalised. (3)

Very old animals have passed the reproductive stage of their lives and are at the end of their lifespan ✓

Old animals may not significantly influence the size of the population ✓

Old or weak animals are often rejected by their herds ✓

Weak animals have a short lifespan and will not contribute good genes to their population ✓

Killing old and weak animals will prevent the population of exceeding the carrying capacity ✓

Genes causing weakness will be removed from the gene pool ✓

any 3

(10)
[30]

Section B: [50]

Total marks: [95]

Cognitive levels distribution

Question	Level 1	Level 2	Level 3	Level 4	Marks
1.1.1			✓		2
1.1.2	✓				2
1.1.3	✓				2
1.1.4	✓				2
1.1.5	✓				2
	8		2		10
1.2.1	✓				1
1.2.2	✓				1
1.2.3	✓				1
1.2.4	✓				1
1.2.5	✓				1
1.2.6	✓				1
1.2.7	✓				1
1.2.8	✓				1
1.2.9	✓				1
	9				9
1.3.1		✓			2
1.3.2		✓			2
1.3.3		✓			2
		6			6
1.4.1	✓				2
1.4.2		✓			3
1.4.3	✓				2
1.4.4			✓		3
	4	3	3		10
1.5.1	✓				1
1.5.2	✓				1
1.5.3	✓				1
1.5.4	✓				1
1.5.5		✓			3
1.5.6		✓			2
1.5.7	✓				1
	5	5			10
2.1.1		✓			2

2.1.2		✓			1
2.1.3		✓			1
2.1.4			✓		1
2.1.5			✓	✓	5 (3+2)
		4	4	2	10
2.2.1			✓		5
2.2.2			✓		5
			10		10
3.1.1	✓				4
3.1.2				✓	4
3.1.3		✓			2
	4	2		4	10
3.2.1	✓				4
3.2.2	✓				4
3.2.3			✓		2
	8		2		10
3.2.1	✓				1
3.2.2	✓				1
3.2.3		✓			2
3.2.4				✓	3
3.2.5				✓	3
	2	2		6	10
	40	22	21	12	95