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Mind the Gap!

Life Sciences
STUDY GUIDE

GRADE 12

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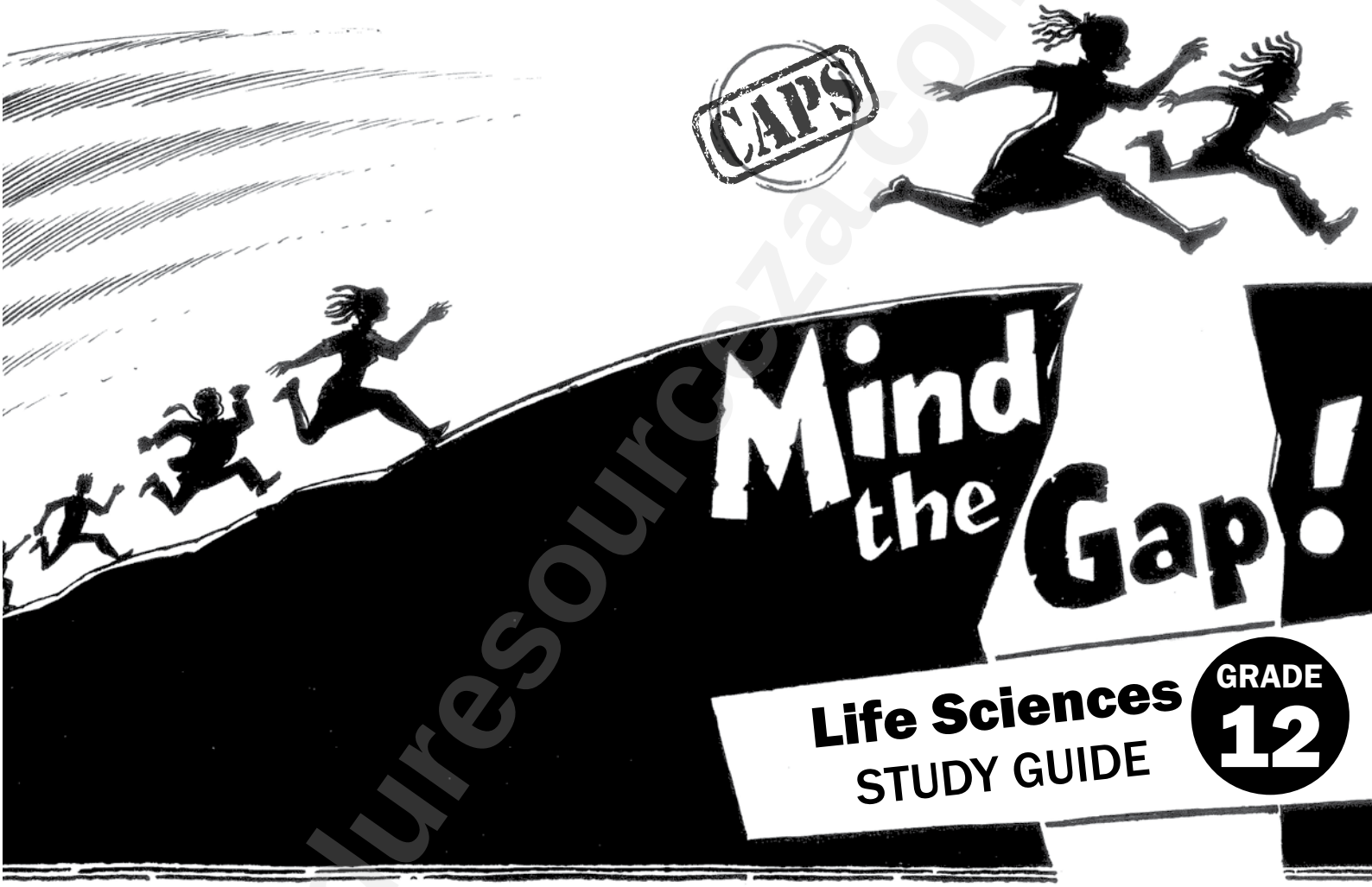

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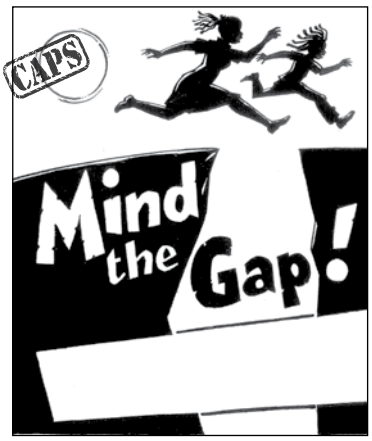

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Curriculum and Assessment Policy Statement (CAPS) Mind the Gap Grade 12 Study Guide Life Sciences
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Ministerial foreword

Matsie Angelina Motshekga, MP
Minister of Basic Education

The Department of Basic Education has pleasure in releasing the second edition of *Mind the Gap* study guides for Grade 12 learners. These study guides continue the innovative and committed attempt by the Department of Basic Education to improve the academic performance of Grade 12 candidates in the National Senior Certificate (NSC) examination.

The study guides have been written by subject expert teams comprised of teachers, examiners, moderators, subject advisors and subject co-ordinators. Research started in 2012 shows that the Mind the Gap series has, without doubt, had a positive impact in improving grades. It is my fervent wish that the *Mind the Gap* study guides take us all closer towards ensuring that no learner is left behind, especially as we move forward in our celebration of 20 years of democracy.

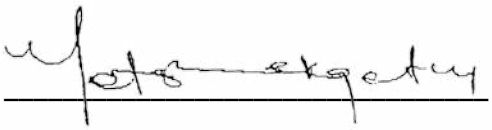
The second edition of *Mind the Gap* is aligned to the 2014 Curriculum and Assessment Policy Statement (CAPS). This means that the writers have considered the National Policy pertaining to the programme, promotion requirements and protocol for assessment of the National Curriculum Statement for Grade 12 in 2014.

The *Mind the Gap CAPS* study guides take their brief in part from the 2013 National Diagnostic report on learner performance and draws on the 2014 Grade 12 Examination Guidelines. Each of the *Mind the Gap* study guides provides explanations of key terminology, simple explanations and examples of the types of questions that learners can expect to be asked in an exam. Marking memoranda are included to assist learners in building their understanding. Learners are also referred to specific questions in past national exam papers and examination memos that are available on the Department's website – www.education.gov.za.

The CAPS edition include Accounting, Economics, Geography, Life Sciences, Mathematics, Mathematical Literacy and Physical Sciences. The series is produced in both English and Afrikaans. There are also nine English First Additional Language study guides. They include EFAL Paper 1 (Language); EFAL Paper 3 (Writing); and a study guide for each of the Grade 12 prescribed literature set works.

The study guides have been designed to assist those learners who have been underperforming due to a lack of exposure to the content requirements of the curriculum and aims to mind-the-gap between failing and passing, by bridging the gap in learners' understanding of commonly tested concepts so candidates can pass.

All that is now required is for our Grade 12 learners to put in the hours preparing for the examinations. Learners make us proud – study hard. We wish each and every one of you good luck for your Grade 12 examinations.



Matsie Angelina Motshekga, MP
Minister of Basic Education
May 2014

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Dear Grade 12 learner

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

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

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

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

Overview of the exam for CAPS Life Sciences Grade 12

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

PAPER 1	WEIGHTING	
Topic	%	MARKS
Term 1		
Meiosis	7	11
Reproduction in Vertebrates	4	6
Human Reproduction	21	31
Term 2		
Responding to the Environment (Humans)	27	40
Term 3		
Human Endocrine System	10	15
Homeostasis in Humans	7	11
Responding to the Environment (Plants)	7	11
Term 4		
Human Impact (Grade 11)	17	25
	100	**150**

PAPER 2	WEIGHTING	
Topic	%	MARKS
Term 1		
DNA: Code of Life	19	27
Meiosis	7	12
Term 2		
Genetics and Inheritance	30	45
Terms 3/4		
Evolution	44	66
	100	**150**

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

Section	Type of question	Marks
A	Short answer, objective questions such as multiple-choice questions, terminology, columns/statement and items	50
B	A variety of question types. There will be two questions of 40 marks each. Both of these questions will be divided into two to four subsections.	2 × 40
C	Essay	20

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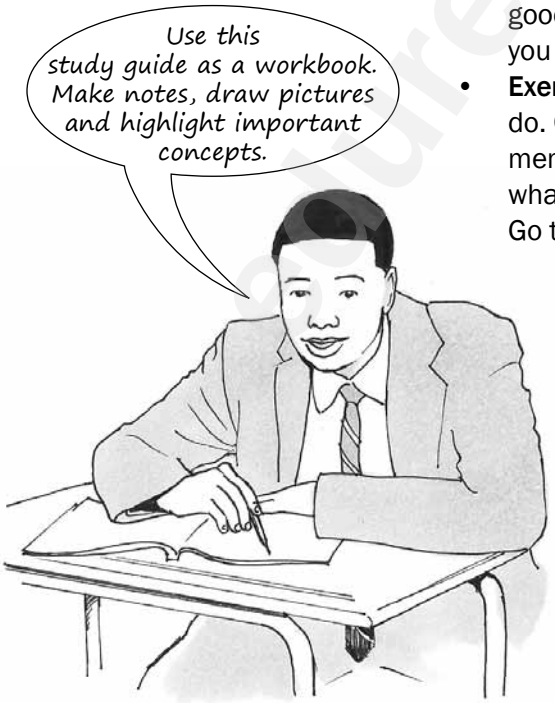
How to use this study guide

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

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

NB	Pay special attention	hint	Hints to help you remember a concept or guide you in solving problems	e.g.	Worked examples
	Step-by-step instructions	exams	Refers you to exam questions		Activities with questions for you to answer

- A **checklist from the exam guidelines** for Life Sciences has been provided on page xvii for you to keep track of your progress. Once you have mastered the core concepts and have confidence in your answers to the questions provided, tick the last column of the checklist.
- The **activities are based on exam-type questions**. Cover the answers provided and do each activity on your own. Then check your answers. Reward yourself for the things you get right. If you get any incorrect answers, make sure you understand where you went wrong before moving on to the next section.
- In Chapter 12, you will find a section on **graphing skills** which you must master when preparing for both Paper 1 and Paper 2. This chapter also provides guidelines on how to answer essay-type questions in the exam.
- You will be asked to draw a **labelled diagram** in the exam. On page 115 to 132 are a set of **blank diagrams** that you can use to practise your drawing and labelling skills. Filling in these blank diagrams is a good way to test yourself and work out what you know well and what you still need more practice in.
- **Exemplar Exam papers** are included in the study guide for you to do. Check your answers by looking back at your notes and the exam memoranda. Past exam papers go a long way in preparing you for what to expect and help reduce exam anxiety.
  Go to **www.education.gov.za** to download past exam papers.



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Top 10 study tips

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

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

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

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

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

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

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

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

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

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

> *If you can't explain it simply, you don't understand it well enough.*
>
> **Albert Einstein**

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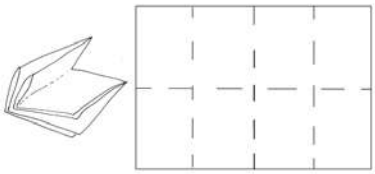
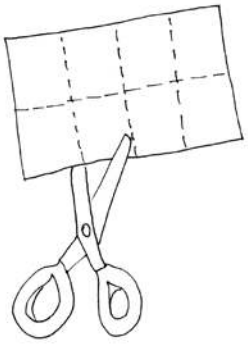
Study skills to boost your learning

This guide includes 3 study techniques you can use to help you learn the material:

1. Mobile notes
2. Mnemonics
3. Mind maps

Mobile notes





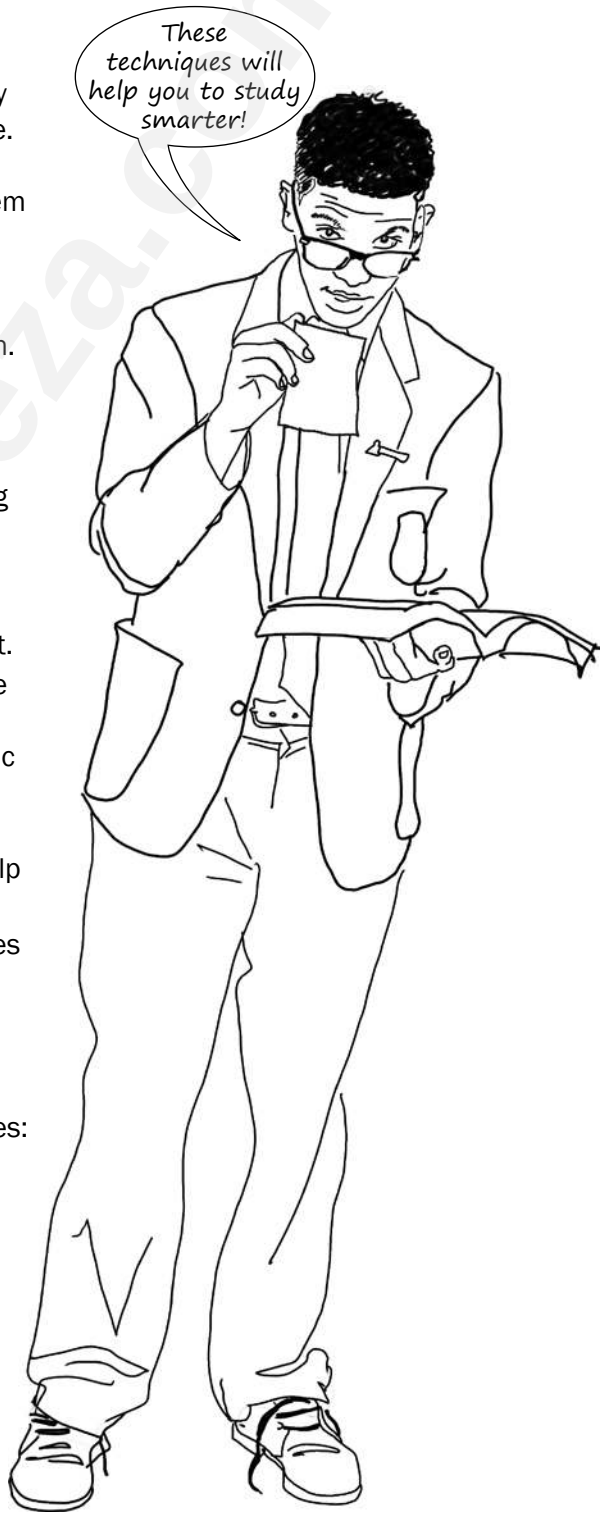
1. Fold an A4 paper into 8 squares. Cut or tear neatly along the folded lines.

2. Write the basic concept on one side of a bit of paper.

3. Write the definition of the basic concept on the back of the piece of paper.

Mobile notes are excellent tools for learning all the key concepts in the study guide. Mobile notes are easy to make and you can take them with you wherever you go:

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



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Mnemonics

A **mnemonic** code is a useful technique for learning information that is difficult to remember.

Below are two examples of mnemonics.

Here is a made-up word to help you remember the structure of a sperm cell – each letter of the word stands for a part of the cell:

M – Mitochondria

A – Acrosome

N – Nucleus

T – Tail

Here is a sentence to help you remember the 4 nitrogenous bases in DNA – each word in the sentence begins with the same letter as one of the nitrogenous bases:

All	**T**eachers	**G**et	**C**hocolate
Adenine	**T**hymine	**G**uanine	**C**ytosine

Mnemonics code information and make it easier to remember.

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

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

> *Education helps one cease being intimidated by strange situations.*
>
> **Maya Angelou**

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Mind maps

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

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

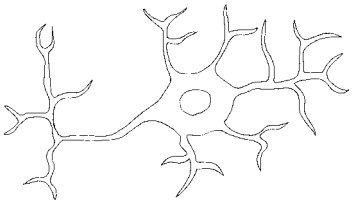


Figure 1: Brain cell or neuron

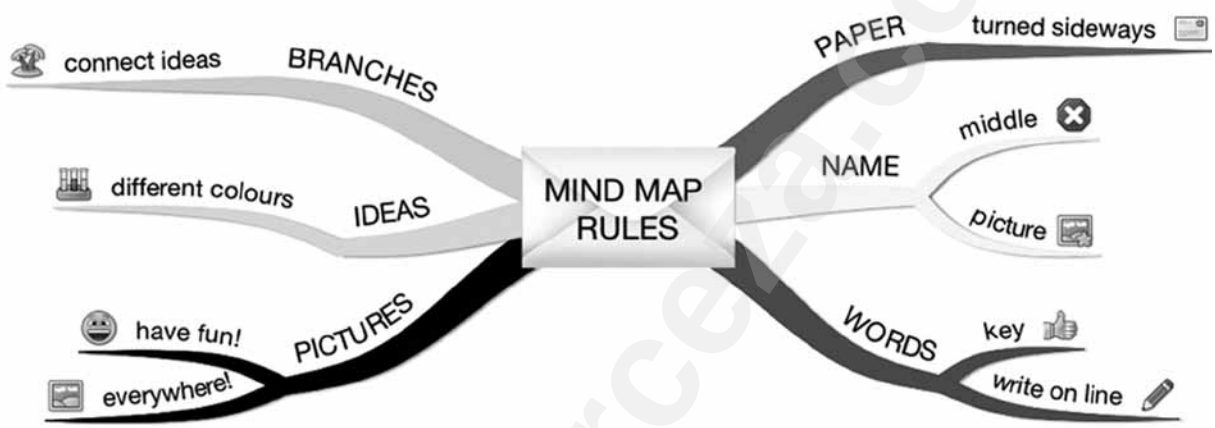


Figure 2: Mind map rules

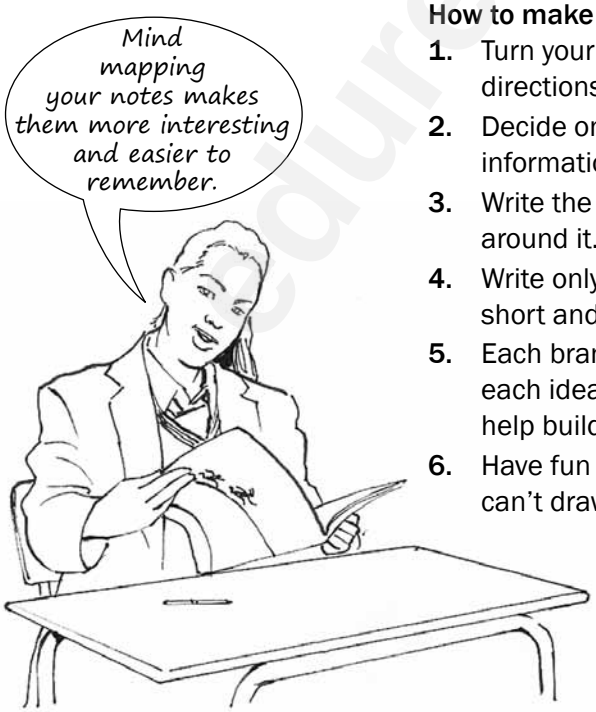
Mind maps work because they show information that we have to learn in the same way that our brains 'see' information.

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

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

How to make your own mind maps:

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



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On the day of the exam …

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

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

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

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

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

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

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

8. Manage your time properly. Don't waste time on questions you are unsure of. Move on and come back if time allows. You have 150 minutes (2½ hours) to answer each of the 150-mark Life Sciences question papers. Spend the following amounts of time on each question:
   - Question 1: 50 marks = 45 minutes
   - Question 2: 40 marks = 35 minutes
   - Question 3: 40 marks = 35 minutes
   - Question 4: 20 marks = 15 minutes

   The remaining 20 minutes can be used to check your answers and attempt to answer any question that you might have left out.

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

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

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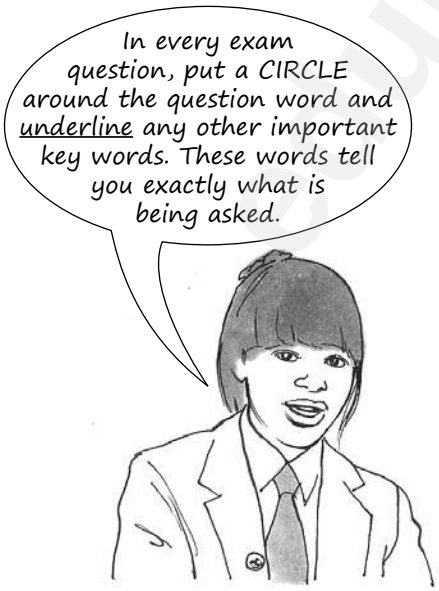
Question words to help you answer questions

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

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



e.g. Examples of question words

Questions

1. Figure 6.12 shows a longitudinal section through the human eye. Study the diagram and answer the questions that follow.
   a) Label parts 2, 3, 4 and 5 respectively. (4)
   b) Name and describe the process that causes part 1 to dilate (become wider). (5)
2. Figure 6.13 is a longitudinal section through the human eye. The structures which enable the eye to focus on objects are missing in this diagram. Study the diagram and answer the questions that follow.
   Draw a longitudinal section through the missing parts of Figure 6.13 to indicate the appearance of these structures when you are...
   a) reading a book. (6)
   b) looking at an object more than 6 metres away. (6)

[21]

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Learner's checklist

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

TOPIC	ASPECT	Covered in study guide	I do not understand	I understand
DNA: The code of life	Discovery of DNA structure	*		
	Nucleic acids terminology	✓		
	Structure of DNA and RNA	✓		
	Differences between DNA and RNA	✓		
	DNA replication and the importance thereof	✓		
	DNA profiling	✓		
	Protein synthesis	✓		
Meiosis	The process of meiosis using diagrams	✓		
	Significance of meiosis	✓		
	Abnormal meiosis	✓		
	Differences between meiosis I and meiosis II	✓		
Reproduction in vertebrates	Diversity in reproductive strategies	✓		
Human reproduction	Male reproductive system	✓		
	Female reproductive system	✓		
	Puberty	✓		
	Menstrual cycle	✓		
	Development of the foetus	✓		
	Gestation	✓		
	Role of placenta	✓		
Genetics and inheritance	Genetic terminology	✓		
	Complete dominance	✓		
	Incomplete dominance	✓		
	Co-dominance	✓		
	Inheritance of sex	✓		
	Sex-linked characteristics	✓		
	Dihybrid crossing	✓		
	Mutations	✓		
	Pedigree diagrams	✓		
	Genetic engineering	✓		
	Genetic counselling	✓		
	Paternity testing and DNA fingerprinting	✓		
Responding to the environment: Humans	The brain	✓		
	Neurons, reflex actions and reflex arcs	✓		
	Peripheral nervous system	*		
	Autonomic nervous system	*		
	Brain disorders and injuries	*		
	Effects of drugs on the central nervous system	*		
	Structure and functions of parts of the eye	✓		

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Responding to the environment: Humans	Accommodation	✓		
	Pupillary mechanism	✓		
	Visual defects	✓		
	Structure and functions of parts of the ear	✓		
	Hearing	✓		
	Balance	✓		
	Hearing defects	✓		
Human endocrine system	Glands and the hormones they secrete	✓		
	Negative feedback – glucose	✓		
	Negative feedback – thyroxin	✓		
Homeostasis in humans	Negative feedback – glucose	✓		
	Negative feedback – carbon dioxide	✓		
	Negative feedback – water	✓		
	Negative feedback – salts	✓		
	The role of the skin on hot and cold days	✓		
Responding to the environment: Plants	Functions of auxins, gibberillins and abscisic acid	✓		
	Role of auxins in phototropism and geotropism	✓		
	Plant defence mechanisms is included	✓		
Evolution	Evidence for evolution	✓		
	Sources of variation	✓		
	Lamarck and Darwin's theories	✓		
	Natural and artificial selection	✓		
	Punctuated equilibrium	✓		
	Speciation	✓		
	Mechanisms for reproductive isolation	✓		
	Evolution in present times	✓		
	Human evolution: similarities to African apes	✓		
	Human evolution: differences from African apes	✓		
	Major phases in hominid evolution	✓		
	Out of Africa hypothesis	✓		
	Phylogenetic trees	✓		
Human impact on the environment	Atmosphere and climate change	✓		
	Water availability	✓		
	Water quality	✓		
	Food security	✓		
	Loss of biodiversity	✓		
	Waste disposal	✓		
Skills	Draw a line graph	✓		
	Draw a bar graph	✓		
	Draw a histogram	✓		
	Draw a pie chart	✓		
	Answering essay questions	✓		

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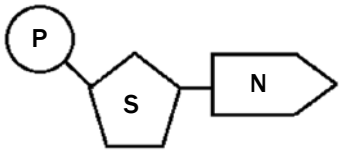
Chapter 1

Paper 2

Nucleic acids

1.1 The structure of DNA and RNA

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



P – Phosphate group

S – Deoxyribose or ribose sugar

N – Nitrogenous base (adenine, thymine, guanine, cytosine or uracil)

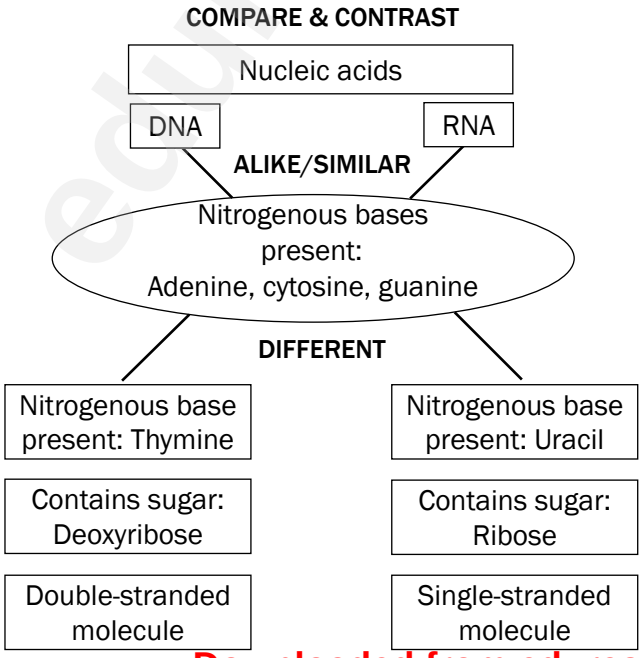
Figure 1.1 A nucleotide

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

DNA has **four** different nitrogenous bases – **adenine**, **thymine**, **guanine** and **cytosine**.	**RNA** has **four** different nitrogenous bases – **adenine**, **uracil**, **guanine** and **cytosine**.
A Adenine	A Adenine
T Thymine	U Uracil
Adenine always pairs with thymine.	RNA contains uracil instead of thymine.
G Guanine	G Guanine
C Cytosine	C Cytosine
Guanine always pairs with cytosine.	

Table 1.1 Nitrogenous bases of DNA and RNA

Figure 1.2 below shows the structure of DNA and RNA. Study the diagrams



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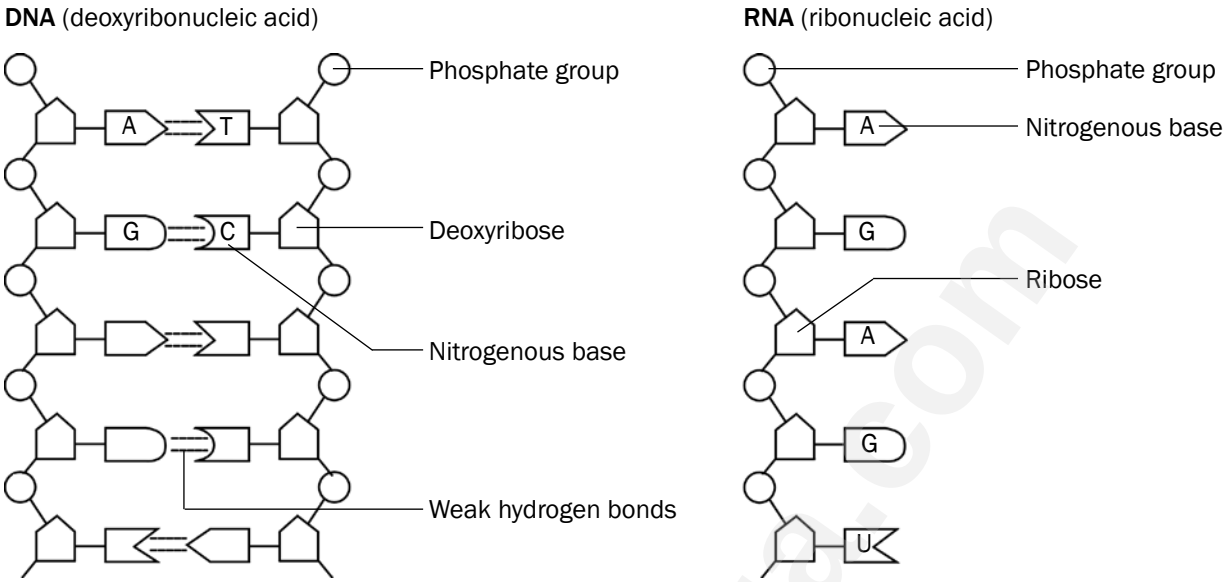
in Figure 1.2, and then read the information in the boxes below the diagrams to find out how to tell a DNA molecule from an RNA molecule.



How to recognise a DNA molecule

- Double-stranded molecule
- Contains the nitrogenous base thymine (T) instead of uracil (U)
- A always joins with T
- G always joins with C

How to recognise an RNA molecule

- Single-stranded molecule
- Contains the nitrogenous base uracil (U) instead of thymine (T)

Figure 1.2 The structure of DNA and RNA

1.2 Differences between DNA and RNA

Table 1.2 below summarises the differences between DNA and RNA molecules.

DNA	RNA
1. Double-stranded molecule	1. Single-stranded molecule
2. Contains deoxyribose (sugar)	2. Contains ribose (sugar)
3. Contains the nitrogenous base, thymine	3. Contains the nitrogenous base, uracil

Table 1.2 The differences between DNA and RNA

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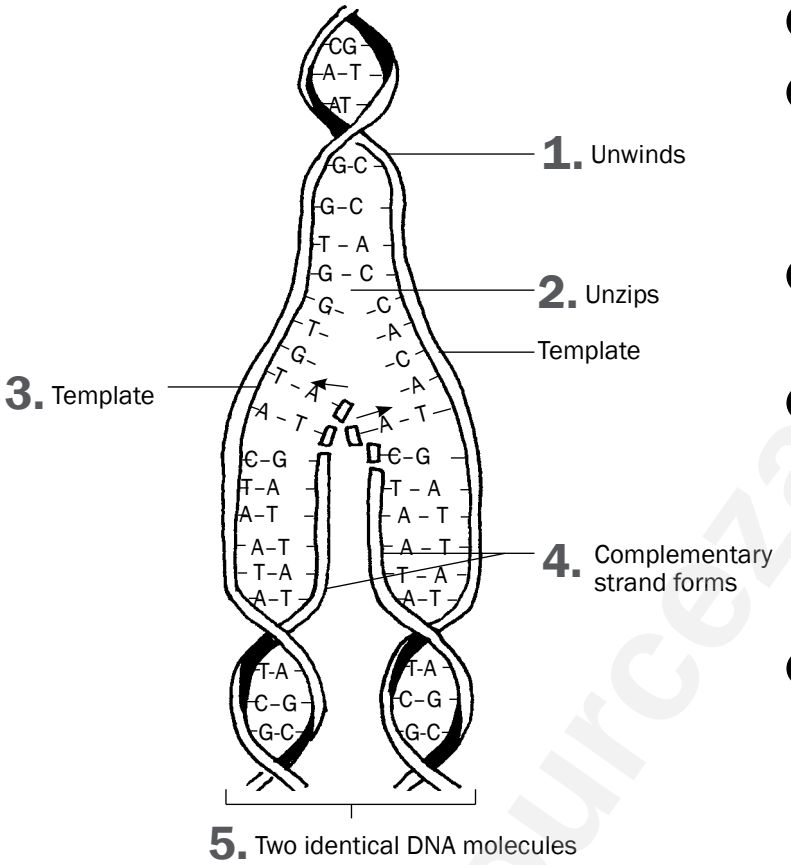
1.3 DNA replication

DNA replication takes place at interphase before mitosis or meiosis begins. DNA replication is the process during which a DNA molecule makes an exact copy (replica) of itself. This is shown in Figure 1.3 below.



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

Figure 1.3 DNA replication

Significance of DNA replication

DNA replication is important because it:

- Doubles the genetic material so it can be shared between the resulting daughter cells during cell division.
- Results in the formation of identical daughter cells during mitosis.

1.4 DNA profiling

Every person except identical twins has her/his own unique DNA profile. It can be described as an arrangement of black bars representing DNA fragments of the person.

It is used to:

- Identify criminals
- Identify dead bodies
- Identify relatives
- Identify paternity

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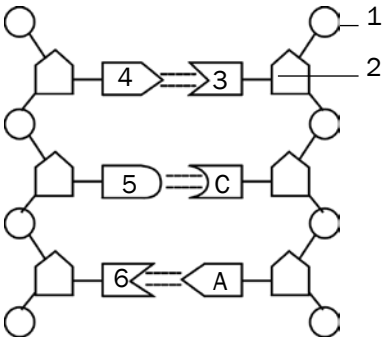


KEY
A – Adenine
C – Cytosine

Figure 1.4 Part of a nucleic acid molecule

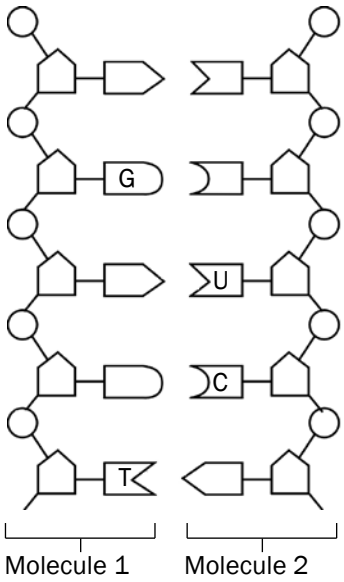


Figure 1.5 Two nucleic acid molecules

Activity 1

1. A DNA molecule contains 600 nitrogen bases. If 20% of this is adenine, determine the number of each nitrogen base in the DNA molecule. (3)

2. Figure 1.4 (left) represents part of a nucleic acid molecule. Study the diagram and answer the questions that follow.

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

2.2 Label the following:

a) Part 1 (1)

b) Part 2 (1)

c) The nitrogenous bases 4, 5 and 6 (3)

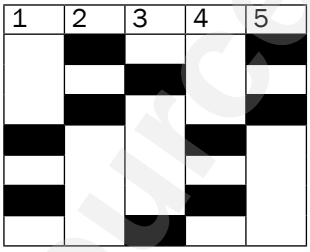
2.3 What is the collective name for the parts numbered 1, 2 and 3? (1)

3. Questions 3.1 and 3.2 are based on Figure 1.5 (left). This is a diagrammatic representation of a **part of two different nucleic acid molecules** found in the cells of organisms during a stage in the process of protein synthesis.

3.1 Name the molecules 1 and 2. (2)

3.2 Give a reason for your answer in question 3.1. (2)

4. The result of profiling various DNA samples in a criminal investigation is shown below



Key:
1. blood sample of victim
2. blood sample of suspect X
3. blood sample of suspect Y
4. first sample of DNA from the crime scene
5. second sample of DNA from crime scene

4.1 Was suspect X or suspect Y involved in the crime? (1)

4.2 Does the DNA of the suspect (from answer 4.1) match the first or second sample? (2)

[17]

Answers to activity 1

1. 20% adenine = 20% thymine✓ 30% cytosine✓ = 30% guanine✓
$\frac{20}{100} \times 600 = 120A = 120T$ $\frac{30}{100} \times 600 = 180C = 180G$ (3)

2.1 DNA✓ (1)

2.2 a) Phosphate✓ group (1)

b) Deoxyribose✓ sugar (1)

c) 4 – adenine (A)✓ 5 – guanine (G)✓
6 – thymine✓ (3)

2.3 Nucleotide✓ (1)

3.1 1 – DNA 2 – mRNA/RNA✓ (2)

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

4.1 Suspect X was involved. ✓ (1)

4.2 The DNA of suspect X matches with the second sample. ✓✓ (2)

[17]

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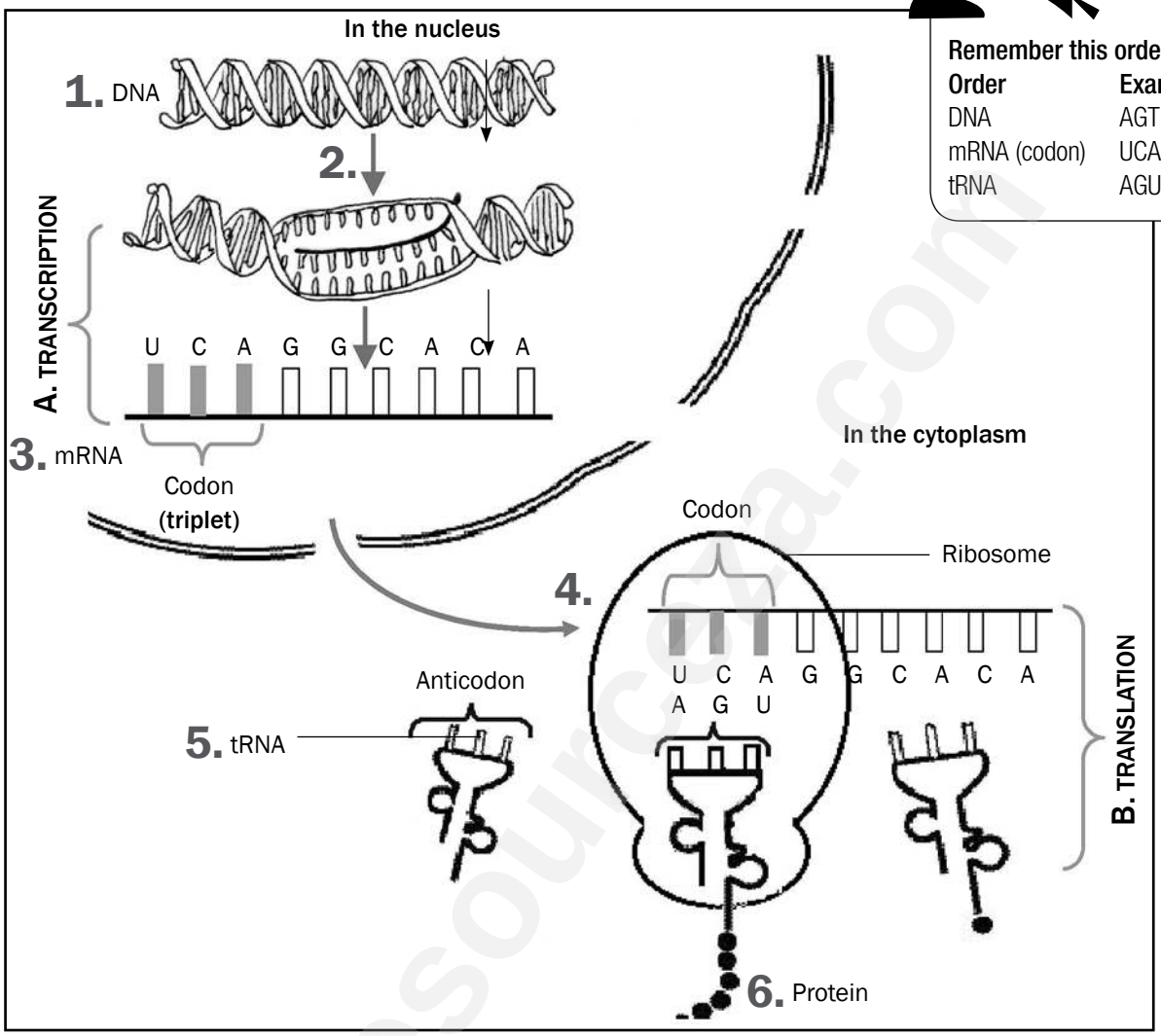
1.5 Protein synthesis

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



NB

Remember this order:

Order	Example
DNA	AGT
mRNA (codon)	UCA
tRNA	AGU

Figure 1.6 The process of protein synthesis

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

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

A Transcription (takes place in the nucleus)

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

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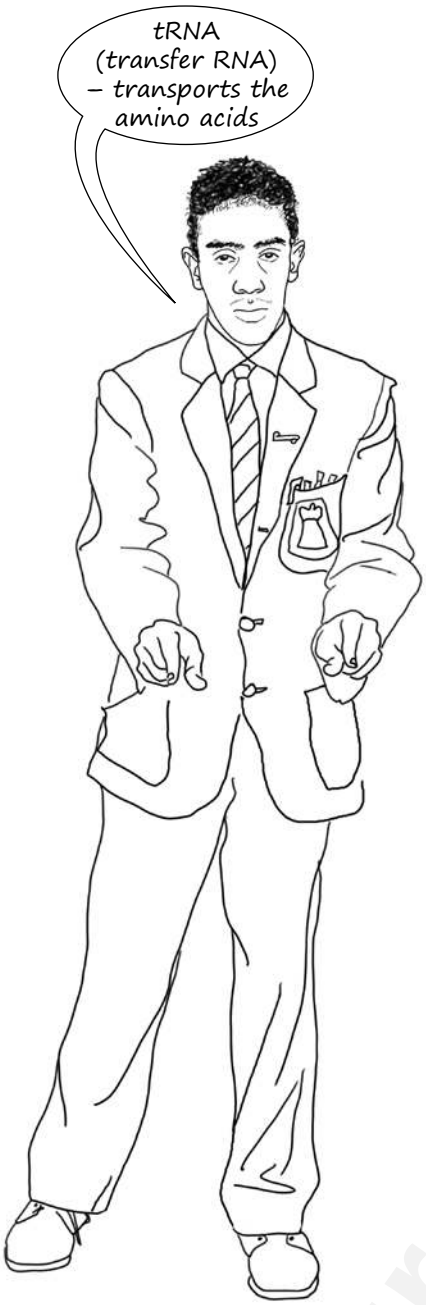

B Translation (takes place in the cytoplasm on the ribosome)

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

The diagram shown in Figure 1.6 (on page 5) may appear in exam questions in different ways. Do not let the different representations confuse you. Just try to identify the following components by looking for the features listed here:

- **DNA** – double-stranded; look for presence of thymine; found in nucleus only.
- **Nuclear membrane** – has nuclear pores through which mRNA moves.
- **mRNA** – single-stranded; look for presence of uracil; contains a triplet of bases (**codon**) found in nucleus and cytoplasm.
- **Ribosome** – usually mRNA attached to it.
- **tRNA** – contains a triplet of bases (**anticodon**); look for attached amino acid.

Activity 2

Question 1

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

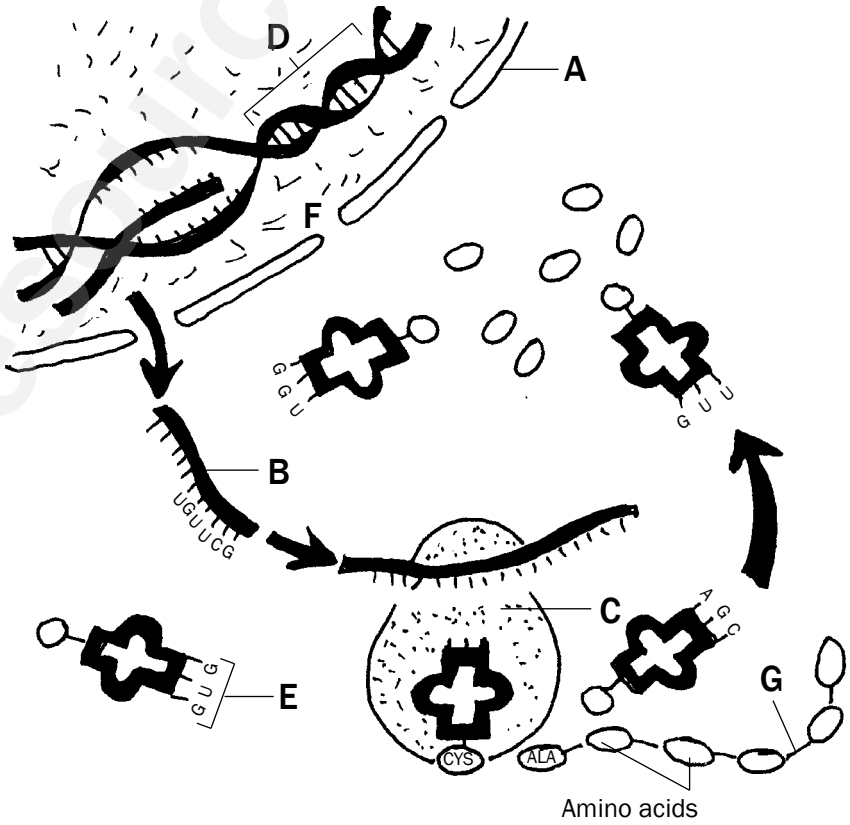

Figure 1.7 Protein synthesis

1.1 Label structures A, B and D. (3)

1.2 State ONE function of molecule D. (1)

exams

For two more problems on **protein synthesis** refer to these National Life Sciences exam papers:

- Life Sciences Paper 1 March 2009 – Question 2.2 on page 9.
- Life Sciences Paper 1 November 2010 – Question 1.5 on page 7.

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1.3 Which stage of protein synthesis takes place at F? (1)
1.4 Identify organelle C. (1)
1.5 Name and describe the stage of protein synthesis that takes place at organelle C. (7)
1.6 Write down the codon of anticodon E from top to bottom. (1)
1.7 Name the type of bond (labelled G) between the amino acids. (1)
[15]

Answers to question 1

1.1 A – Nuclear membrane✓
B – mRNA✓
D – DNA✓ (3)
1.2 Carrying hereditary characteristics from parents to their offspring ✓
OR Controls the synthesis (manufacturing) of proteins✓ (1)
1.3 Transcription✓ (1)
1.4 Ribosome✓ (1)
1.5 Translation✓

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

1.6 CAC✓ (the anticodon is GUG, so the complementary codon is CAC) (1)
1.7 Peptide Bond (1)
[15]

Question 2

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

Amino acid	Base triplet in DNA template
Leu (leucine)	GAA
His (histidine)	GTA
Lys (lysine)	TTT
Pro (proline)	GGG
Ala (alanine)	CGA
Trp (tryptophan)	ACC
Phe (phenylalanine)	AAA
Gly (glycine)	CCT

Table 1.3 Different amino acids and their DNA base triplets

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Remember this order:

Order	**Example**
DNA	CGA
mRNA (codon)	GCU
tRNA	CGA

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

Ala	**His**	**Trp**	**Leu**	**Lys**

2.1 Name the process by which mRNA is formed from a DNA template. (1)

2.2 How many mRNA codons would be involved in forming the portion of protein shown above? (1)

2.3 Write down the sequence of the first **three** mRNA codons (from left to right) for this portion of the protein. (3)

[5]

Answers to question 2

2.1 Transcription✓ (1)

2.2 5✓ (1)

2.3 GCU✓ – CAU✓ – UGG✓ (3)

[5]

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Chapter 2

Paper 1 and 2

Meiosis

2.1 What is meiosis?

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

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

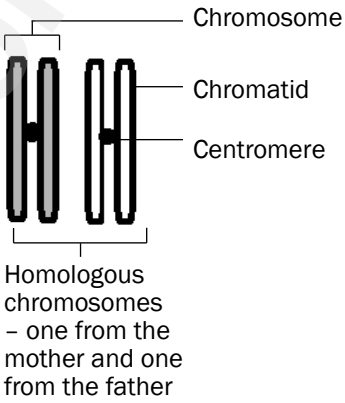


Figure 2.1 Homologous chromosomes

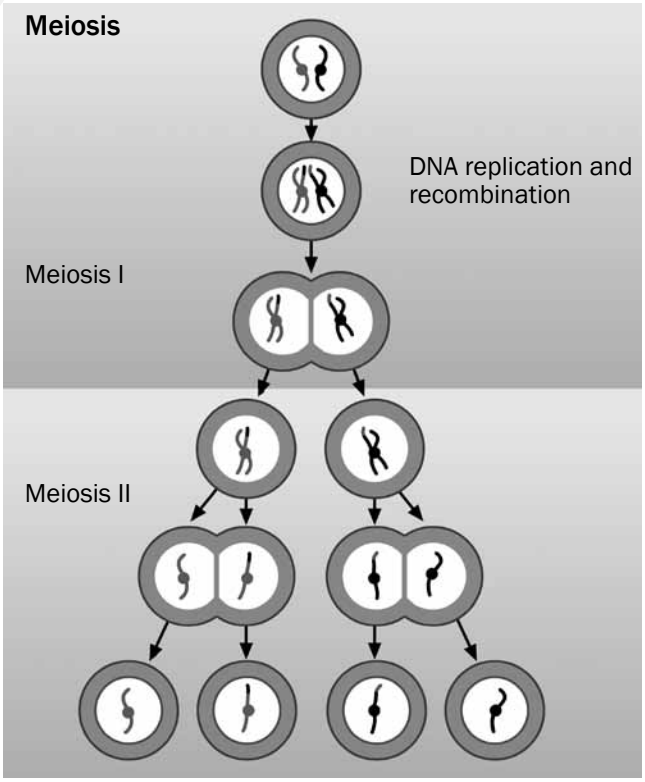
2.2 The process of meiosis in animal cells

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

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

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

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



Now turn the page to find out what happens during each stage of meiosis I and II.

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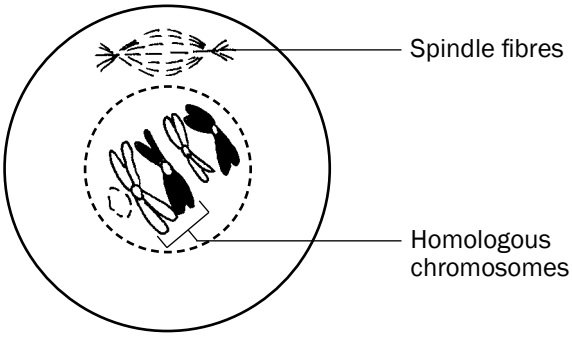
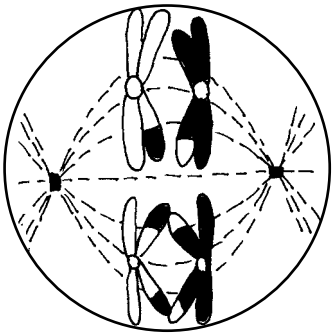
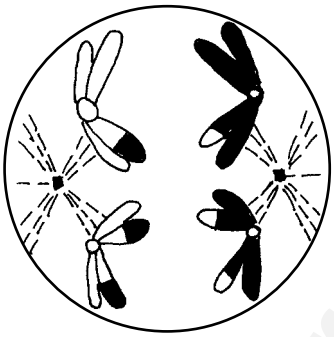
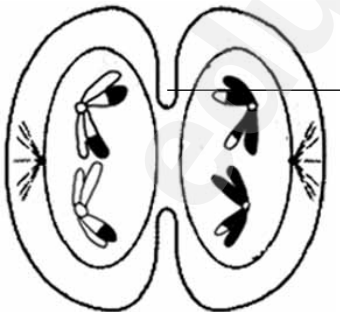
2.2.1 First meiotic division

 *Figure 2.2 Prophase 1*	***Prophase 1*** • Chromosomes shorten and become visible as two chromatids joined by a centromere. • Homologous pairs of chromosomes are now visible. • The nuclear membrane and nucleolus disappear. • The spindle starts to form. • Chromatids from each homologous pair touch. The point where they touch is called a chiasma. • DNA is crossed over (swopped) at the chiasma. • The spindle continues to form.
 *Figure 2.3 Metaphase 1*	*Metaphase 1* • The spindle extends across the whole cell. • The homologous chromosomes line up along the equator of the spindle in their homologous pairs. • One chromosome of each pair lies on either side of the equator. • The centromere of each chromosome attaches to the spindle fibres.
 *Figure 2.4 Anaphase 1*	*Anaphase 1* • The spindle fibres shorten and pull each chromosome of each chromosome pair to opposite poles of the cell.
 *Figure 2.5 Telophase 1*	*Telophase 1* • The chromosomes reach the poles of the cell. • Each pole has half the number of chromosomes present in the original cell. • The cell membrane constricts and divides the cytoplasm in half to form two cells.

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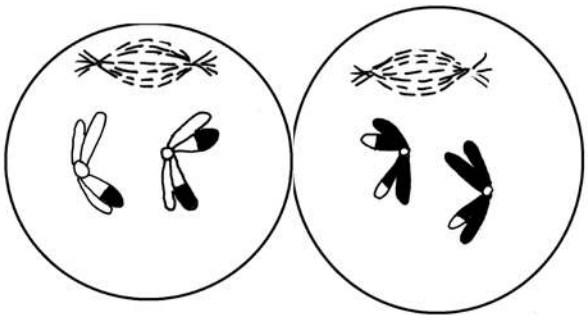
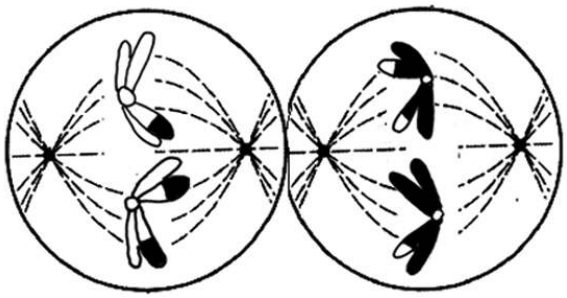
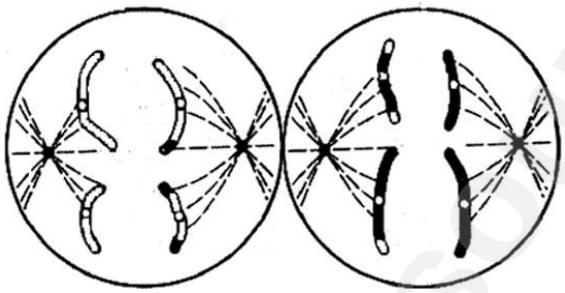
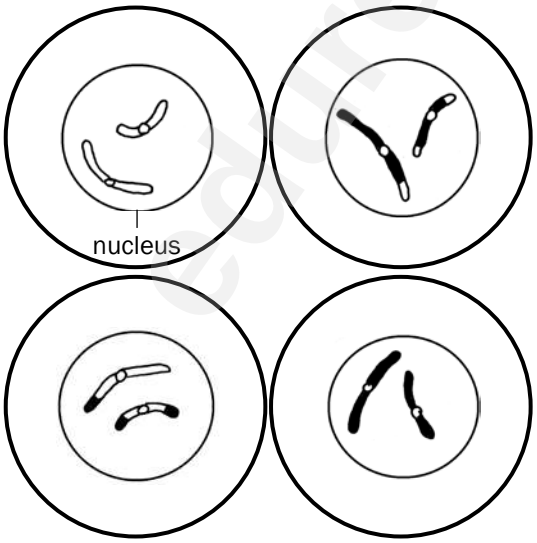
2.2.2 Second meiotic division

 *Figure 2.6 Prophase 2*	*Prophase 2* • Each cell formed during meiosis I now divides again. • A spindle forms in each of the new cells.
 *Figure 2.7 Metaphase 2*	*Metaphase 2* • Individual chromosomes line up at the equator of each cell, with the centromeres attached to the spindle fibres.
 *Figure 2.8 Anaphase 2*	*Anaphase 2* • The spindle fibres start to contract. • The centromeres split and daughter chromosomes/ chromatids are pulled to the opposite poles of each cell.
 *Figure 2.9 Telophase 2*	*Telophase 2* • The daughter chromosomes/chromatids reach the poles and a new nucleus forms. • The cell membrane of each cell constricts and the cytoplasm divides into two cells. • Four haploid daughter cells are formed. • Each daughter cell has half the number of chromosomes of the original cell. • The daughter cells are genetically different from each other.

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An easy way to remember the events of meiosis is to use the word mnemonic **IPMAT.**

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

2.3 The significance of meiosis

There are two reasons why meiosis is important.

1. It reduces the number of chromosomes by half, in other words from diploid to haploid. This ensures that sex cells have half the number of chromosomes of other somatic cells so that when fertilisation occurs the zygote formed has the correct number of chromosomes. It balances the doubling effect of fertilisation.
2. Crossing over introduces genetic variation. Genetic variation results in offspring that are better adapted to a particular environment and ensures that they will have a better chance of survival.

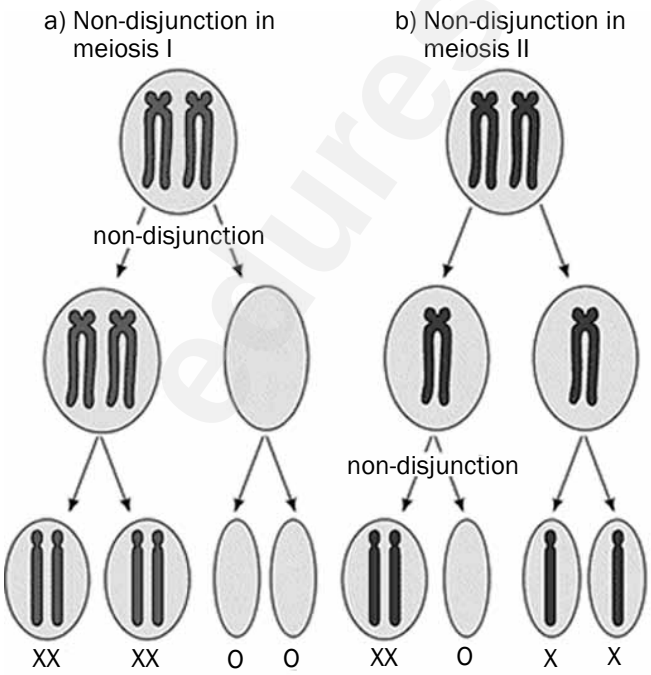

Figure 2.10 Non-disjunction meiosis I and meiosis II
XX : 2 chromosomes X : 1 chromosome O : no chromosomes

2.4 Abnormal meiosis

- Sometimes mistakes occur during the process of meiosis.
- This can happen in Anaphase 1 where the homologous chromosomes may not separate. Also called non-disjunction.
- It can also happen in Anaphase 2 when there is non-disjunction of the sister chromatids.
- If there is non-disjunction of chromosome pair 21 in humans it leads to the formation of an abnormal gamete with an extra copy of chromosome 21.
- If there is fusion between a normal gamete and an abnormal gamete (with extra copy of chromosome 21) it leads to Down Syndrome.

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2.5 Differences between meiosis I and meiosis II

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

Table 2.1 The differences between meiosis I and meiosis II

e.g. Worked example

Study the diagrams below of two stages of meiosis then answer the questions that follow.

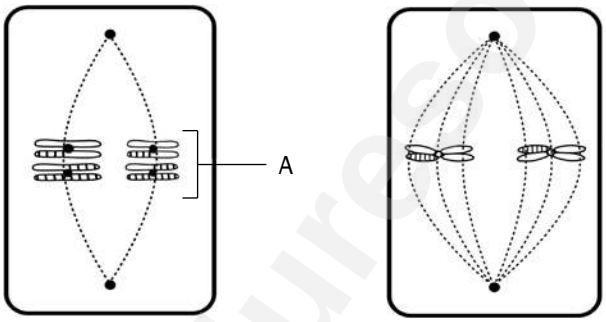

Diagram I Diagram II

Figure 2.11 Two stages of meiosis

1. State ONE visible reason in Diagram I which indicates that meiosis is taking place. (1)
2. How many chromosomes would be present in each daughter cell at the end of meiosis in this cell? (1)
3. Describe what takes place in the cell after the phase shown in Diagram I. (3)
4. Tabulate TWO visible differences between the phases of meiosis shown in Diagrams I and II. (5)

[10]

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Answers to worked example

1. The chromosomes are lined up at the equator of the cell in their homologous pairs.✓
   OR
   The chromosomes show evidence of crossing over.✓ (1)
2. Two ✓ chromosomes. (1)
3. The next phase is Anaphase 1. The spindle fibres contract.✓ (shorten) and pull each chromosome✓ of each chromosome pair to opposite poles✓ of the cell. (3)
4. ✓

Diagram I (metaphase 1)	Diagram II (metaphase 2)
1. Chromosomes are lined up at the equator in homologous pairs.✓	1. Chromosomes are lined up at the equator individually.✓
2. Four chromosomes are present.✓	2. Two chromosomes are present.✓

(5)
[10]

Activity 1

Question 1

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

1.1	The structure that joins the two halves of a double-stranded chromosome	(1)
1.2	A pair of chromosomes, one inherited from each parent, that have the same genes at the same locus	(1)
1.3	A single-stranded chromosome formed during Anaphase 2	(1)
1.4	The point of contact between two chromosomes of a homologous pair during crossing over	(1)
1.5	One half of a double-stranded chromosome	(1)
1.6	The phase in meiosis where crossing over occurs	(1)

[6]

Answers to question 1

1.1 Centromere✓ (1)
1.2 Homologous chromosomes✓ (1)
1.3 Daughter chromosome/chromatid✓ (1)
1.4 Chiasma✓/chiasmata✓ (1)
1.5 Chromatid✓ (1)
1.6 Prophase 1✓ (1)
[6]

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Question 2

Figure 2.12 (right) represents a process taking place during meiosis. Study the diagram and answer the questions that follow.

2.1 Provide labels for parts A, B, C and D. (4)

2.2 Name the process in meiosis that is illustrated in Figure 2.12. (1)

2.3 State ONE importance of the process you named in question 2.2. (2)

2.4 Draw a diagram of the structure labelled A to show its appearance immediately after the process you named in question 2.2. (2)

[9]

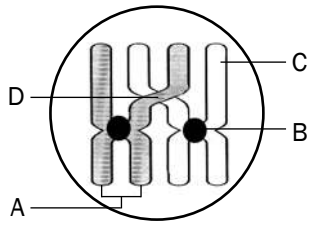

Figure 2.12 Diagram representing a process taking place during meiosis

Answers to question 2

2.1 A – Chromosome✓
B – Centromere✓
C – Chromatid✓
D – Chiasma✓/chiasmata (4)

2.2 Crossing over✓ (1)

2.3 It introduces genetic✓ variation✓ (2)

2.4
- A double-stranded chromosome with the strands joined by a centromere✓
- There is evidence of crossing over.✓ (2)

[9]

Question 3

Figure 2.13 (right) represents an animal cell in a phase of meiosis. Study the diagram and answer the questions that follow.

3.1 State whether the phase of meiosis shown in Figure 2.13 is meiosis I or meiosis II. (1)

3.2 Give ONE visible reason for your answer in question 3.1. (1)

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

3.4 How many chromosomes:

a) were present in the parent cell before meiosis began? (1)

b) will be present in each cell at the end of meiosis? (1)

3.5 State ONE place in a human female where meiosis would take place. (1)

3.6 Could the cell represented in Figure 2.13 be that of a human? (1)

3.7 Explain your answer to question 3.6. (2)

3.8 Give TWO reasons why meiosis is biologically important. (2)

3.9 Give the term for the situation when some of the chromosomes do not separate correctly during the phase shown in Figure 2.13. (1)

[13]

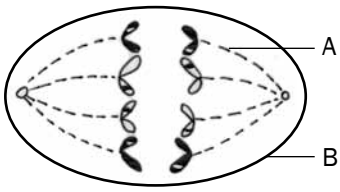

Figure 2.13 Diagram representing a phase of meiosis

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Answers to question 3

3.1 Meiosis II✓ (1)

3.2 Daughter chromosomes/chromatids are being pulled to the opposite poles✓ (1)

3.3 A – Spindle fibre✓
B – Cell membrane✓ (2)

3.4 **a)** 8✓
b) 4✓ (2)

3.5 Ovaries✓ (1)

3.6 No✓ (1)

3.7 There are only 4 chromosomes present✓ instead of 23.✓ (2)

3.8 It introduces genetic variation.✓
It balances the doubling effect of fertilisation as it halves the number of chromosomes in the sex cells.✓ (2)

3.9 Non-disjunction✓ (1)

[13]

exams

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

- Life Sciences Paper 1 February/March 2012: Version 1 – Question 2.1 on page 9.
- Life Sciences Paper 1 November 2010 – Question 2.1 on page 10.
- Life Sciences Paper 1 February/March 2010 – Question 1.4 on page 6.
- Life Sciences Paper 1 November 2009 – Question 1.5 on page 7.

Question 4

The diagram below shows the nuclei of the four cells that resulted from meiosis of chromosome pair 21 in a woman.

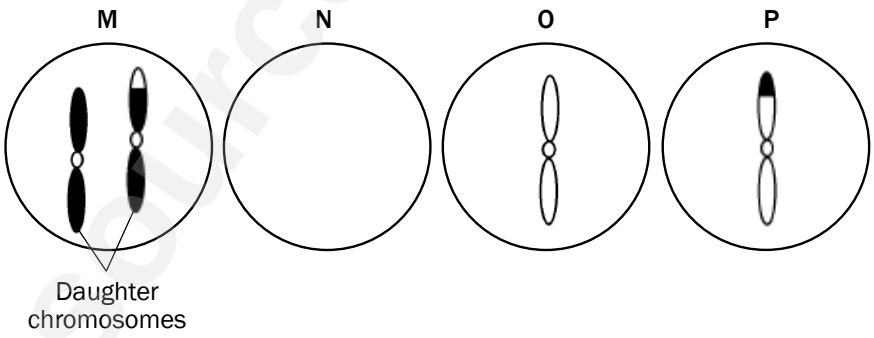

Figure 2.14: Diagram that shows the nuclei of four cells resulted from meiosis

4.1 Explain why nucleus **N** does NOT have a chromosome pair 21. (2)

4.2 Name and explain the disorder that will result if diagram **M** represents an egg cell that fuses with a normal sperm cell. (3)

[5]

Answers to question 4

4.1 During Anaphase 1 the chromosome pair 21 does not separate✓/ non-disjunction. Gamete M will have an extra copy of chromosome number 21 and therefore gamete N does not have a copy of chromosome 21✓ (2)

4.2 Down syndrome✓/Trisomy 21 if gamete M fuses with normal sperm having 1 copy of chromosome 21 ✓ the resulting zygote will have 3 copies of chromosome 21✓ (3)

[5]

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Chapter 3

Paper 1

Reproduction in vertebrates

Different groups in the animal kingdom have different strategies to maximise reproductive success in different environments. These are a few of the strategies used by vertebrates.

Strategy	How it works?	What is its advantage?
External Fertilisation	The sperm fertilises the egg outside the body of the female, usually in water.	Water prevents the eggs from drying out and allows the sperm to swim towards the egg.
Internal Fertilisation	The male deposits its sperm inside the reproductive organs of the female and fertilisation occurs inside the female's reproductive organs.	Allows terrestrial animals to reproduce in a dry environment without the need for water. Internal fertilisation is more certain than external fertilisation.
Ovipary	Eggs are laid and hatching takes place outside the mother's body.	Egg provides nutrition for the developing embryo and protects the embryo. A shelled egg frees these animals from the need to reproduce in water.
Vivipary	The young develop inside the uterus of the mother after the eggs are fertilised internally.	More efficient development of the embryo as nutrients are received for a longer period from the mother's blood through a placenta. Embryo is protected in the body of the mother.
Ovovivipary	Young develop from eggs that are fertilised internally and retained within the mother's body after fertilisation until they hatch.	Embryos obtain their nutrients from the egg yolk. The eggs are protected from predators until hatching occurs.
Amniote Egg	Embryo protected by the shell of the egg; egg consists of many extraembryonic membranes that serve different functions.	Amniote egg protects embryo from dehydration. Yolk sac provides nutrition, Allantois for excretion, chorion for gas exchange.
Precocial Development	Hatchlings are quite well-developed when they hatch – eyes open, able to move, able to feed. Brain size and intelligence remains the same throughout their lives.	Hatchlings are more prepared to handle the challenges of the environment; More independent.
Altricial Development	Hatchlings are poorly-developed when they hatch. Unable to feed on their own, cannot move. Brain size and intelligence increases a lot after hatching.	Parental care afforded to protect the young from predators.
Parental Care	Parental care offered through building of nests, protecting the eggs, protecting the young, teaching the young.	Increases chances of survival of the young.

Activity 1

Questions

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 to 5).

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COLUMN I	COLUMN II
1. Oviparous	A Eggs are produced B Eggs are always incubated by the female
2. Ovoviviparous	A Eggs incubated in nests B Eggs incubated in the female's body
3. Precocial	A Small, helpless offspring born B Intense parental care required
4. Viviparous	A Gestation period required B Live offspring born
5. Altricial	A Intense parental care required B Offspring can look after themselves

(5 × 2)
[10]

Answers to activity 1

1. A only (B is wrong, because some animals, like insects, simply lay their eggs and do not incubate them. In some birds both the male and female incubate the eggs)
2. B only (A is wrong, because the eggs are not released from the female's body)
3. None (Precocial animals are born quite well-developed, they can live independently from their parents and find their own food, so parental care is not required)
4. Both A and B
5. A only (B is wrong, because altricial animals are born small and helpless. They cannot look after themselves or find their own food. Their parents must look after them, protect them and feed them.)

(5 × 2)
[10)

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Chapter 4

Paper 1

Reproduction

4.1 Male reproductive system

Figure 4.1 below shows the different parts of the male reproductive system and their functions.

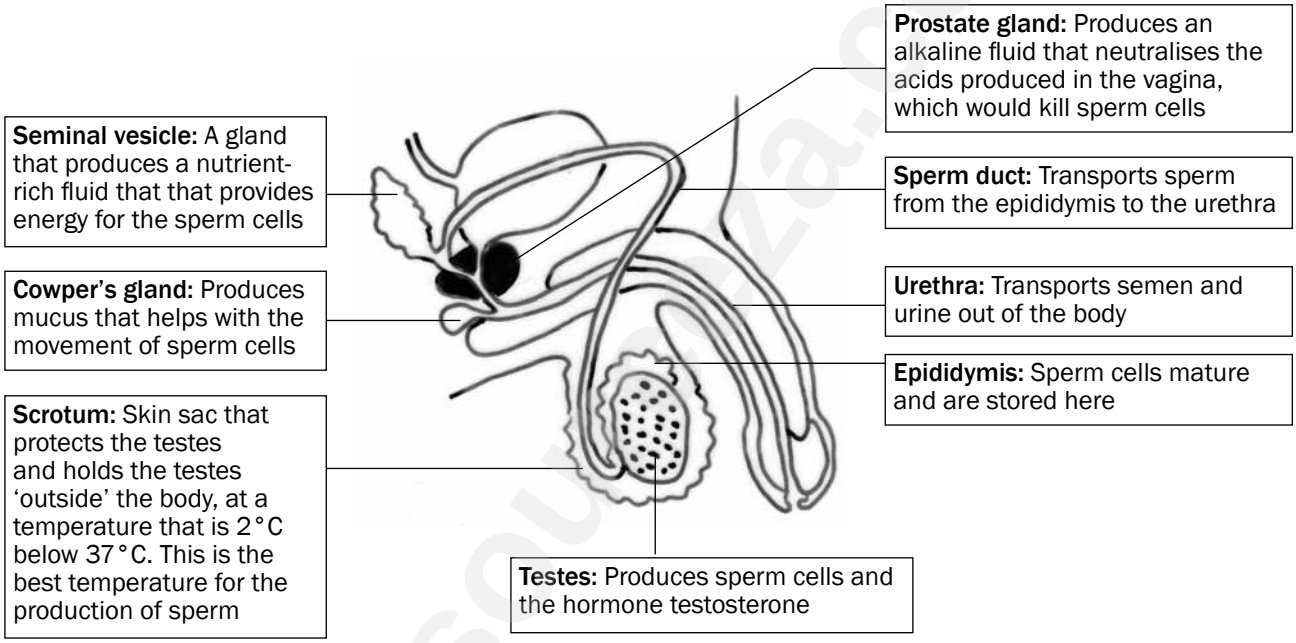

Figure 4.1 Structure of the male reproductive system

Functions of testosterone

The testes produce the hormone **testosterone**, which has the following functions:

1. Development of male secondary sexual characteristics, such as beard, pubic hair, deep voice and a muscular body.
2. Stimulates the maturation of sperm cells.

Structure of a sperm cell

Figure 4.2 below shows the different parts of a sperm cell and their functions.

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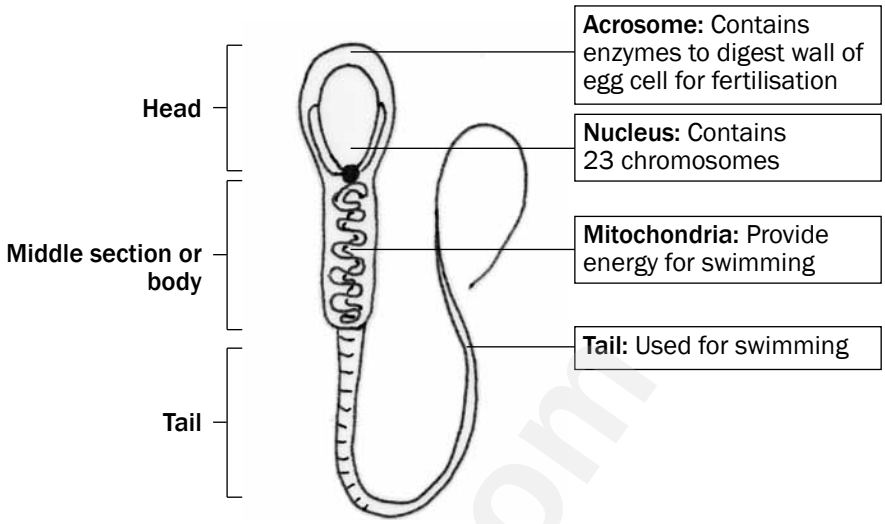

Figure 4.2 Structure of a sperm cell

Activity 1

Questions

1. Name the accessory glands of the male reproductive system and give ONE function of each. (10)
2. Name the organ where testosterone is produced. (1)
3. Give TWO functions of testosterone. (2)
4. Name all the parts of the sperm cell that are responsible for movement. State what the function of each part is. (4)
5. Explain the role of the nucleus of the sperm cell in fertilisation. (3)

[20]

Answers to activity 1

1. Seminal vesicle✓ produces a fluid that contains nutrients✓ for the sperm cells, so that they have energy to swim.✓
   Prostate gland✓ produces an alkaline fluid✓ that neutralises acids✓produced in the vagina, so that sperm cells are protected.✓
   Cowper's gland✓ produces mucus✓ that helps with the movement✓of sperm cells. (10)
2. Testes✓ (1)
3. Testosterone is responsible for the development of male secondary sexual characteristics✓ and it stimulates the maturation of sperm cells.✓ (2)
4. Mitochondria✓ provide energy for swimming.✓
   Tail✓ moves in a whip-like fashion to propel the sperm cell forwards.✓ (4)
5. The nucleus contains 23 chromosomes (n)✓, and fuses with the nucleus of an egg cell, which also contains 23 chromosomes (n)✓. The result is a zygote with 46 chromosomes (2n).✓ (3)

[20]

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4.2 Female reproductive system

Figure 4.3 below shows the different parts of the female reproductive system and their functions.

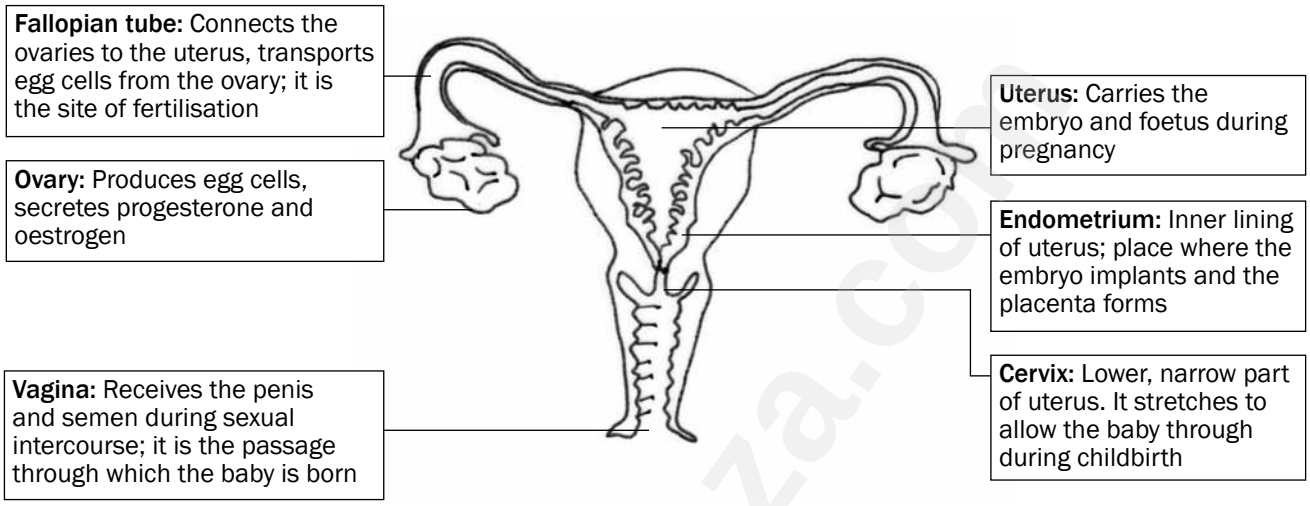

Figure 4.3 Structure of the female reproductive system

Activity 2

Questions

Provide the correct biological term for the following definitions.

1. The inner lining of the uterus (1)
2. Tube that connects the ovaries to the uterus (1)
3. The structure that produces female hormones (1)
4. The part where development of the embryo/foetus normally takes place in humans (1)

[4]

Answers to activity 2

1. Endometrium✓
2. Fallopian tube✓
3. Ovary/placenta✓
4. Uterus✓

[4]

4.3 Puberty

Puberty is the period in humans in which they experience physical changes in their bodies in order to be capable of sexual reproduction.

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Puberty in males	Puberty in females
Stimulated by testosterone	Stimulated by oestrogen
Growth of male sex organs	Growth of female sex organs
Start of the production of sperm cells	Start of the menstrual cycle and production of ova
Growth of pubic hair, facial hair and body hair	Growth of pubic hair
Development of muscles and deepening of voice	Growth and development of breasts and widening of hips

4.4 Menstrual cycle

The series of diagrams in Figure 4.4 below shows the events occurring in the ovary (ovarian cycle) and uterus (uterine cycle) during the menstrual cycle. The days are not exact, but are averages.

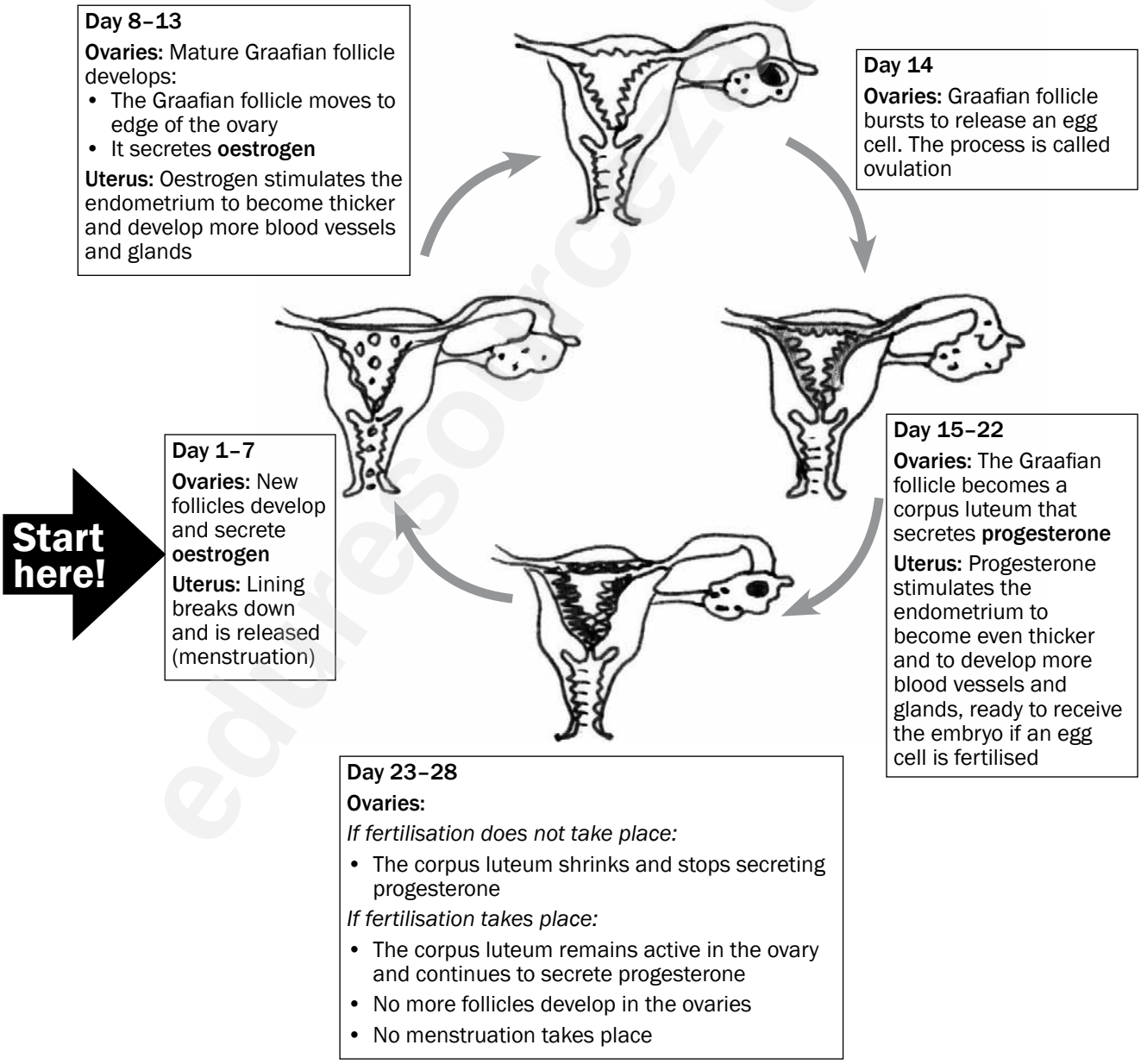

Figure 4.4 The menstrual cycle

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4.5 Hormonal control of the menstrual cycle

The graph in Figure 4.5 below shows changes in the ovary, uterus and in the level of hormones during a 28-day menstrual cycle.

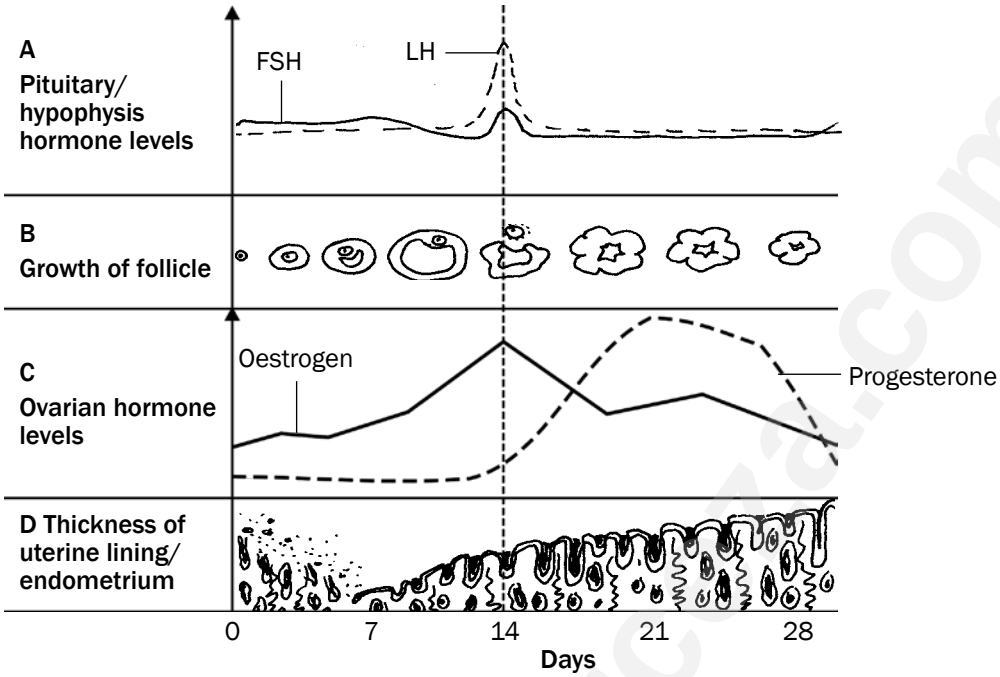

Figure 4.5 Hormonal regulation of the female reproductive cycle

The hormonal changes that take place at A, B, C and D in the graph in Figure 4.5 above are explained in Table 4.1 below.

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

Table 4.1 Hormonal changes during the menstrual cycle

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Activity 3

Study Figure 4.6 below and answer the questions that follow.

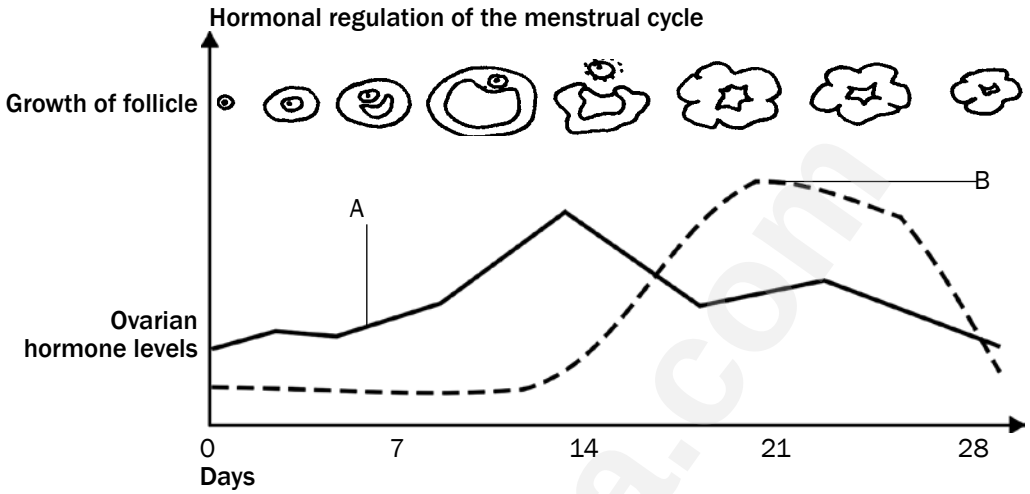

Figure 4.6 Hormonal changes during the menstrual cycle

1. Name the hormones A and B. (2)
2. Give reasons for your answers in question 1. (2)
3. What event occurs on day 14? (1)
4. Name the other two hormones involved in this cycle. (2)
5. Did fertilisation occur during the cycle shown in Figure 4.6? (1)
6. Explain your answer in question 5. (2)

[10]

NB

Make sure you know how to interpret the graph in Figure 4.6 before you try to answer the questions:

- All the information refers to the ovary.
- The information is presented in graph form. The days of the menstrual cycle are indicated on the X-axis.
- The graph should be read from left to right in the same way that you read a sentence.
- The graph illustrates the concentrations of two hormones, namely oestrogen and progesterone.

Answers to activity 3

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

[10]

hint

Here is a hint to help you to remember the names of the two hormones:

- **O** stands for **O**estrogen and when it is high, **O**vulation occurs.
- **P** stands for **P**rogesterone and when it remains high, there is a **P**regnancy.

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4.6 Development of the foetus

Figure 4.7 below shows the stages in the development of the foetus.

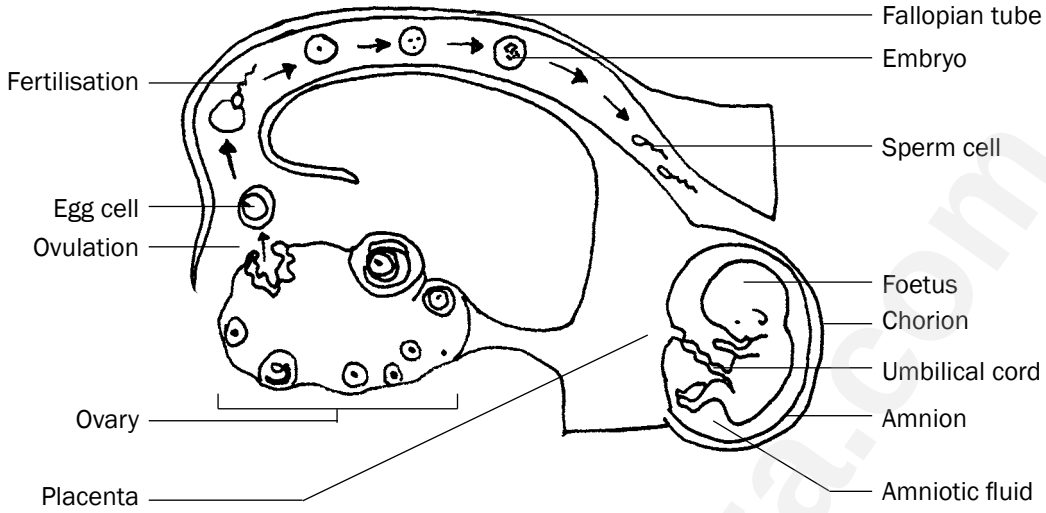

Figure 4.7 Stages in the development of the foetus

Explanation of Figure 4.7

1. In the ovary a mature Graafian follicle bursts (usually on day 14 of the menstrual cycle) and releases an egg cell. This process is called **ovulation**.
2. **Fertilisation** takes place high up in the fallopian tube. The egg cell (containing 23 chromosomes) and sperm cell (containing 23 chromosomes) fuse to form a zygote (containing 46 chromosomes).
3. The zygote divides by mitosis to form a morula, then a blastocyst, and finally an **embryo** as it moves down the Fallopian tube.
4. It takes about 5 to 7 days for the embryo to reach the **uterus**.
5. In the uterus the embryo settles on the endometrium and sinks into it, embedding itself in the endometrium. This process is called **implantation**.
6. After implantation, the embryo produces many finger-like structures called villi from the outer membrane of the embryo, which is known as the **chorion**.
7. The villi grow into the tissue of the uterus to form a **placenta**.
8. The placenta is attached to the embryo by the **umbilical cord**. It has 2 **umbilical arteries** (which carry deoxygenated blood from the embryo towards the placenta) and 1 **umbilical vein** (which carries oxygenated blood from the placenta to the embryo).
9. The embryo is enclosed in a fluid-filled sac called the **amnion**. The fluid is called the amniotic fluid.
10. After about 8 weeks, the embryo develops structures such as limbs and all the organs of the body. Now it is called a **foetus**.
11. Gestation is the period between fertilisation and the birth of the baby. It usually lasts for a period of 9 months (39–40 weeks).
12. The stages involved in the natural birth process are:
    - Dilation of the cervix (labour)
    - Expulsion of the foetus.
    - Delivery of the afterbirth (placenta) and extra-embryonic membranes.

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Activity 4

Questions

1. On which day of the menstrual cycle does ovulation usually take place? (1)
2. What happens to the Graafian follicle after ovulation? (1)
3. Name the TWO hormones that are released by structures in the ovaries. (2)
4. Give THREE functions of the amniotic fluid. (3)
5. Give TWO substances that can move from the mother to the foetus through the placenta. (2)
6. Give TWO substances that can move from the foetus to the mother through the placenta. (2)

[11]

Answers to activity 4

1. Day 14✓ (1)
2. It changes into a corpus luteum.✓ (1)
3. Oestrogen✓ and progesterone.✓ (2)
4. The amniotic fluid protects the foetus against shock✓, drying out✓ and temperature changes.✓ (3)
5. Oxygen✓, nutrients✓ (amino acids, glucose, other sugars), viruses✓ and drugs✓ (2)
6. Carbon dioxide✓ and waste products✓ (urea). (2)

[11]

exams

For more questions on the **female reproductive system**, refer to the following National Life Sciences exam paper:

- Life Sciences Paper 1 November 2010 – Question 3.1 on page 12.
- Life Sciences Paper 1 March 2011: Version 1 – Question 3.1 on page 11.

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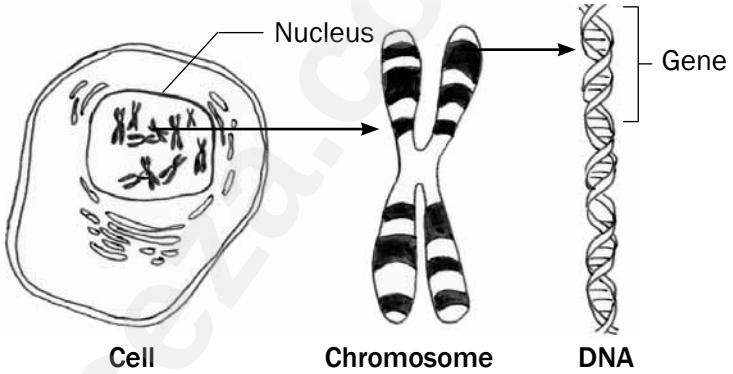
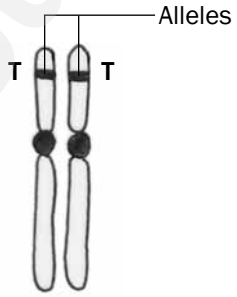
Chapter 5

Paper 2

Genetics

5.1 Key concepts

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

Term	Explanation	Diagram/Additional notes
Gene	A small portion of DNA coding for a particular characteristic.	
Alleles	Different forms of a gene which occur at the same locus (position) on homologous chromosomes.	**Dominant allele (T) – tall plant** **Recessive allele (t) – short plant**
Genotype	Genetic composition (make-up) of an organism.	 • Homozygous dominant (both alleles are dominant) • Genotype TT • Phenotype – tall
Phenotype	The physical appearance of an organism determined by the genotype, e.g. tall, short.	
Dominant allele	An allele that is expressed (shown) in the phenotype when found in the heterozygous (Tt) and homozygous (TT) condition.	• Homozygous recessive (both alleles are recessive) • Genotype tt • Phenotype – short
Recessive allele	An allele that is masked (not shown) in the phenotype when found in the heterozygous (Tt) condition. It is only expressed in the homozygous (tt) condition.	
Heterozygous	Two different alleles for a particular characteristic, e.g. Tt.	• Heterozygous (one dominant and one recessive allele) • Genotype Tt • Phenotype – tall
Homozygous	Two identical alleles for a particular characteristic, e.g. TT or tt.	

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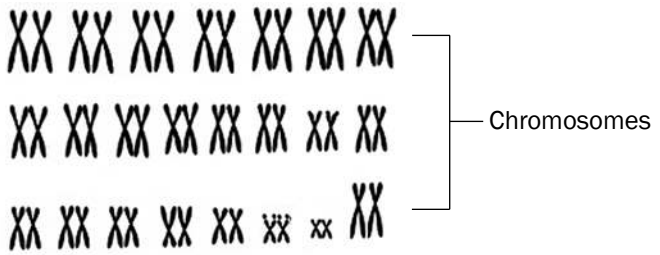
Term	Explanation	Diagram/Additional notes	
Monohybrid cross	Only one characteristic or trait is being shown in the genetic cross.	*Example*: Flower colour only, e.g. yellow flower or white flower **OR** shape of seeds only, e.g. round seeds or wrinkled seeds.	
Complete dominance	A genetic cross where the dominant allele masks (blocks) the expression of a recessive allele in the heterozygous condition.	In this type of cross the allele for tall (T) is dominant over the allele for short (t). The offspring will therefore **be tall** because the dominant allele (T) masks the expression of the recessive allele (t).	Tall (TT) × short (tt) Tall (Tt)
Incomplete dominance	A genetic cross between two phenotypically different parents produces offspring different from both parents but with an intermediate phenotype.	*Example:* If a red-flowered plant is crossed with a white-flowered plant and there is incomplete dominance – the offspring will have **pink flowers (intermediate colour).**	Red flower – White flower Pink flowers
Co-dominance	A genetic cross in which both alleles are expressed equally in the phenotype.	*Example:* If a red-flowered plant is crossed with a white-flowered plant and there is co-dominance the offspring has **flowers with red and white patches.**	Red flower × White flower Flowers with red and white patches
Multiple alleles	More than two alternative forms of a gene at the same locus.	*Example:* Blood groups are controlled by three alleles, namely I^A, I^B and i.	
Sex-linked characteristics	Characteristics or traits that are carried on the sex chromosomes.	*Examples:* Haemophilia and colour-blindness The alleles for haemophilia (or colour-blindness) are indicated as superscripts on the sex chromosomes, e.g. X^HX^H (normal female), X^HX^h (normal female), X^hX^h (female with haemophilia), X^HY (normal male), X^hY (male with haemophilia).	
Karyotype	The number, shape and arrangement of all the chromosomes in the nucleus of a somatic cell.		
Cloning	Process by which genetically identical organisms are formed using biotechnology.	*Example:* Dolly the sheep was cloned using a diploid cell from one parent; therefore it had the identical genetic material of that parent.	
Genetic modification	The manipulation of the genetic material of an organism to get desired changes.	*Example:* The insertion of human insulin gene in plasmid of bacteria so that the bacteria produce human insulin.	
Human genome	The mapping of the exact position of all the genes in all the chromosomes of a human.	*Example:* Gene number 3 on chromosome number 4 is responsible for a particular characteristic.	

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Activity 1

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

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

[5]

Answers to activity 1

1. B✓ **2.** H✓ **3.** C✓ **4.** E✓ **5.** G✓ (5 × 1)

[5]

5.2 Genetic crosses

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

✓ ✓ **P_1** Phenotype × ✓

Genotype × ✓

Meiosis

Gametes × ✓

Fertilisation

F_1 Genotype ✓

Phenotype ✓

OR

Gametes		

1 mark for correct gametes
1 mark for correct genotypes

[6]

1. The problem on the next page shows that a cross between a heterozygous parent (Tt) and a homozygous recessive (tt) parent produces F_1 offspring that are 50% heterozygous (Tt) and 50% homozygous recessive (tt).
2. A cross between a homozygous dominant (TT) parent and a homozygous recessive (tt) parent produces F_1 offspring that are 100% heterozygous (Tt).
3. A cross between a homozygous dominant (TT) and a heterozygous (Tt) parent produces F_1 offspring that are 50% homozygous dominant (TT) and 50% heterozygous (Tt).
4. A cross between two heterozygous (Tt) parents produces F_1 offspring that are 25% homozygous dominant (TT), 50% heterozygous (Tt) and 25% homozygous recessive (tt).

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5.2.1 Complete dominance

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

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

e.g. Genetic problem 1

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

Read the problem carefully and note the following steps:

- Identify the **phenotypes** of the man and the woman (**parents/P_1**), i.e. the man is a tongue-roller and the woman is a non-tongue-roller. .....**Step 1**
- Identify the **genotypes** of the two parents, i.e. the man is **heterozygous** (Tt) and the woman can only be a non-tongue-roller if she is **homozygous recessive** for this characteristic, i.e. she must have the genotype (tt) ..... **Step 2**
- The next step is to show how the alleles are separated through the process of **meiosis** into separate **gametes**, i.e. in the man the gametes (sperm) will contain either the 'T' allele or the 't' allele. In the woman the egg can only contain the 't' allele.....**Step 3**
- The next step shows that **fertilisation** takes place. Indicate all possible combinations of how sperm cells fuse with a possible egg cell to show the possible **genotypes** of the **F_1 generation** that could arise.....**Step 4**
- Interpret the **phenotypes** of all the possible genotypes from the cross .....**Step 5**

Solution to genetic problem 1

	P_1	Phenotype	Tongue-roller ×	Non-tongue-roller✓	.....**Step 1**
		Genotype	Tt ×	tt✓	.....**Step 2**
		Meiosis			
✓	✓	**Gametes**	T and t ×	t ✓	.....**Step 3**
		Fertilisation			.....**Step 4**
	F_1	Genotype	Tt	tt ✓	.....**Step 4**
		Phenotype	Tongue-roller	Non-tongue-roller✓	..... **Step 5**

(Max 6 marks)

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5.2.2 Incomplete dominance

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

e.g. Genetic problem 2

A homozygous snapdragon plant with red flowers (**R**) was cross-pollinated with a homozygous snapdragon plant with white (**W**) flowers. All the plants that grew from the cross had **pink flowers**. Represent a genetic cross to show the possible genotypes and phenotypes of the F_1 generation of plants.

Solution to genetic problem 2

	P_1	Phenotype	Red	×	White✓	**Step 1**
		Genotype	RR	×	WW✓	**Step 2**
		Meiosis				
✓	✓	**Gametes**	R	×	W✓	**Step 3**
		Fertilisation				**Step 4**
	F_1	Genotype	RW✓			**Step 4**
		Phenotype	Pink✓			**Step 5**

5.2.3 Co-dominance

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

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

e.g. Genetic problem 3

A plant with white flowers was cross-pollinated with a plant with red flowers. All the plants that grew from the cross had flowers with **equal distribution of red and white colour**. Represent a genetic cross to show the possible genotypes and phenotypes of the F_1 generation of plants.

Solution to genetic problem 3

	P_1	Phenotype	Red	×	White✓	**Step 1**
		Genotype	RR	×	WW✓	**Step 2**
		Meiosis				
✓	✓	**Gametes**	R	×	W✓	**Step 3**
		Fertilisation				**Step 4**
	F_1	Genotype	RW✓			**Step 4**
		Phenotype	Flower with equal distribution of red and white colour✓			**Step 5**

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5.2.4 Inheritance of sex

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

e.g. Genetic problem 4

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

Solution to genetic problem 4

	P_1	Phenotype	Male	×	Female✓	**Step 1**
		Genotype	XY	×	XX✓	**Step 2**
		Meiosis				
✓	✓	**Gametes**	X and Y	×	X✓	**Step 3**
		Fertilisation				**Step 4**
	F_1	Genotype	XX,		XY✓	**Step 4**
		Phenotype	Female,		Male✓	**Step 5**
					50% chance✓	

5.2.5 Inheritance of sex-linked characteristics

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

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

e.g. Genetic problem 5

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

The alleles for haemophilia are indicated as superscripts on the sex chromosomes, e.g. X^HX^H (normal female), X^HX^h (carrier/heterozygous normal female), X^hX^h (female with haemophilia), X^HY (normal male), X^hY (male with haemophilia).

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Solution to genetic problem 5

P_1	Phenotype	normal father	x	heterozygous/carrier normal mother✓	..... **Step 1**
	Genotype	X^HY	x	X^HX^h ✓	..... **Step 2**
	Meiosis				
✓ ✓	**Gametes**	X^H and Y	x	X^H and X^h✓	..... **Step 3**
	Fertilisation				..... **Step 4**
F_1	Genotype	$X^H X^H$, $X^H X^h$,		X^H Y,	X^h Y✓ ..... **Step 4**
	Phenotype	2 normal daughters		1 normal son	1 son with haemophilia✓**Step 5**

Activity 2

Question 1

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

Fur colour in mice is controlled by a gene with two alleles. A homozygous mouse with black fur was crossed with a homozygous mouse with brown fur. All offspring had black fur. Using the symbols B and b to represent the two alleles for fur colour, show diagrammatically a genetic cross between a mouse that is heterozygous for fur colour and a mouse with brown fur. Show the possible genotypes and phenotypes of the offspring. (6)

Question 2

In rabbits the dominant allele (B) produces black fur and the recessive allele (b) produces white fur. Use a genetic cross to show the possible phenotypes and genotypes of the F_1 generation for fur colour if two heterozygous rabbits are crossed. (6)

exams

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

- Life Sciences Paper 1 November 2010 – Question 2.2 on page 11.
- Life Sciences Paper 1 November 2011 Version 1 – Question 2.1 on page 8.

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Answers to activity 2

Question 1

✓	P_1	Phenotype	Black	×	Brown✓
		Genotype	Bb	×	bb✓
	✓	*Meiosis*			
		Gametes	B and b	×	b✓
		Fertilisation			
	F_1	Genotype	Bb and bb✓		
		Phenotype	Black and brown✓		

(Max 6)

Question 2

✓	P_1	Phenotype	Black × Black ✓
		Genotype	Bb × Bb✓
	✓	*Meiosis*	
		Gametes	B, b × B, b✓
		Fertilisation	
	F_1	Genotype	BB ; Bb ; Bb ; bb✓
		Phenotype	Black ; White✓

any (6)

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5.2.6 Dihybrid cross

- A dihybrid cross involves the inheritance of two characteristics. Mendel explained the results obtained from dihybrid crosses according to his Law of Independent Assortment.
- According to the Law of Independent Assortment, alleles of a gene for one characteristic segregate independently of the alleles of a gene for another characteristic. The alleles for the two genes will therefore come together randomly during gamete formation.
- This means that the two characteristics are transmitted to the offspring independently of one another.
- The above law only applies if the genes for the two characteristics are not on the same chromosome.

Steps you should follow in working out a dihybrid cross:

e.g. Example

In pea plants, the allele for tallness (T) is dominant and the allele for shortness (t) is recessive. The allele for purple flowers is dominant (P) and the allele for white flowers is recessive (p). Two plants, heterozygous for both tallness and purple flowers, were crossed.

STEP	What to do generally	What to do in this problem
Step 1	Identify the phenotypes of the two plants for each of the two characteristics.	According to the statement of the problem, both parents are tall and have purple flowers.
Step 2	Choose letters to represent the alleles for the gene responsible for each characteristic.	Use the letters, e.g. **T** for tall, **t** for short, **P** for purple, and **p** for white as provided in the question.
Step 3	Write the genotypes of each parent.	According to the statement of the problem, both parents are heterozygous for each characteristic. Their genotype will therefore be **TtPp**.
Step 4	• Determine the possible gametes that each parent can produce. • Remember that each parent will have two alleles for each gene. • The gametes of each parent will have only one allele for each gene because of segregation during meiosis. • Remember that because of the principle of independent assortment an allele for one gene could appear in the same gamete with any of the alleles for the other gene.	• Each parent has the genotype TtPp. • If we represent the alleles for each gene in the following format, then we can see how these alleles could come together randomly (principle of independent assortment) to form the four types of gametes: TP; Tp; tP and tp as shown below. Alleles: T, t P: **TP**, **tP** p: **Tp**, **tp**
Step 5	Enter the possible gametes at the top and side of a Punnett square.	Please refer to the solution that follows.

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Step 6	• Because of random fertilisation, gametes from both parents could fuse in different combinations to form the offspring. • In the punnet square, write down the genotypes of the offspring that will result from each possible combination of gametes.	Please refer to the solution that follows.
Step 7	Determine the phenotypes of the offspring from the genotypes obtained in the punnet square.	Please refer to the solution that follows.

Solution to the problem

P_1 Phenotype Tall, Purple × Tall, Purple ..... **Step 1**

Genotype TtPp × TtPp ..... **Step 2,3**

Meiosis and Fertilisation

gametes	TP	Tp	tP	tp
TP	TTPP	TTPp	TtPP	TtPp
Tp	TTPp	TTpp	TtPp	Ttpp
tP	TtPP	TtPp	ttPP	ttPp
tp	TtPp	Ttpp	ttPp	ttpp

Steps 4-6

F_1 Genotype 9 different genotypes, as in the table above

Phenotype 9 tall, purple flowered plants (T–P–);
3 short, purple flowered plants (ttP–);
3 tall, white flowered plants (T–pp), and
1 short, white flowered plant (ttpp)..... **Step 7**

Activity 3

Question

In hamsters, the allele for black coat colour (B) is dominant over the allele for white coat colour (b). The allele for rough coat (R) is dominant over the allele for smooth coat (r). If you cross a hamster that is heterozygous black and homozygous rough, with one that is heterozygous black and heterozygous rough, what will be the phenotypes and genotypes of the offspring? (Use the steps 1–7 to arrive at an answer).

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Answer to activity 3

P_1	Phenotype	Black, Rough coat × Black, Rough coat	...**Step 1**
	Genotype	BbRR × BbRr	..... **Step 2,3**

Meiosis and Fertilisation

gametes	BR	BR	bR	bR
BR	BBRR	BBRR	BbRR	BbRR
Br	BBRr	BBRr	BbRr	BbRr
bR	BbRR	BbRR	bbRR	bbRR
br	BbRr	BbRr	bbRr	bbRr

Steps 4-6

F_1	Genotype	6 different genotypes, as in the table above	
	Phenotype	12 with a black, rough coat and 4 with a white, rough coat	.....**Step 7**

5.3 Mutations

A mutation is any sudden unexpected change in the genetic structure of a cell. Mutations occur suddenly and randomly and may be caused by many environmental agents such as X-rays and certain chemicals.

Mutations may be harmful or harmless to the organism in which they occur. **Harmful mutations** cause changes in DNA that can cause errors in protein sequencing, that can result in partially or completely non-functional proteins. **Harmless mutations** have no effect on the structure or functioning of the organism. **Useful mutations** can be advantageous to the organism and they are passed on from parent to offspring.

Gene mutations are mutations that affect a single or a few base pairs in just a single gene, while **Chromosomal aberrations** refer to changes in the normal structure or number of chromosomes.

Mutations result in new genotypes as we move from one generation to the next. This leads to variation within a species.

Gene mutations can cause genetic disorders:

- **Haemophilia:** Absence of the protein needed for the formation of blood clots due to a mutant gene.
- **Colour blindness:** Absence of the proteins that make up either the red or green cones/photoreceptors in the eye.
- **Albinism:** Absence of the protein that forms the pigment melanin.

Chromosomal aberrations e.g. Down syndrome is where there is an extra chromosome (47 instead of 46) in the zygote.

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5.4 Pedigree diagrams

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

Remember the following steps when interpreting pedigree diagrams:

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

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

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

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

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

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

Activity 4

The pedigree diagram in Figure 5.1 shows inheritance of eye colour in humans over three generations of a family. Brown eye colour (B) is dominant over blue eye colour (b). Study the diagram and then answer the questions that follow.

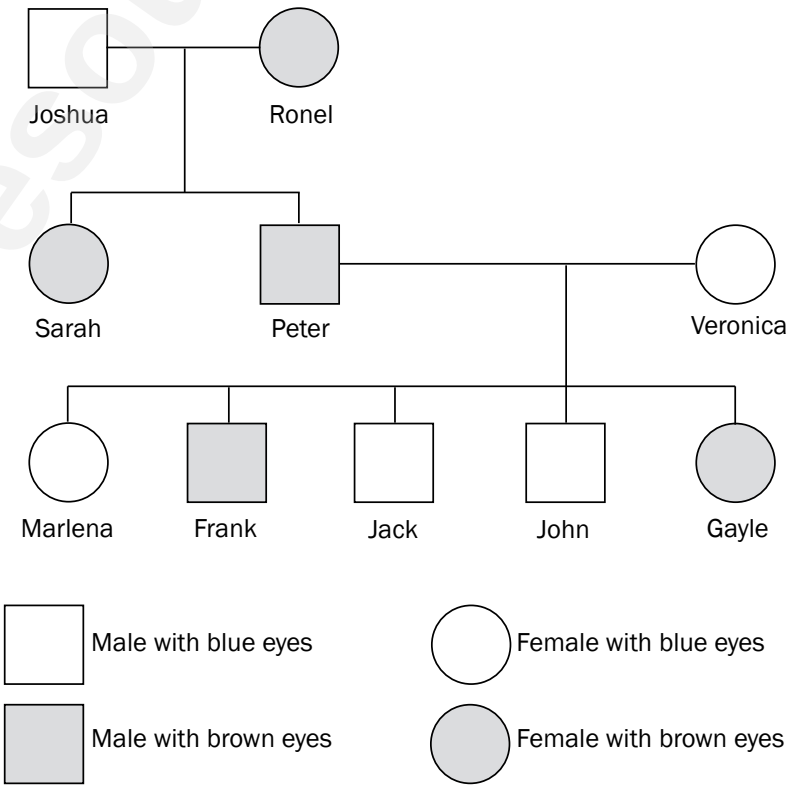

Figure 5.1 Pedigree diagram showing inheritance of eye colour

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Note the following in the pedigree diagram on page 38:

- Squares represent males and circles represent females.
- The horizontal line between a square (Joshua) and a circle (Ronel) shows that they have mated.
- The vertical line flowing from the horizontal line represents the offspring (Sarah and Peter) of the two parents (Joshua and Ronel).
- **Brown eye colour (B) is dominant over blue eye colour (b)** – stated in problem. ..... Step **1**
- Joshua, Jack and John are males with blue eyes.
- Veronica and Marlena are females with blue eyes.
- Peter and Frank are males with brown eyes.
- Ronel, Sarah and Gayle are females with brown eyes.

  Step 2
- Joshua, Veronica, Marlena, Jack and John will have the genotype 'bb'. The recessive characteristic only shows up in the homozygous condition..... **Step 3**
- *Example:* The genotype of Peter is 'Bb' – working backwards from the offspring Marlena or Jack or John who are homozygous recessive. This means that one of the recessive alleles of Marlena, Jack and John, i.e. 'b', must have come from parent Peter and the other one from parent Veronica ..... **Steps 4 and 5**
- Ronel could be homozygous dominant (BB) or heterozygous dominant (Bb) ..... **Step 6**

Questions

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

[9]

Answers to activity 4

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

[9]

exams

For two more problems on **pedigree diagrams** refer to these National Life Sciences exam papers:

- Life Sciences Paper 1 March 2010 – Question 1.5 on page 7.
- Life Sciences Paper 1 March 2012 Version 1 – Question 2.4 on page 11.

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5.5 Genetic engineering

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

Activity 5

Question

State FOUR disadvantages and FOUR advantages of genetic engineering. **[8]**

Answer to activity 5

Four disadvantages of genetic engineering:

- Expensive✓/research money could be used for other needs
- Interfering with nature✓/immoral
- Potential health impacts✓
- Unsure of long-term effects✓ (4)

Four advantages of genetic engineering:

- Production of medication/resources cheaply✓
- Control pests with specific genes inserted into a crop✓
- Using specific genes to increase crop yields✓/food security
- Selecting genes to increase shelf-life of plant products✓ (4)

[8]

5.6 Genetic counselling

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

Activity 6

Question

A young couple wants to have a child, but they are aware of a serious genetic disorder in one of their families that could be carried through to their offspring. State THREE benefits of genetic counselling in this case. **[3]**

Answer to activity 6

Three benefits of genetic counselling:

- To be given advice on the risk of transferring the defective gene✓/ to find the probability of passing on the defective gene to the offspring
- To be given an explanation of the procedure involved in DNA testing✓
- To be given an explanation of the results of DNA testing✓ **[3]**

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Chapter 6

Paper 1

Responding to the environment – humans

The human nervous system

The nervous system is responsible for processing and transmitting information throughout the body:

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

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

6.1 The brain

6.1.1 Structure and functions of the brain

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

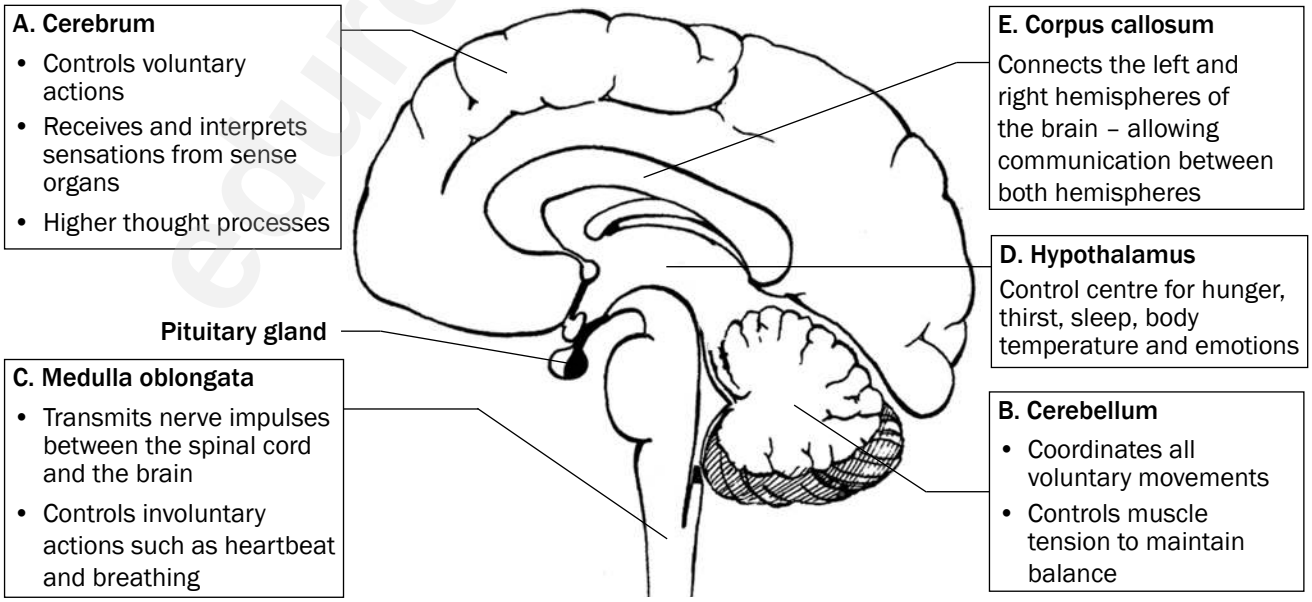

Figure 6.1 The structure and functions of the brain

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Activity 1

Questions

Write down the name of the part which:

1. Controls heartbeat (1)
2. Contains the centres that control balance, muscle tone and equilibrium (1)
3. Has centres that interpret what you see (1)
4. Coordinates voluntary muscle movements (1)
5. Controls body temperature (1)

[5]

Answers to activity 1

1. Medulla oblongata✓ (1)
2. Cerebellum✓ (1)
3. Cerebrum✓ (1)
4. Cerebellum✓ (1)
5. Hypothalamus✓ (1)

[5]

6.2 Neurons

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

hint

About mind maps:

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

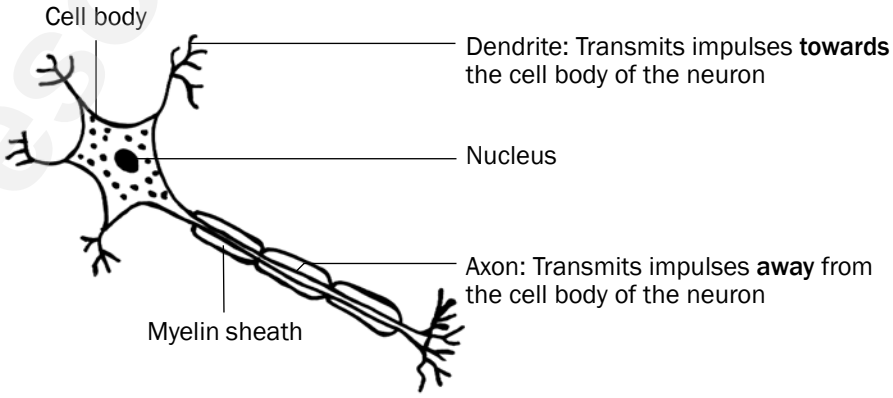

Figure 6.2 A neuron

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

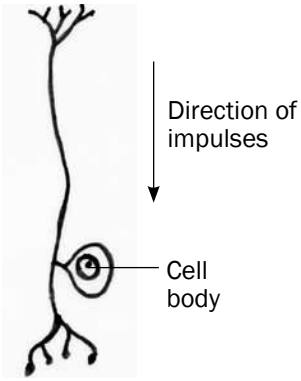
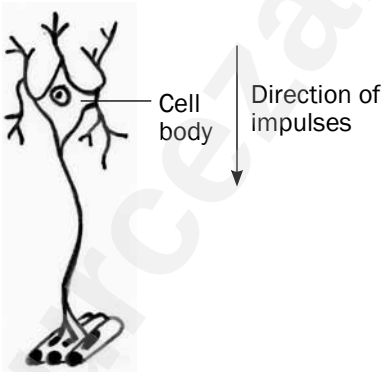
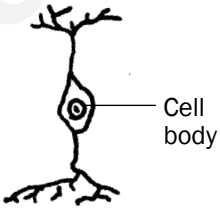
Type of neuron	Function	Structure
Sensory (afferent) neuron **Senses the stimulus**	Transmits impulses from the sense organs or receptors to the spinal cord and brain.	 *Figure 6.3 Sensory neuron*
Motor (efferent) neuron **Response to the stimulus**	Transmits impulses from the brain and spinal cord to the effectors (muscles and glands). The effectors bring about the response.	 *Figure 6.4 Motor neuron*
Interneuron (connector) **Found in the brain and spinal cord**	Links the sensory neuron to the motor neuron.	 *Figure 6.5 Interneuron*

Table 6.1 Sensory, motor and interneurons

A **synapse** is the functional connection between the axon of one neuron, and the dendrites of another neuron.

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6.3 Reflex arc

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

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

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

The path of a reflex arc:

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

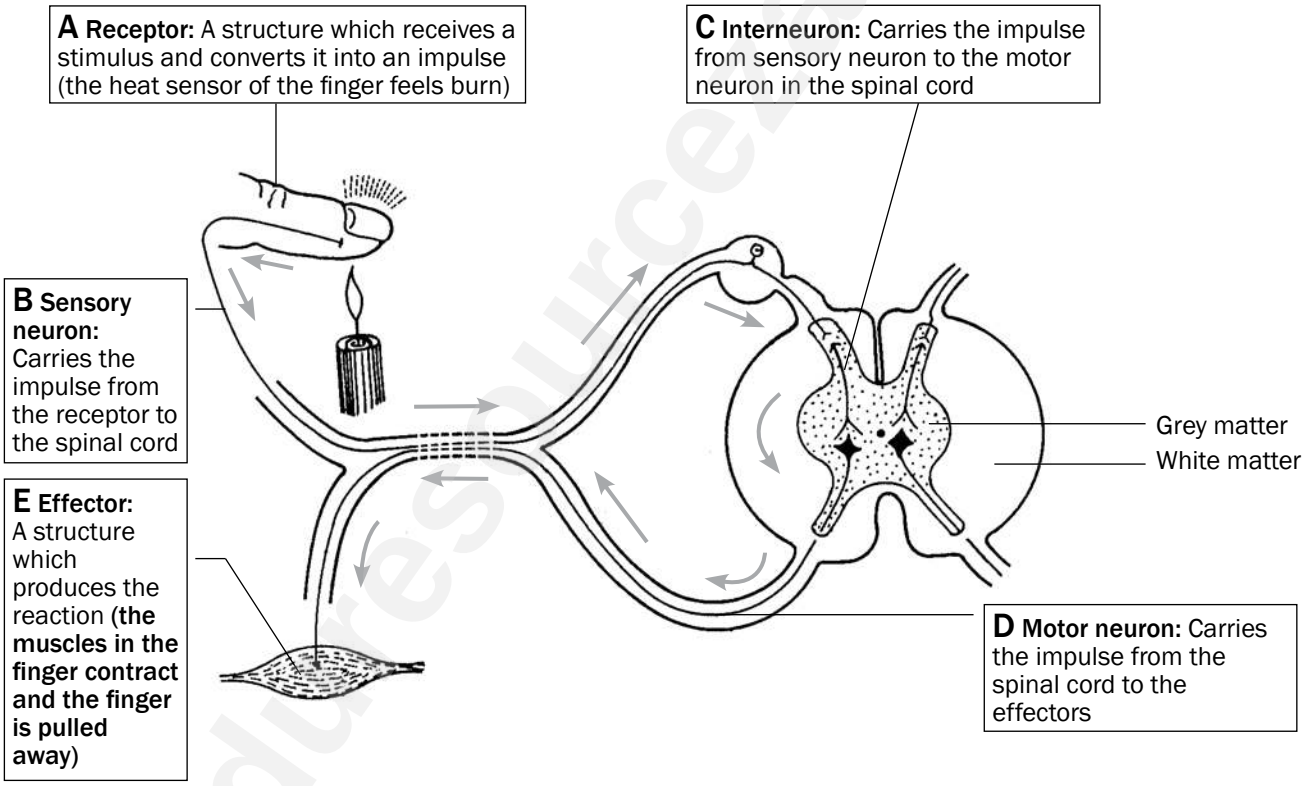

Figure 6.6 The reflex action of withdrawing a finger when placed in a flame

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Activity 2

Questions

Use the diagram of the reflex arc in Figure 6.6 on page 44 to answer the following questions.

1. Part B indicates the ...
   - **A** dendrite of the motor neuron.
   - **B** axon of the motor neuron.
   - **C** dendrite of the sensory neuron.
   - **D** axon of the sensory neuron. (2)
2. The correct sequence in which impulses move from the receptor to the effector in the reflex arc in Figure 6.6 is ...
   - **A** A → B → C → D→ E
   - **B** C → A → B → E→ D
   - **C** C → B → E → D→ A
   - **D** A → D → E → B→ C (2)
3. Give the correct term for the following definitions:
   - **a)** A structure which receives a stimulus and converts it into a impulse
   - **b)** A structure which responds to a stimulus, e.g. a muscle or gland
   - **c)** A neuron that carries impulses from the central nervous system to the effectors
   - **d)** A neuron that carries impulses from the receptors to the central nervous system
   - **e)** A neuron that carries impulses from a sensory neuron to a motor neuron in the spinal cord
   - **f)** A very quick, automatic action that involves the spinal cord and not the brain
   - **g)** The pathway along which an impulse is transmitted to bring about a response to a stimulus during a reflex action 7 × 1 = (7)

[11]

Answers to activity 2

1. C✓✓ (2)
2. A✓✓ (2)
3. **a)** Receptor✓
   - **b)** Effector✓
   - **c)** Motor/efferent neuron✓
   - **d)** Sensory/afferent neuron✓
   - **e)** Interneuron✓/ connector
   - **f)** Reflex action✓
   - **g)** Reflex arc✓ 7 × 1 = (7)

[11]

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6.4 The human eye

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

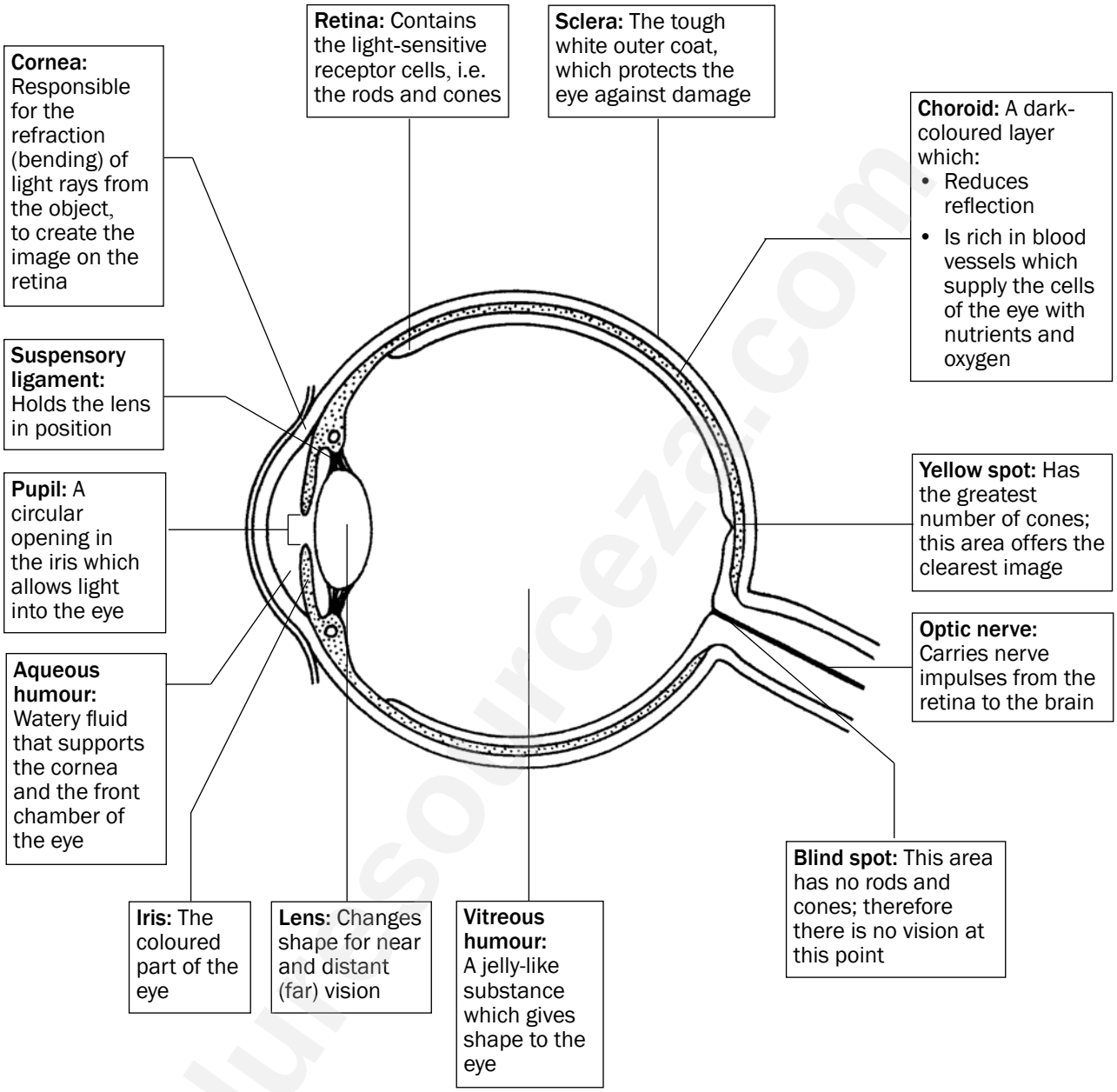

Figure 6.7 The structure of the eye

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6.4.1 Accommodation

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

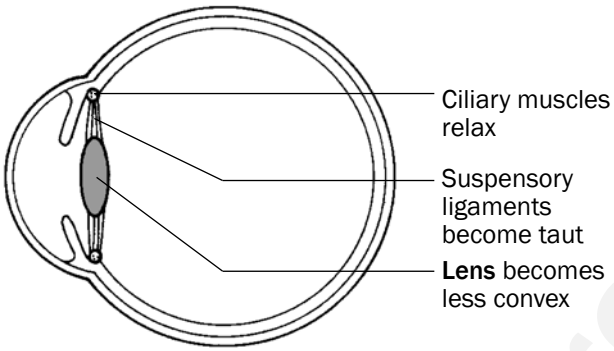
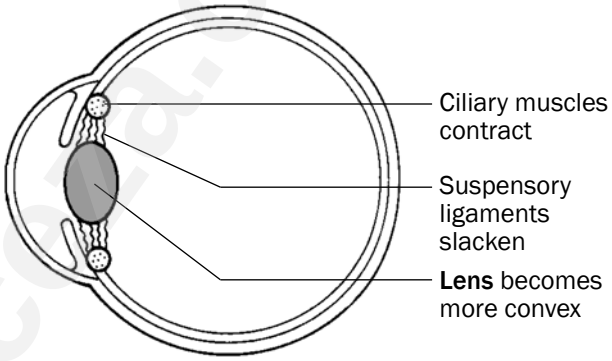
Distant vision (objects further than 6 m)	Near vision (objects closer than 6 m)
1. Ciliary muscles relax	1. Ciliary muscles contract
2. Suspensory ligaments tighten (become taut)	2. Suspensory ligaments slacken
3. Tension on **lens** increases	3. Tension on **lens** decreases
4. **Lens** is less convex (flatter)	4. **Lens** becomes more convex (more rounded)
5. Light rays are refracted (bent) less	5. Light rays are refracted (bent) more
6. Light rays are focused onto the retina	6. Light rays are focused onto the retina
 *Figure 6.8 Distant vision*	 *Figure 6.9 Near vision*

Table 6.2 Accommodation of the eye for distant and near vision

6.4.2 Pupillary mechanism

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

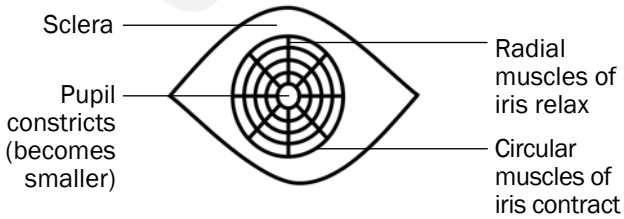
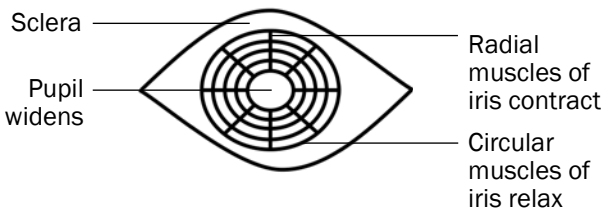
Light is bright	Light is dim
1. Radial muscles of the iris relax	1. Radial muscles of the iris contract
2. Circular muscles of the iris contract	2. Circular muscles of the iris relax
3. Pupil constricts (gets smaller)	3. Pupil widens (gets bigger)
4. Less light enters the eye	4. More light enters the eye
 *Figure 6.10 The pupil in bright light*	 *Figure 6.11 The pupil in dim light*

Table 6.3 Pupillary mechanism

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6.4.3 Visual defects

Short sightedness

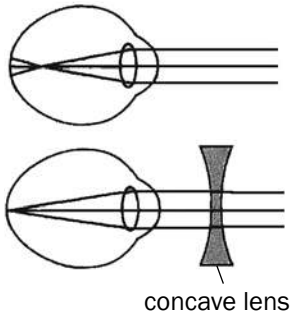

Figure 6.12 A

Long sightedness

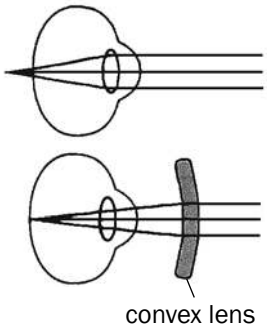

Figure 6.12 B

Visual defect	Nature of the defect	Corrective measures
Short-sightedness Near objects can be seen clearly (myopia)	• Inability of lens to become more flat/eyeball is longer than normal • Lens bends the light rays too much • As a result it falls in front of the retina • causing the image to be blurred • Cannot see distant objects clearly	Wearing glasses with converging (biconcave) lens Figure 6.12 A
Long-sightedness Objects far away can be seen clearly (hyperopia)	• Inability of lens to become more convex/eyeball is shorter than normal • Lens does not bend light rays enough • As a result it falls behind the retina • causing the image to be blurred • Cannot see near objects clearly	Wearing glasses with converging (biconvex) lens Figure 6.12 B
Astigmatism	• The curvature of the lens or cornea is uneven resulting in distorted images	Glasses with lenses shaped to correct the distortion
Cataracts	• Lens becomes cloudy and opaque	Surgery to replace the lens with a synthetic lens

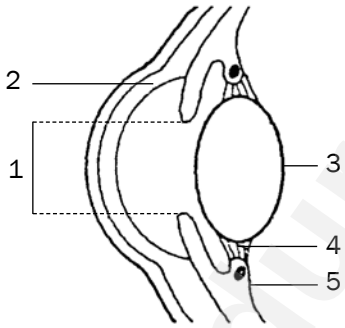

Figure 6.13 Longitudinal section through the human eye

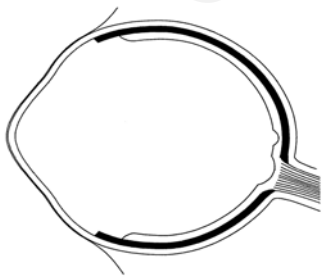

Figure 6.14 Longitudinal section through a human eye

Activity 3

Questions

1. Figure 6.13 shows a longitudinal section through the human eye. Study the diagram and answer the questions that follow.
   a) Label parts 2, 3, 4 and 5 respectively. (4)
   b) Name and describe the process that causes part 1 to dilate (become wider). (5)
2. Figure 6.14 is a longitudinal section through the human eye. The structures which enable the eye to focus on objects are missing in this diagram. Study the diagram and answer the questions that follow.

   Draw a longitudinal section through the missing parts of Figure 6.14 to indicate the appearance of these structures when you are ...
   a) reading a book. (6)
   b) looking at an object more than 6 metres away. (6)

[21]

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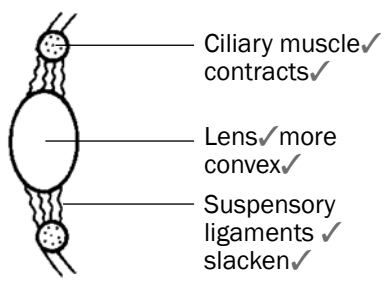
Answers to activity 3

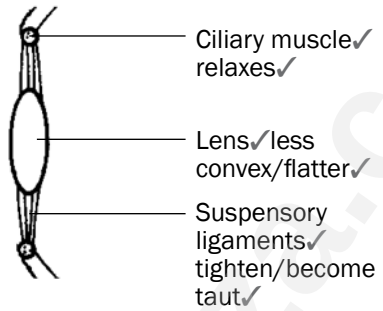
1. a) 2 – Cornea✓
   3 – Lens✓
   4 – Suspensory ligaments✓
   5 – Ciliary muscles✓/ body (4)

   b) Pupillary mechanism✓/ pupil reflex
   The radial muscles✓of the iris contract✓and the circular muscles✓ relax.✓
   The pupil dilates and more light enters the eye.✓ (5)

2. a) b)



(6)



(6)

[21]

6.5 The human ear

6.5.1 Structure of the ear

The human ear consists of three main parts:

- The outer ear
- The middle ear
- The inner ear

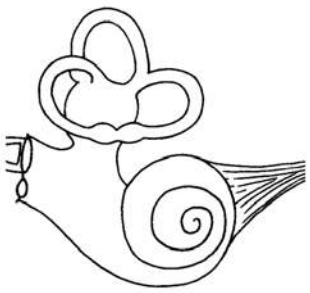
Outer	Middle	Inner
		

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Figure 6.15 below shows the structure and function of each part of the human ear.

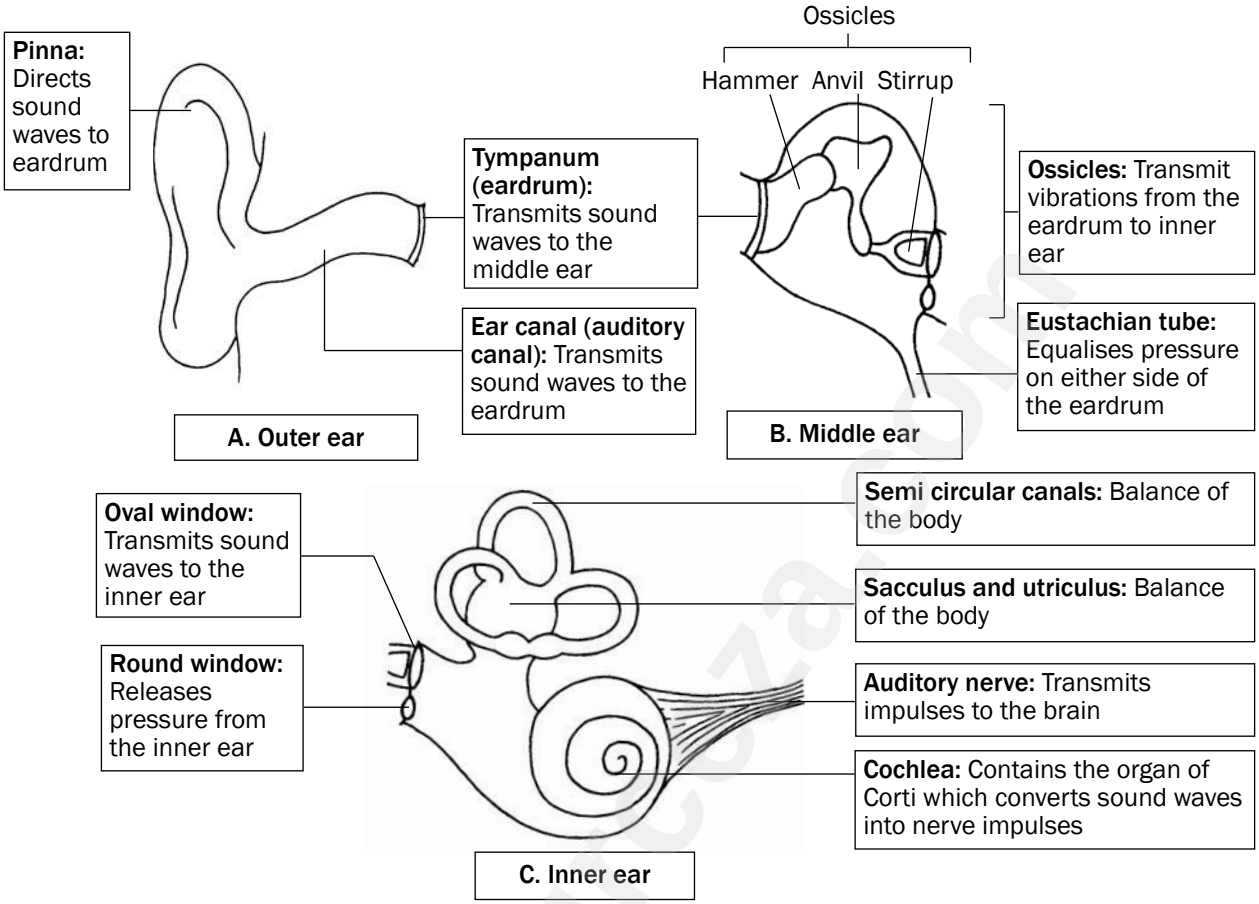

Figure 6.15 The structure of the ear

6.5.2 Hearing

Figure 6.16 below shows how the three parts of the ear work together to make it possible for us to hear. **The grey arrows show the path of a sound wave.**

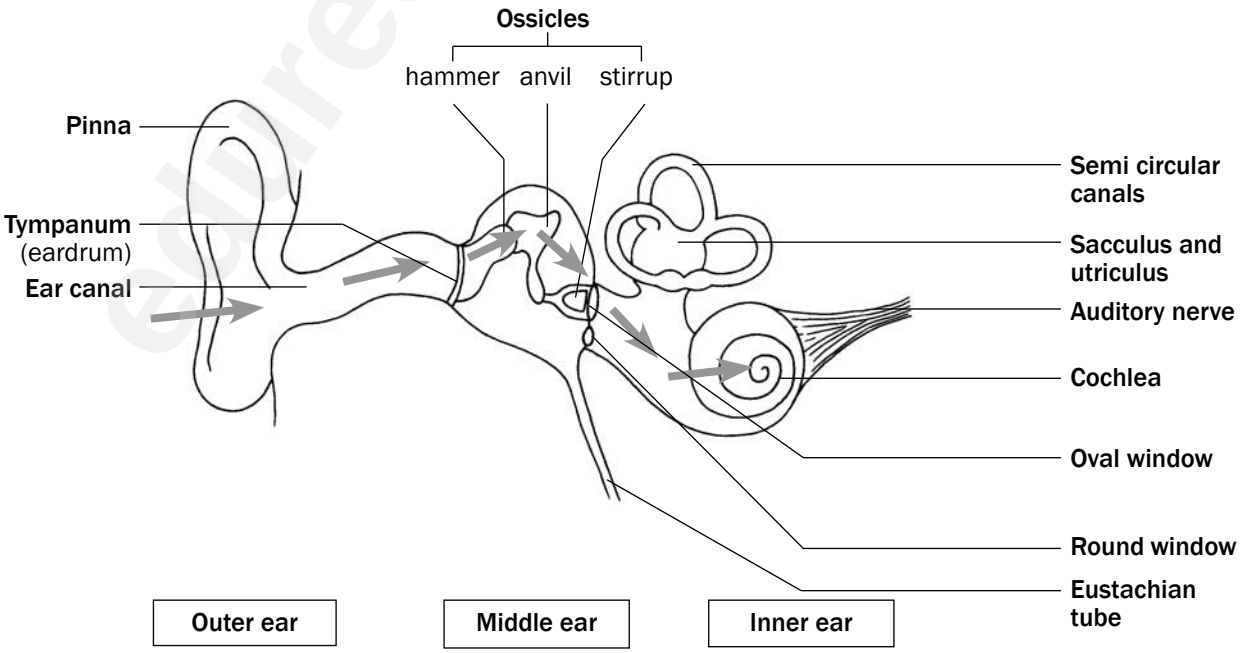

Figure 6.16 How hearing takes place

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Look at Figure 6.16 above and read the information in Table 6.4 below to understand how hearing takes place.

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

Table 6.4 The hearing process

6.5.3 Balance

The human ear is responsible for balance in this way:

1. The **cristae** in the semicircular canals are stimulated by changes in the direction and speed of movement
2. The **maculae** in the sacculus and utriculus are stimulated by changes in the position of the head

When stimulated, the cristae and maculae convert the stimuli received into nerve impulses.

The nerve impulses are transported along the auditory nerve to the **cerebellum** to be interpreted.

The cerebellum then sends impulses to the muscles to restore balance.

6.5.4 Hearing defects

Hearing defect	Causes	Treatment
Middle ear infection	• Excess fluid in the middle ear caused by pathogen infection	• Inserting grommets • Antibiotics
Deafness	• Injury to parts of the ear, nerves or parts of brain responsible for hearing • Hardened wax • Hardening of ear tissues such as ossicles	• Hearing aids • Cochlear implants

Table 6.5 Hearing defects

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Activity 4

Questions

Study Figure 6.17 below and answer the questions that follow.

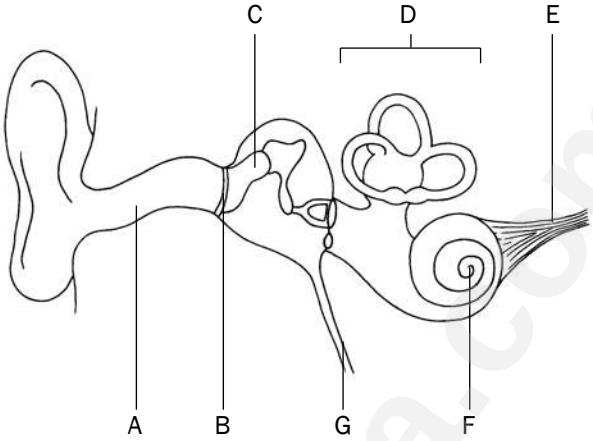

Figure 6.17 Parts of the ear

1. Identify the parts labelled B, C and F. (3)
2. Give the function of the pinna. (2)
3. Write the letter of the part which:
   a) contains receptors for balance. (1)
   b) equalises the pressure on either side of part B. (1)
   c) transmits impulses to the brain. (1)
4. Describe how hearing occurs. (8)

[16]

exams

For more questions on the **human nervous system**, refer to the following National Life Sciences exam papers:

- Life Sciences Paper 2 March 2012: Version 1 – Question 2.1 on page 9 and Question 2.2 on page 10.
- Life Sciences Paper 2 November 2011: Version 1 – Question 1.4 on page 9; Question 2.1 on page 11 and Question 2.2 on page 12.

Answers to activity 4

1. B – Tympanic membrane✓
   C – Malleus/hammer/an ossicle✓
   F – Cochlea✓ (3)
2. It directs sound waves✓ into the auditory canal✓. (2)
3. a) D✓
   b) G✓
   c) E✓ (3)
4.
   - Sound waves are directed into the auditory canal✓ by the pinna✓.
   - The sound waves make the tympanic membrane vibrate✓ and the vibrations are passed on to the ossicles✓ in the middle ear.
   - The ossicles make the oval window vibrate✓ and this causes pressure waves to be set up in the inner ear.
   - These vibrations also cause the organ of Corti✓ to be stimulated and it generates impulses which are sent to the cerebrum✓ along the auditory nerve✓.
   - The cerebrum interprets the impulses as sound✓. (8)

[16]

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Chapter 7

Endocrine system

7.1 The human endocrine system

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

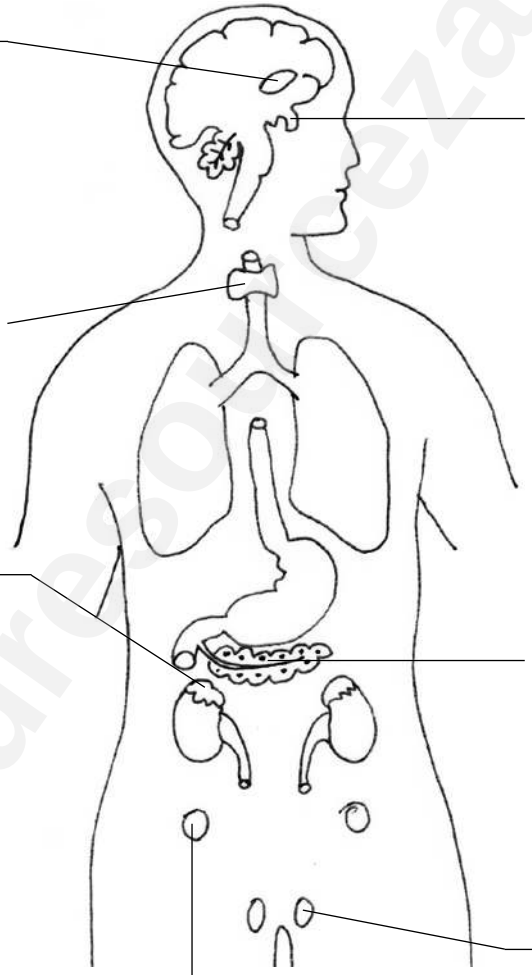
Hypothalamus:
ADH (antidiuretic hormone)
- Target organ: Kidney
- Controls the concentration of water in the blood

Thyroid gland:
Thyroxin
- Controls basic metabolic rate

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

Decreases:
- blood flow to the digestive system and skin

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



Ovary (only females):
Reproductive hormones:
Oestrogen and ***progesterone***
- Oestrogen – stimulates puberty in females, promotes thickening of the endometrium
- Progesterone – promotes thickening of the endometrium, maintains pregnancy

Pituitary gland (hypophysis):
GH (growth hormone)
- Controls growth

TSH (thyroid stimulating hormone)
- Stimulates thyroid gland to secrete thyroxin

Reproductive hormones:
FSH, LH and prolactin
- FSH – stimulates the development of the follicle in the ovaries
- LH – stimulates ovulation, and stimulates development of the corpus luteum
- Prolactin – stimulates the mammary glands to secrete milk

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

Insulin
- Stimulates conversion of glucose to glycogen (reduces the blood glucose levels)

Testes (only males):
Reproductive hormone:
Testosterone
- Stimulates the maturation of sperm cells
- Stimulates puberty in males

Figure 7.1 The human endocrine system

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7.2 Negative feedback

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

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

7.2.1 General sequence of events in a negative feedback mechanism

Step 1: An imbalance is **detected**.

Step 2: A control centre is **stimulated**.

Step 3: Control centre responds.

Step 4: Message sent to target organ/s.

Step 5: The target organ **responds**.

Step 6: It **opposes/reverses** the imbalance.

Step 7: Balance is restored.

7.2.2 Example of a negative feedback mechanism

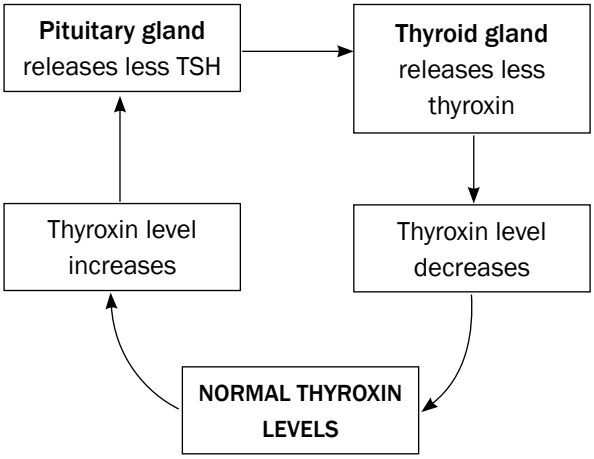
We will look at the regulation of thyroxin in the human body. There are two glands involved in the control of thyroxin levels:

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

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

Situation 1

Step 1:	Thyroxin levels **increase** above normal limits
Step 2:	Pituitary gland is stimulated
Step 3:	Pituitary gland produces **less TSH**
Step 4:	Low TSH level stimulates the thyroid gland
Step 5:	The thyroid gland secretes **less thyroxin**
Step 6:	The thyroxin level thus **decreases**
Step 7:	Thyroxin level returns to normal



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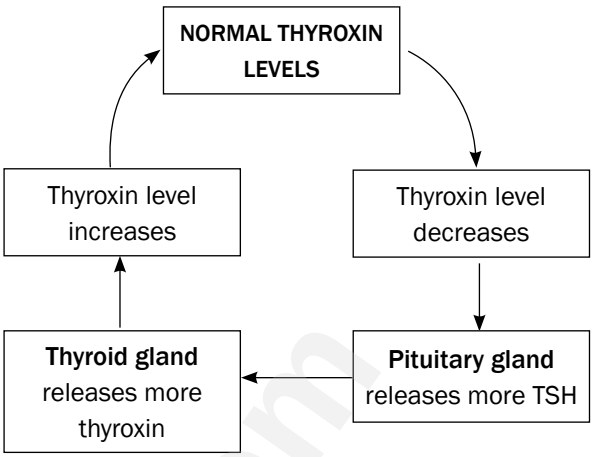
Situation 2	
Step 1:	Thyroxin levels **decrease** below normal limits
Step 2:	Pituitary gland is stimulated
Step 3:	Pituitary gland produces more TSH
Step 4:	High TSH level stimulates the thyroid gland
Step 5:	The thyroid gland secretes more thyroxin
Step 6:	The thyroxin level thus increases
Step 7:	Thyroxin level returns to normal



Activity 1

Question

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

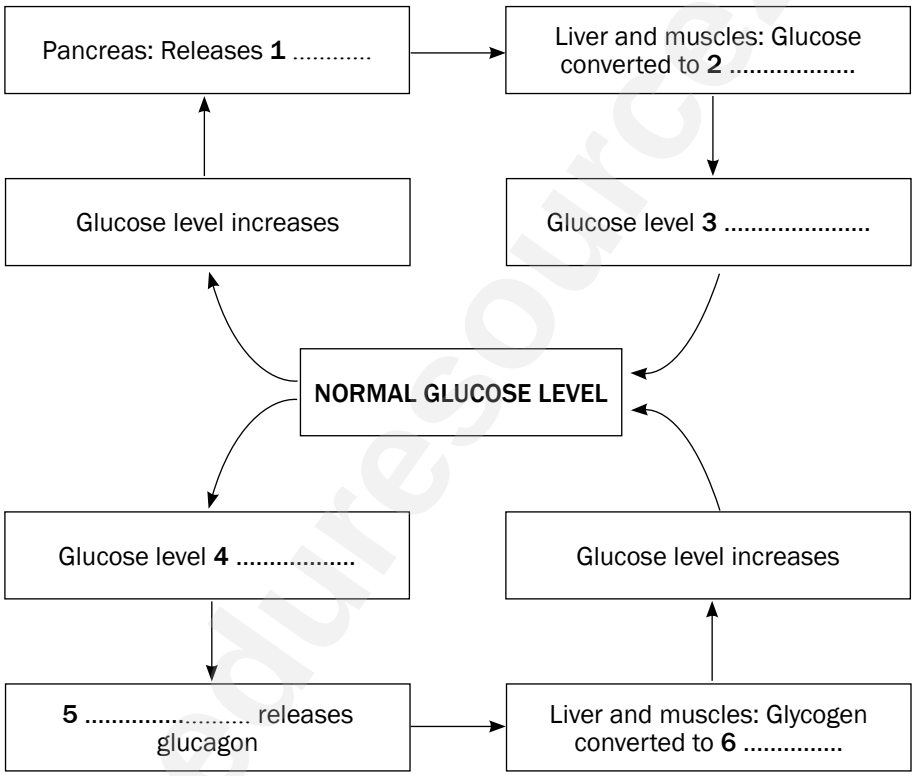


Figure 7.2 The negative feedback system to control glucose levels in the body

Answers to activity 1

1. Insulin✓
2. Glycogen ✓
3. Decreases✓
4. Decreases✓
5. Pancreas ✓
6. Glucose✓

[6]

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8 Chapter

Homeostasis in humans

8.1 Introduction

Homeostasis is the process of maintaining a constant internal environment within the body. The internal environment refers to the blood and tissue fluid that surrounds the cells of the body. Homeostasis enables the body to function efficiently, despite changes that might occur in the external or internal environment.

Changes in temperature, glucose levels, carbon dioxide levels, water levels and salt levels of the internal environment affects the homeostatic balance of the body. Negative feedback mechanisms operate in the human body to detect changes or imbalances in the internal environment and to restore the balance.

8.2 Negative feedback mechanisms

General sequence of events in a negative feedback mechanism :

Step 1: An imbalance is **detected**.

Step 2: A control centre is **stimulated**.

Step 3: Control centre **responds**.

Step 4: **Message** sent to target organs/s.

Step 5: The target organ **responds**.

Step 6: It **opposes/reverses** the imbalance.

Step 7: **Balance** is restored.

8.2.1 The regulation of glucose levels in the internal environment

When the glucose level in the blood increases above normal levels:	
Step 1	Glucose levels in the blood **increase** above normal levels
Step 2	The **pancreas** is stimulated
Step 3	to secrete **insulin** into the blood
Step 4	**Insulin** travels in the blood to the **liver**
Step 5	where it stimulates the conversion of excess glucose to **glycogen** which is then stored
Step 6	The glucose level in the blood now **decreases**
Step 7	and returns to **normal**

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When the glucose level in the blood decreases below normal levels:	
Step 1	Glucose levels in the blood **decrease** below normal levels
Step 2	The pancreas is stimulated
Step 3	to secrete **glucagon** into the blood
Step 4	Glucagon travels in the blood to the liver
Step 5	where it stimulates the conversion of stored glycogen to glucose
Step 6	The glucose level in the blood now **increases**
Step 7	and returns to normal

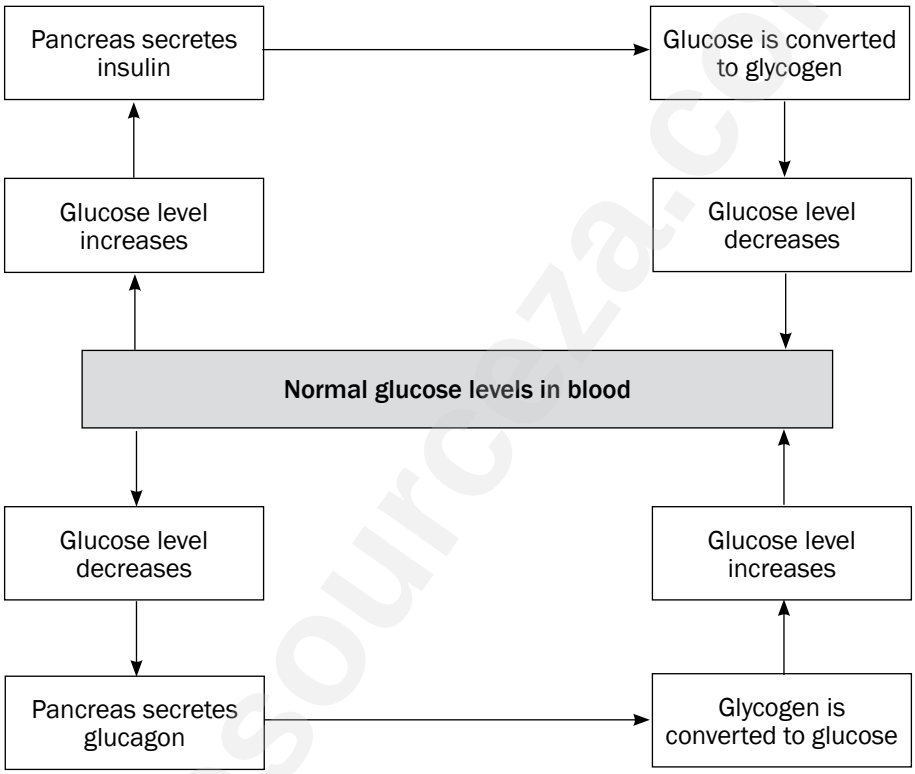

Figure 8.1 Negative feedback mechanism to regulate the glucose levels

8.2.2 The regulation of carbon dioxide levels in the internal environment

When the CO_2 level in the blood increases above normal levels:	
Step 1	CO_2 levels in the blood **increase** above normal levels
Step 2	Receptor cells in the carotid artery in the neck are stimulated
Step 3	To send impulses to the medulla oblongata in the brain
Step 4	Medulla oblongata stimulates breathing muscles (intercostal muscles and diaphragm) and heart
Step 5	Breathing muscles contract more actively – increases the rate and depth of breathing. The heart beats faster.
Step 6	More CO_2 is taken to and exhaled from the lungs
Step 7	The CO_2 level in the blood returns to normal

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8.2.3 The regulation of water balance in the internal environment (osmoregulation)

When the blood has less water than normal:	
Step 1	Blood has less water than normal
Step 2	The hypothalamus is stimulated
Step 3	and sends impulses to the pituitary gland to secrete more ADH
Step 4	ADH travels in the blood to the kidneys
Step 5	ADH increases the permeability of the collecting ducts and the distal convoluted tubules of the kidney
Step 6	More water is re-absorbed and passed to the surrounding blood vessels
Step 7	The water level in the blood returns to normal

When the blood has more water than normal:	
Step 1	Blood has more water than normal
Step 2	The hypothalamus is stimulated
Step 3	and sends impulses to the pituitary gland to stop secreting ADH/to secrete less ADH
Step 4	No ADH/less ADH travels in the blood to the kidneys
Step 5	The collecting ducts and the distal convoluted tubules of the kidney become less permeable to water
Step 6	Less water is re-absorbed and passed to the surrounding blood vessels. More water is now lost
Step 7	The water level in the blood returns to normal

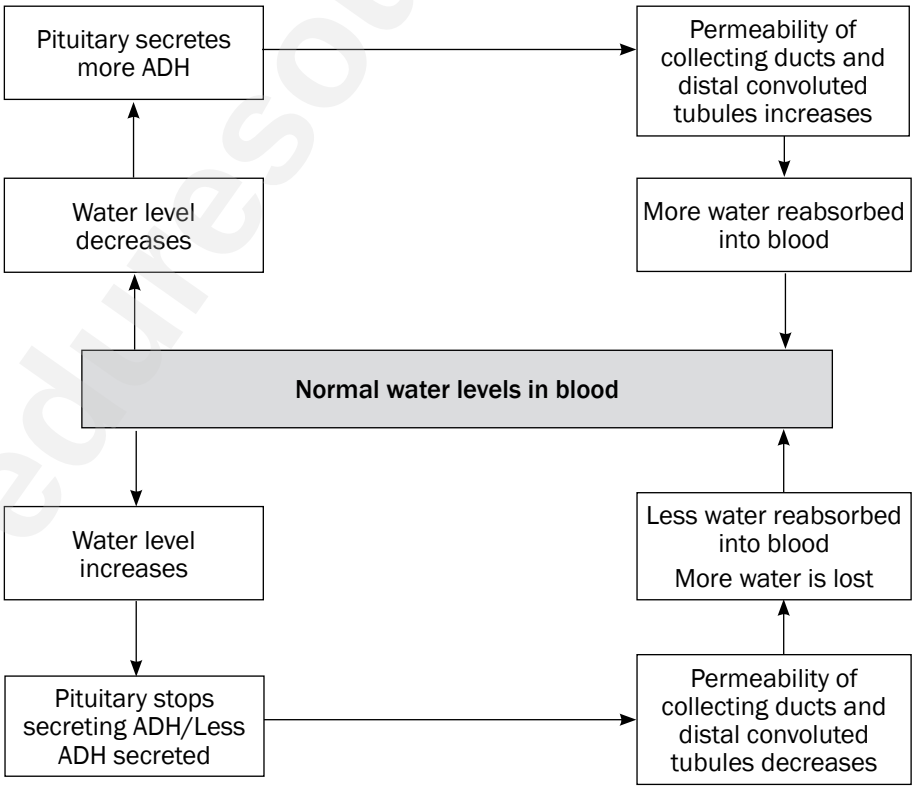

Figure 8.2 Negative feedback mechanism to regulate the water balance

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8.2.4 The regulation of salt balance in the internal environment

When the salt level in the blood decreases:	
Step 1	The salt level in the blood decreases
Step 2	Receptor cells in the afferent and efferent arterioles of the kidney detect the low salt level
Step 3	The adrenal gland is stimulated
Step 4	into secreting more aldosterone
Step 5	Aldosterone increases the re-absorption of sodium ions from the renal tubules in the kidney into the surrounding blood vessels
Step 6	The salt level in the blood vessels increases
Step 7	and returns to normal

When the salt level in the blood increases:	
Step 1	The salt level in the blood increases
Step 2	Receptor cells in the afferent and efferent arterioles of the kidney detect the high salt level
Step 3	The adrenal gland is stimulated
Step 4	to stop secreting aldosterone/to secrete less aldosterone
Step 5	This decreases the re-absorption of sodium ions from the renal tubules in the kidney into the surrounding blood vessels
Step 6	The salt level in the blood vessels decreases
Step 7	and returns to normal

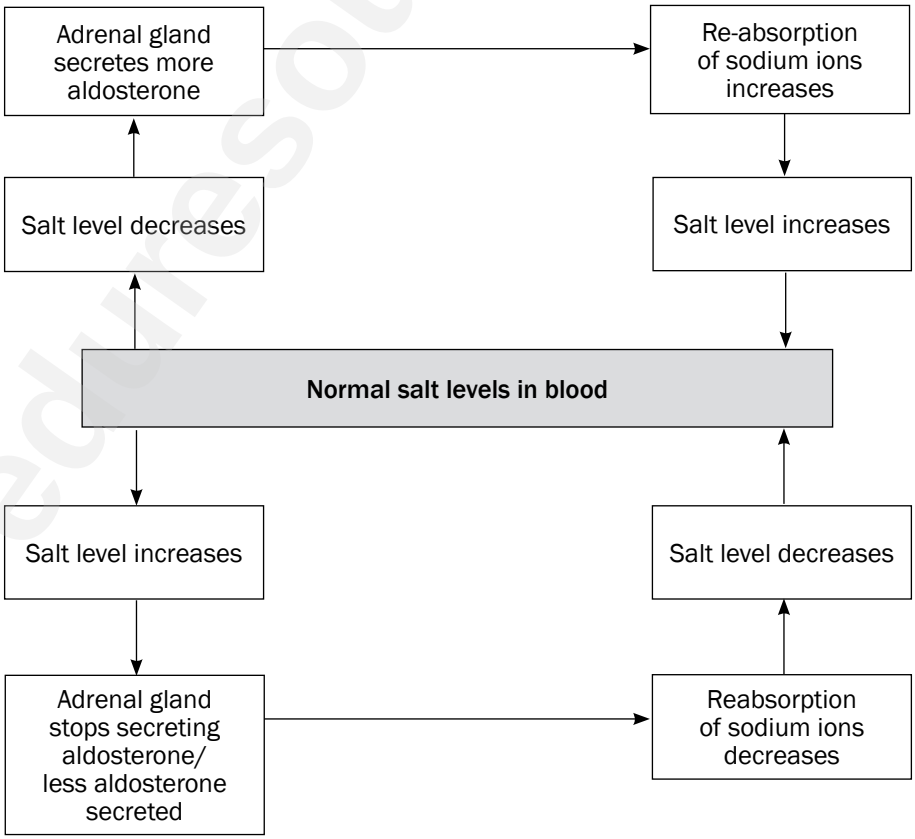

Figure 8.3 Negative feedback mechanism to regulate the salt balance

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8.3 The process of temperature regulation

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

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

Figure 8.4 below shows how the body temperature is regulated by the hypothalamus and the skin.

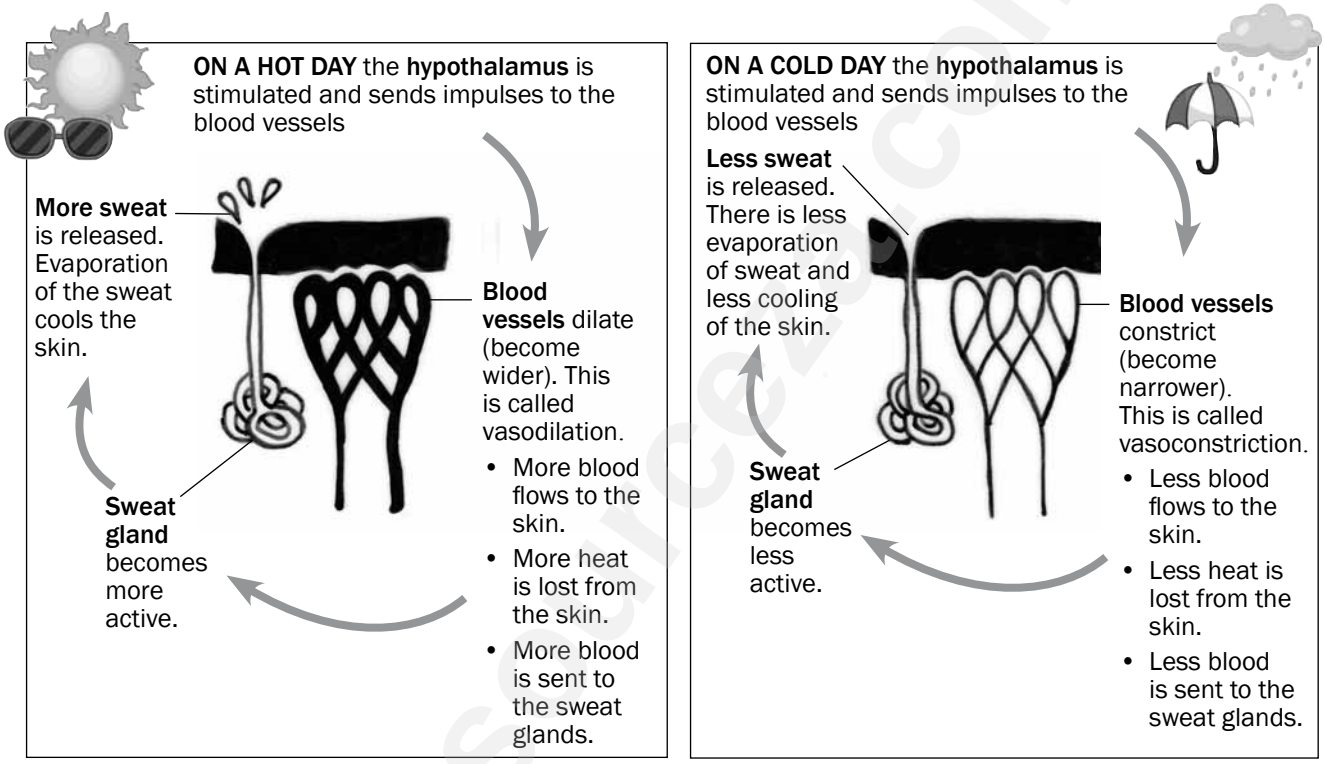

Figure 8.4 The homeostatic mechanism to regulate body temperature

Activity 1

Questions

1. Name the heat regulation centre in the brain. (1)
2. What happens to the blood vessels of the skin on a cold day? (1)
3. Describe how the state of the blood vessels mentioned in question 2 decreases heat loss. (4)
4. What happens to blood vessels of the skin on a hot day? (1)
5. Describe how the state of the blood vessels mentioned in question 4 increases heat loss. (4)

[11]

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Answers to activity 1

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

[11]

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9 Chapter

Responding to the environment – plants

9.1 Growth and development in plants

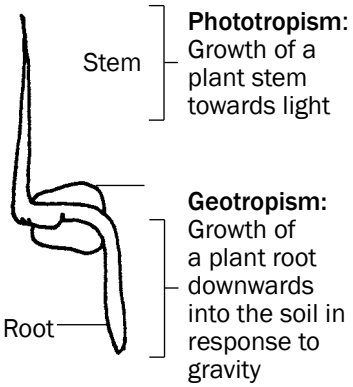

Figure 9.1 A germinating seedling

Growth and development in plants are controlled by hormones. Auxin is an example of a hormone.

Tropism is the growth or turning movement of a plant or part of a plant in response to an environmental stimulus.

- **Phototropism** is the growth of a plant in the direction of a **light** source.
- **Geotropism** is the growth of a plant in response to **gravity**.

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

Activity 1

Questions

Complete the table:

Term	Description
a)	Chemical messenger in the plant
b)	Growth of a plant stem towards light
Geotropism	c)
Tropism	d)

[4]

Answers to activity 1

a) Plant hormone✓
b) Phototropism✓
c) Growth of a plant root in response to gravity✓
d) Growth movement of a part of a plant in response to an environmental stimulus✓ [4]

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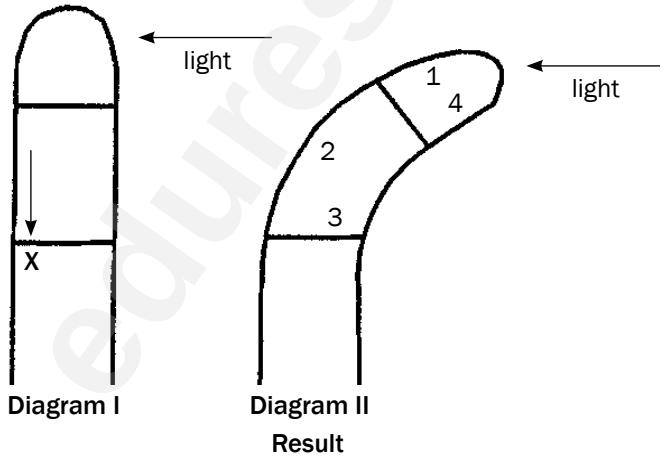
9.2 Role of auxins in phototropism and geotropism

Role of auxins in phototropism	Role of auxins in geotropism
Produced at the tip of stem/shoot	Produced at the tip of roots
Auxins move downward evenly	Auxins move upwards evenly
This even distribution brings about equal growth on all sides of the stem	This even distribution brings about equal growth on all sides of the root
As a result the stem grows upward	As a result the root grows downward
When the stem is exposed to **unilateral light** (light from one side only)	When the root is placed **horizontally** (only one side exposed to gravity)
The auxin concentration will be high on the dark side – light destroys auxins	The auxin concentration will be high on the lower side of the root - gravity attracts auxins
More growth occurs on the dark side because auxins stimulate growth on the dark side	More growth occurs on the upper side of the root because auxins on the lower side inhibit growth
As a result the stem bends towards the light	As a result the root bends downwards

Activity 2

Questions

QUESTIONS 1 to 2 are based on Diagrams I and II which illustrate the response of the tip of a young shoot to a light stimulus.



1. The arrow **X** represents the unequal distribution of ...
   - **A** abscisic acid.
   - **B** mineral salts.
   - **C** gibberellins.
   - **D** auxins.

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2. The curving of the shoot in Diagram II is due to more rapid cell growth in region(s) ...
   A 1.
   B 2.
   C 1 and 4.
   D 3 and 4.

3. The diagram above represents ...
   A. geotropism.
   B. apical dominance.
   C. phototropism.
   D. gravity. 3 × 2

[6]

Answers to activity 2

1. D✓✓
2. B✓✓
3. C✓✓ 3 × 2

[6]

9.3 Plant defence mechanisms

Plants are eaten by herbivores and attacked by pathogenic organisms such as viruses, bacteria and fungi, causing them to become diseased. Plants protect themselves from these threats using chemicals and thorns.

Activity 3

1. Describe TWO methods used by plants as defence mechanisms (4)

Answers to activity 3

1. Plants have thorns✓ on their stems and leaves. They are unable to escape from herbivores, and the thorns are used to protect themselves. ✓
   The chemical secretion of plants is poisinous to some organisms. ✓
   Sticky secretions given of by plants make it difficult for insects and animals to eat the plant ✓

[4]

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Chapter 10

Evolution

A theory is an explanation of something that has been observed in nature which can be supported by facts, generalisations, tested hypotheses, models and laws.

A hypothesis is a possible solution to a problem.

10.1 Evidence for evolution

- **Fossil evidence:** The evidence that shows characteristics that make us similar to, or different from African apes comes largely from a study of fossils (thousands of fossil fragments).
- **Genetic evidence:** Scientists state that organisms are closely related and are likely to have a common ancestor if they have:
  - Identical DNA structure
  - Similar sequence of genes
  - Similar portions of DNA with no functions and
  - Similar mutations (mitochondrial DNA)

  Species that are closely related have a greater similarity to each other than distant species.
- **Cultural evidence:** Cultural evidence from studies of tools and weapons, as well as language is also used to show similarities and differences between humans and African apes.

10.2 Sources of variation

The genotypes and therefore phenotypes (appearance) of individuals of the same species are different from each other because:

- **Crossing over** in Prophase I of meiosis involves an exchange of genetic material, leading to new combinations of maternal and paternal genetic material in each new cell resulting from meiosis.
- **Random arrangement of maternal and paternal chromosomes** at the equator during metaphase allows different combinations of chromosomes/chromatids to go into each new cell resulting from meiosis, making them different.
- **Random fertilisation** between different egg cells and different sperm cells formed by meiosis result in offspring that are different from each other.
- **Random mating** between organisms within a species leads to a different set of offspring from each mating pair.
- **A mutation** changes the structure of a gene or chromosome and therefore the organism's genotype. Since the genotype influences the phenotype, it creates organisms with new, different characteristics from one generation to the next.

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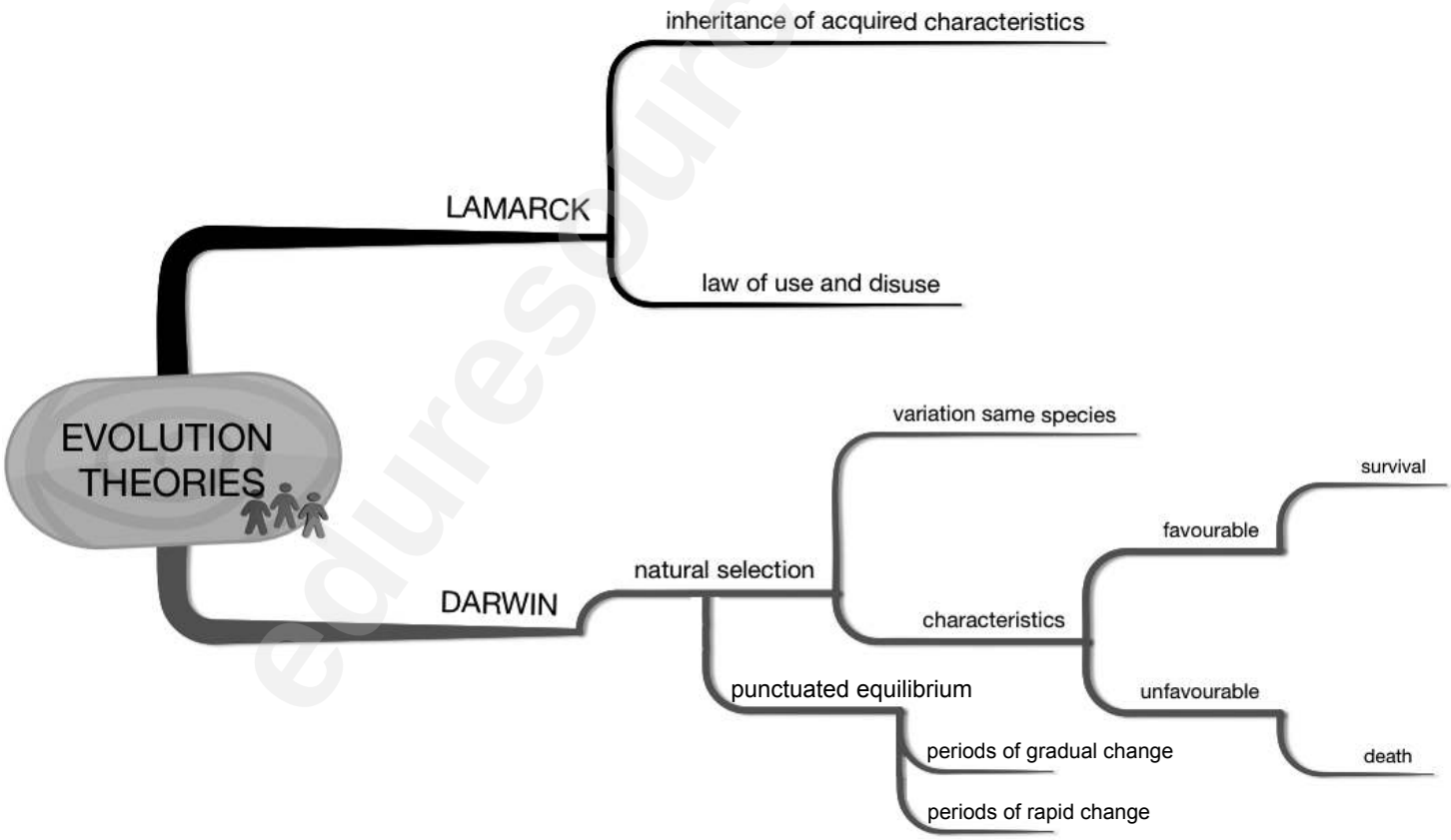
10.3 Theories of Lamarck and Darwin

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

1. **The inheritance of acquired characteristics:**
   Characteristics developed during the life of an individual (acquired characteristics) can be passed on to their offspring.
2. **The law of use and disuse:**
   As an organism uses a structure or organ more regularly, it becomes better developed or enlarged. If an organism does not use a structure or organ frequently, it becomes less developed or reduced in size and may disappear altogether.

Charles Darwin explained evolution in terms of **natural selection** which states that:

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



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10.4 Applying the ideas of Lamarck and Darwin

Figure 10.1 below shows a series of changes involving cacti plants over a period of time. Some notes are included on the events at A, B and C.

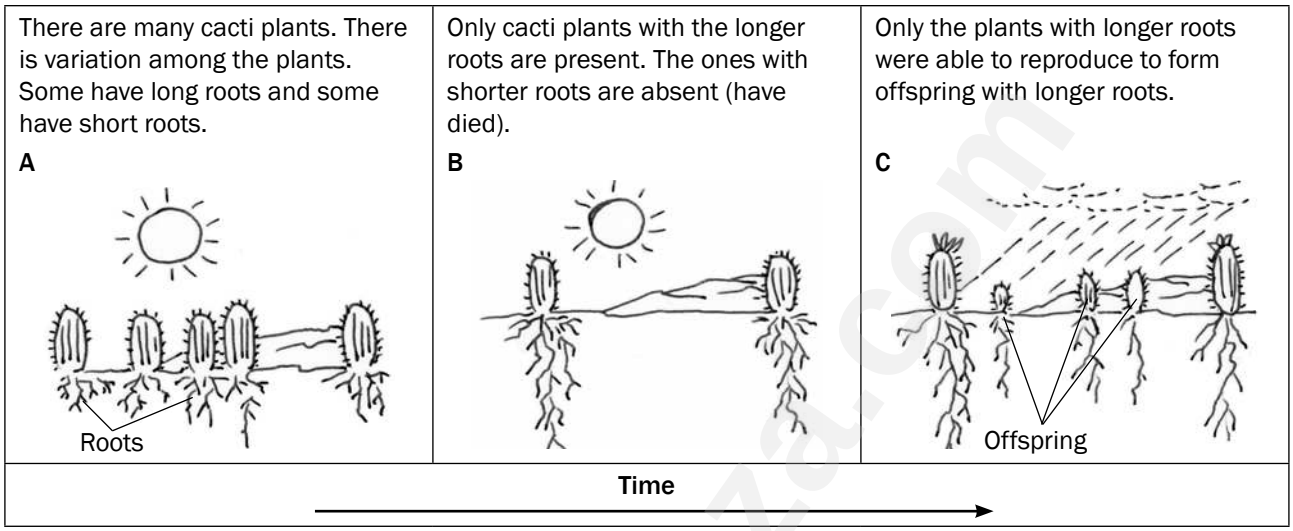

Figure 10.1 Changes in cacti plants over time

We can use Figure 10.1 to describe how Darwin would have explained how modern cacti plants may have developed longer roots as compared to their ancestors with shorter roots.

The second column in Table 10.1 below gives **Darwin's** explanation of how modern cacti plants may have developed longer roots. The first column contains questions that guide the explanation from one point to the next. You will be able to use the same questions to guide you when answering questions on Darwin's theory using any other example, for example the development of longer necks in modern giraffes.

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

Table 10.1 Darwin's explanation for changes in cacti plants over time

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The second column in Table 10.2 below states how **Lamarck** would have explained how modern cacti plants may have developed longer roots when compared to their ancestors with shorter roots. The first column contains guiding questions that will help you answer other questions on Lamarck's theory using any other example, for example the development of longer necks in modern giraffes.

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

Table 10.2 Lamarck's explanation for changes in cacti plants over time

Activity 1

Questions

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

[14]

NB

Use the guiding questions in Tables 10.1 and 10.2.

Answers to activity 1

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

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Answers to activity 1 (continued)

2.
   - As a result of **genetic variation**✓ in the giraffe population some giraffe had **longer necks than others.**✓
   - As a result of **leaves being available only higher up on trees,**✓ giraffes competed for these leaves.
   - Giraffes with **shorter necks died.**✓
   - Giraffes with **longer necks survived.**✓
   - This is **natural selection.**✓
   - The allele ✓ for longer necks was **passed on to subsequent generations.**✓
   - Eventually all the giraffes had **longer necks.**✓ (7)
3. There is no evidence✓ to show that acquired characteristics are inherited✓/There is no evidence that structures used more frequently become more developed or vice versa (2)

[14]

exams

For more questions on **Lamarck and Darwin,** refer to the following National Life Sciences exam papers:

- Life Sciences Paper 2 November 2008 – Question 2.3 on page 12.
- Life Sciences Paper 2 November 2009 – Question 2.2 on page 9.
- Life Sciences Paper 2 March 2010 – Question 2.1 and 2.2 on page 9.
- Life Sciences Paper 1 November 2010 – Question 3.1 and 3.2 on page 11.
- Life Sciences Paper 1 November 2011: Version 1 – Question 3.3 on page 10.
- Life Sciences Paper 1 March 2012: Version 1 – Question 4.2 on page 14.

10.5 Differences between natural selection and artificial selection

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

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

Natural selection	Artificial selection
The **environment or nature** is the selective force.	**Humans** represent the selective force.
Selection is in response to **suitability to the environment.**	Selection is in response to **satisfying human needs.**
Occurs within **a species.**	May involve **one or more species** (as in cross breeding).

Table 10.3 The differences between natural selection and artificial selection

10.6 Punctuated Equilibrium

Based on the explanations of Lamarckism and Darwinism, it is thought that evolution takes place through an accumulation of small or gradual changes that occur over a long period of time. This is supported by the many transitional fossils in the fossil record which show the progressive change over time.

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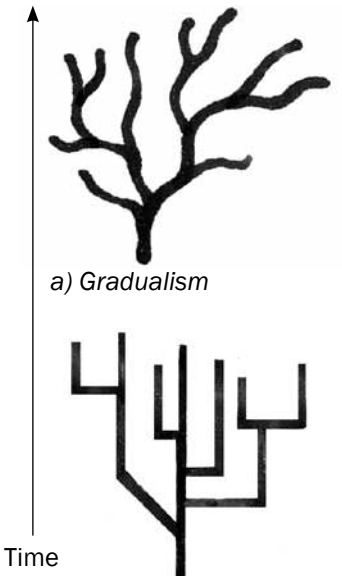

a) Gradualism

b) Punctuated equilibrium

Figure 10.2 Phylogenetic trees that show a) gradualism and b) punctutated equilibrium

Punctuated equilibrium is a hypothesis that explains the speed at which evolution takes place through natural selection:

- According to punctuated equilibrium, evolution is not always gradual as proposed by Lamarckism and Darwinism.
- Evolution involves long periods of time where species do not change or change very little (known as equilibrium).
- This alternates with (is punctuated by) short periods of time where rapid changes occur.
- As a result, new species are formed in a short period of time, relative to the long periods of no/little change.
- This is supported by the absence of transitional fossils (usually termed 'missing links') indicating the period of rapid change.

10.7 Speciation

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

We can describe the process of speciation as follows:

exams

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

- Life Sciences Paper 2 November 2008 – Question 3.3 on page 13.
- Life Sciences Paper 2 November 2009 – Question 2.1 on page 9.
- Life Sciences Paper 2 March 2010 – Question 3.2 on page 13.
- Life Sciences Paper 2 March 2011 – Question 3.1 on page 9.
- Life Sciences Paper 1 November 2011: Version 1 – Question 3.4 on page 10.
- Life Sciences Paper 1 March 2012: Version 1 – Question 3.4 on page 12.

10.7.1 Speciation

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

10.7.2 Mechanism for reproductive isolation

Geographic isolation causes speciation. Reproductive isolation isolates the gene pool of a species. Examples of reproductive isolation:

- Breeding at different times of the year.
- Species-specific courtship behaviour.
- Adaptation to different pollinators in plants.
- Infertile offspring.

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Activity 2

1. Use the information in Figure 10.3 below to explain how a new species of rabbit has arisen because of a geographical barrier. [9]

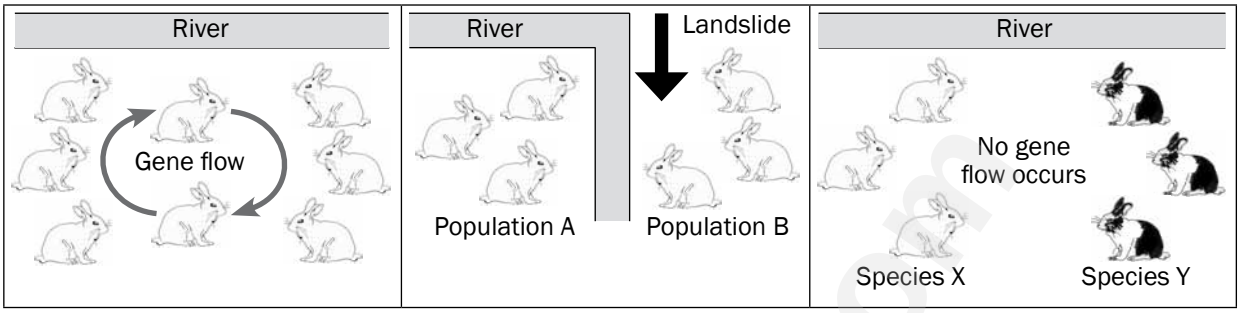

Diagram 1 Diagram 2 Diagram 3

Figure 10.3 Speciation in a rabbit population

2. The diagram below represents the changes in a population of bacteria over time as a result of exposure to an antibiotic over time.

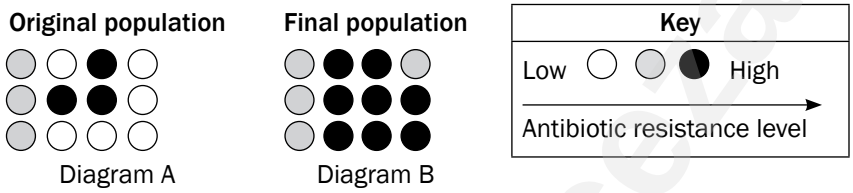

Figure 10.4. Development of antibiotic resistance in a bacteria population

Explain, in terms of natural selection, the shift in the resistance level of the bacteria illustrated above. [8]

Answer to activity 2

1.
- A population of rabbits become **split**✓ **by a geographical barrier/river.**✓
- As a result, the two parts of the population **cannot interbreed.**✓
- There **is no gene flow**✓ between the two populations.
- **Natural selection occurs independently**✓ in each population due to **different environmental conditions**✓ on either side of the river.
- As a result, the two populations become **genotypically and phenotypically different**✓over a period of time.
- Even if the geographical barrier is removed (ie the river returns to its normal course at some later time), the rabbits will **not be able to interbreed again.**✓
- We say that one or both parts of the rabbit population have become a **new species**✓. [9]

2. **There is a large degree of variation in the bacteria population**✓
- When the antibiotic was first used, it killed off a large number of bacteria✓
- But some bacteria were resistant to the antibiotic✓ and survived✓
- Those that survived were able to reproduce✓
- Increasing the population of resistant bacteria✓
- Continued use of the antibiotic had little effect on the resistant bacteria✓
- Hence the resistant bacteria increased✓
- And non-resistant bacteria decreased✓ [8]

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10.8 Human evolution

So far in this chapter you have seen that:

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

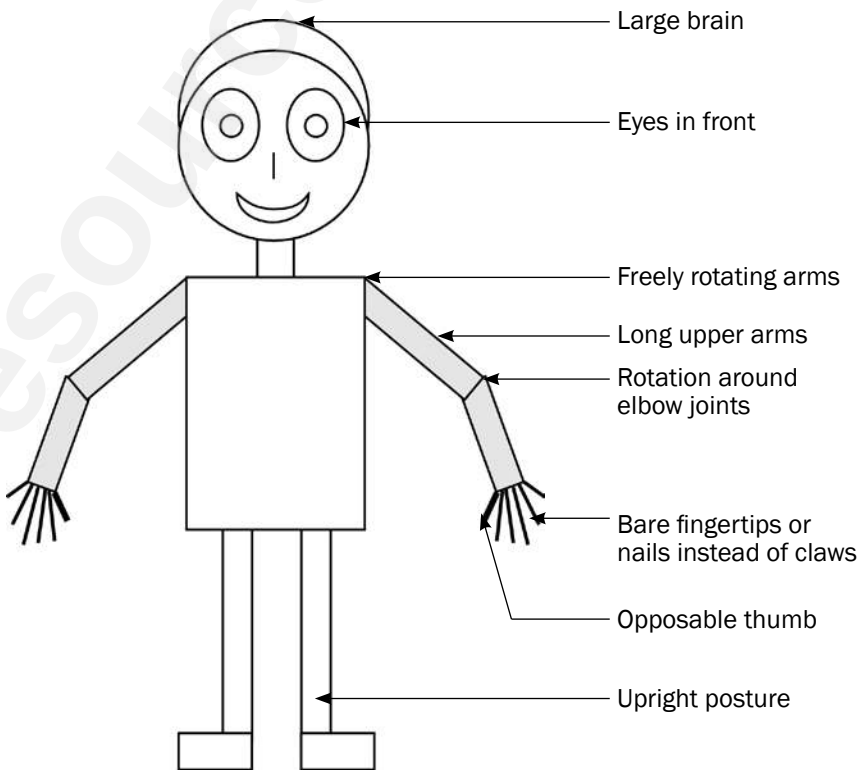
Natural selection and speciation can also be used to explain **how humans have evolved**.

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

10.8.1 Similarities between humans (*Homo sapiens*) and African apes

Figure 10.5 below shows characteristics of humans that are similar to that of African apes.

Figure 10.5 Characteristics humans and African apes have in common



Now try this:

1. Cover the labels on Figure 10.5 and try to list the common features of humans and African apes by looking at the parts that the arrows are pointing to.
2. Write down the EIGHT similarities without looking at the diagram.

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10.8.2 Differences between humans (*Homo sapiens*) and African apes

Table 10.4 below is a comparison between the anatomical characteristics of Humans (*Homo sapiens)* and African apes according to the features listed in the first column.

FEATURE	Humans (*Homo sapiens*)	African Apes
Cranium	Large cranium/brain	Small cranium/brain
Brow Ridges	Brow ridges are not well developed	Brow ridges well developed
Spine	More curved spine (S-shaped spine)	Less curved spine (C-shaped spine)
Pelvic girdle	Short, wide pelvis	Long, narrow pelvis
Canines	Small canines	Large canines
Palate shape	Small and semi-circular	Long and rectangular
Jaws	• Small jaws • Less protruding jaws/less-prognathous	• Large jaws • More protruding jaws/more prognathous
Cranial ridges	No cranial ridge	Cranial ridge across the top of the cranium
Foramen Magnum	Foramen magnum in a forward position	Foramen magnum in a backward position

Table 10.4: The anatomical differences between humans and African apes.

Now try this:

1. Study the differences listed in Table 10.4 above by referring to the features shown in Figure 10.6 below.

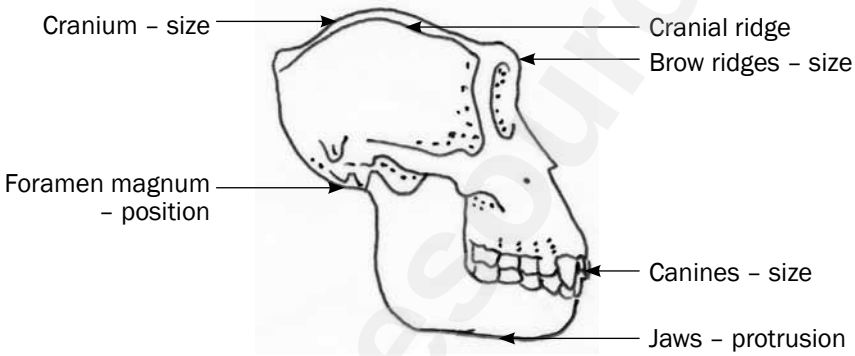

Figure 10.6 Labelled diagram of an African ape skull

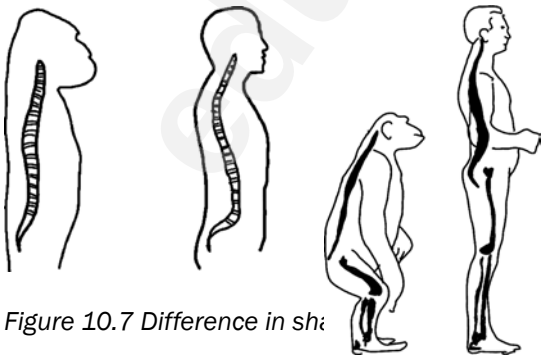

Figure 10.7 Difference in sha

2. Now write down the differences using the above diagrams but without referring to Table 10.4.

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Activity 3

Question 1

Study the two skulls shown in Figure 10.8 below and answer the questions that follow.

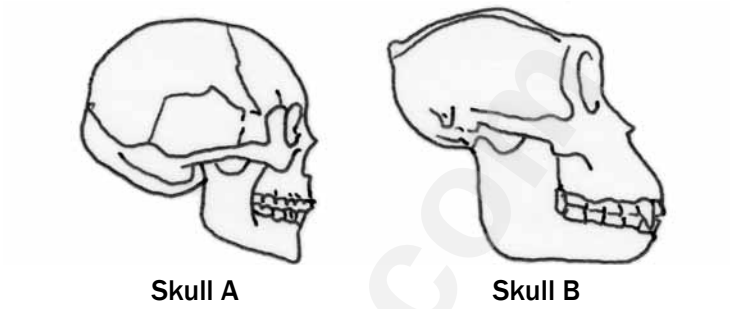

Figure 10.8 Skull diagrams of two organisms

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

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

[6]

Answers to question 1

1.1 Skull B✓ (1)

1.2 Pronounced brow ridge✓
Protruding jaw/prognathous✓
Large canine✓
Small cranium✓
Cranial ridge across the top of the cranium✓ (5)

[6]

Question 2

The diagrams in Figure 10.9 below represent the skulls of three organisms: Taung child (*Australopithecus africanus*), a modern human (*Homo sapiens*) and a gorilla (*Gorilla gorilla*). The arrow indicates the position of the foramen magnum (the opening that allows the spinal cord to connect with the brain). Study the diagrams and answer the questions that follow:

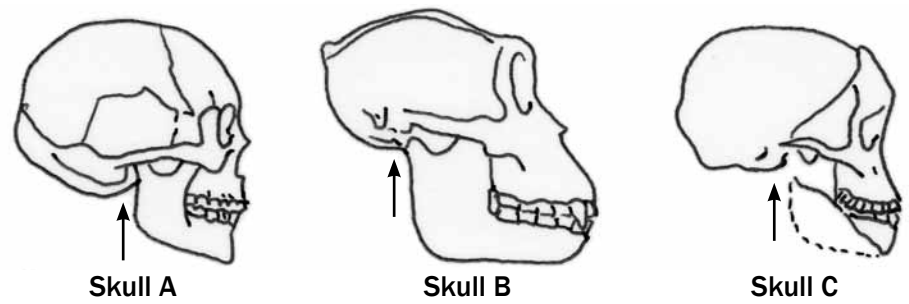

Figure 10.9 Skull diagrams showing the position of the foramen magnum

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2.1 Identify the organisms that are represented by each of skulls A, B and C. (3)

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

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

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

[14]

Answers to question 2

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

2.2

Skull A	Skull B
Brow ridge reduced/absent✓	Pronounced brow ridge✓
Non-prognathous/non-protruding jaw✓	Prognathous/protruding jaw✓
Poorly developed canines✓	Large canines✓
No cranial ridges✓	Cranial ridges present✓
Large cranium✓	Small cranium✓

(any 3 × 2) (6)

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

2.4 It has features of the skull that are intermediate✓ between that of skulls A and B, e.g. jaw protrudes more than in skull A but less than in skull B✓, face not flat in skull of B but flat in skull A. (3)

[14]

exams

For more questions on **human evolution**, refer to the following National Life Sciences exam papers:

- Life Sciences Paper 2 November 2008 – Question 3.1 on page 13.
- Life Sciences Paper 2 March 2009 – Question 1.5 on page 8.
- Life Sciences Paper 2 March 2010 – Question 4.2 on page 16.
- Life Sciences Paper 1 November 2010 – Question 3.3 on page 12.
- Life Sciences Paper 2 March 2011 – Question 3.2 on page 10.
- Life Sciences Paper 1 November 2011: Version 1 – Question 3.1 and 3.2 on pages 9 and 10.

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10.8.3 Major phases in hominid evolution

The table below shows the characteristics of different organisms (as obtained from a study of their fossils) that are thought to be in the same line that led to the evolution of modern humans. The fossils are dealt with in the order in which they appeared on Earth (as calculated by the age of the fossil using dating techniques).

Organism	When organism existed	Fossil site	Discovered by	Characteristics
Ardipithecus ramidus	5 – 4 mya	North-East Ethiopia	Tim White	Brain size: 300–350 ml Forward position of foramen magnum Very prognathous (more protruding jaws) Heavy brow ridges Pelvis structure: bipedal and tree climbing
Australopithecus afarensis	4 – 2,7 mya	Ethiopia, Kenya, Tanzania	Donald Johanson	Brain size: 375–550 ml Forward position of foramen magnum Very prognathous Heavy brow ridges Canines large and pointed Long arms No cranial ridge
Australopithecus africanus	3 – 2 mya	Taung; Sterkfontein	Raymond Dart	Brain size: 428–625 ml Forward position of foramen magnum Prognathous Brow ridges Teeth large, canines not long Long arms No cranial ridge
Australopithecus sediba	1,9 – 1,8 mya	Malapa Cave – in the cradle of humankind	Lee Burger	Brain size: 420 ml Less prognathous Brow ridges Large teeth, canines not long Long arms No cranial ridge
Homo habilis	2,2 – 1,6 mya	Tanzania	Louis and Mary Leakey	Brain size: 650 ml Less prognathous Less pronounced brow ridges Human-like teeth – smaller canines Long arms
Homo erectus	2 – 0,4 mya	Java in Indonesia and then Swartkrans	Eugene Dubois	Brain size: 900 ml Prognathous Cranial ridges Short canines Longer legs and shorter arms
Homo sapiens	200 000 years ago – present	Makapansgat in Limpopo; Border Cave in KZN; Blombos Cave in the Western Cape	Tim White	Brain size: 1200–1800 ml No brow ridges Small teeth Short arms

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Activity 4

1. What general observation can you make about the characteristics as one moves from the earlier to the later organisms listed in the table? (2)
2. Use information in the table to describe the specific evolutionary trend (how each of the features changed over time) relating to each of the following characteristics:
   - **2.1** Brain size
   - **2.2** Position of foramen magnum
   - **2.3** Prognathous jaws
   - **2.4** Dentition
   - **2.5** Development of brow ridges 5 × 2 (10)
3. State the significance of the changes that occurred as they apply to each of the following characteristics:
   - **3.1** Brain size
   - **3.2** Position of foramen magnum
   - **3.3** Prognathous jaws
   - **3.4** Dentition
   - **3.5** Development of brow ridges 5 × 2 (10)
4. Explain how the information in the table provides evidence for the 'Out of Africa' hypothesis. (2)

[24]

Answers to activity 4

1. There is a gradual change in the characteristics✓ over a period of time. ✓ (2)
2. **2.1** Brain size: Increase✓ in brain size✓
   - **2.2** Position of foramen magnum: Movement to a more✓ forward position✓
   - **2.3** Prognathous jaws: Change from more prognathous✓ to less prognathous✓
   - **2.4** Dentition: Decrease in the size✓ of the teeth✓OR decrease✓ in the size✓ of the canines
   - **2.5** Development of brow ridges: Brow ridges become less✓ developed✓ 5 × 2 (10)
3. **3.1** Brain size: Increased brain size allows for processing information more quickly ✓and for processing a larger amount of information. ✓
   - **3.2** Position of foramen magnum: More forward position of the foramen magnum✓ indicates bipedalism. ✓ A decrease in the length of the arms indicates a decreased dependency on its use in locomotion and therefore shows a more advanced stage of bipedalism. This is usually accompanied by an increase in the length of the legs.
   - **3.3** Prognathous jaws: A less prognathous jaw indicates a smaller jaw. ✓ A small jaw is sufficient since there was a change from eating raw food to eating cooked food. ✓
   - **3.4** Dentition: The change from large to smaller teeth✓was due to the change in diet from raw food to cooked food✓

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Answers to activity 4 (continued)

3.5 Development of brow ridges: Brow ridges became less developed since the action of the smaller jaws✓did not create forces great enough for the skull to have increased strength from the brow ridges✓ 5 × 2 (10)

4. The information in the table shows that fossils of the different organisms that are considered to have existed in the same line as humans✓ were all found in Africa. ✓ (2)

[24]

10.8.4 Out of Africa hypothesis

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

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

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

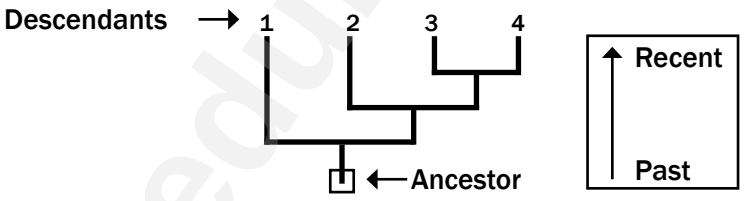
10.8.5 Phylogenetic trees

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

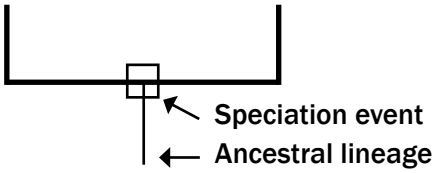
hint

Hints on interpreting phylogenetic trees

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



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



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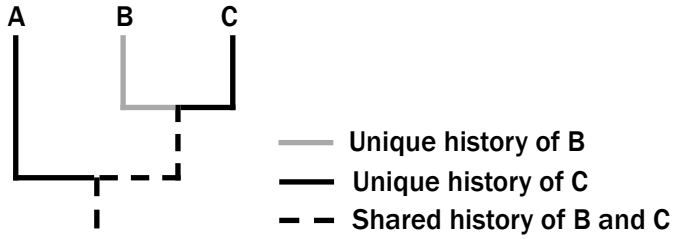
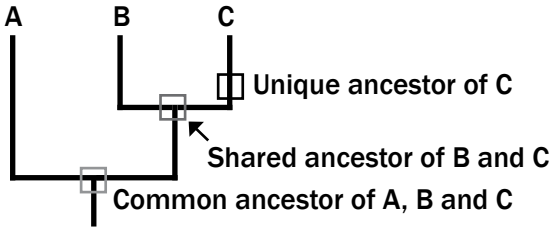
Each lineage has a part of its history that is unique and parts that are shared with other lineages.



Similarly, each lineage has ancestors that are unique to that lineage and common ancestors that are shared with other lineages.



e.g. Worked example

Look at the phylogenetic tree in Figure 10.10 and read the following information:

- Start in the past (4,5 mya) and read towards the present. This means that the oldest common ancestor of all the hominids on this tree is *A. ramidus.*
- Each branch on the tree represents a point where the common ancestor split into one, two or more groups. In this case, the new species that evolves is shown as a side branch while the original species continues its evolutionary line up the trunk of the tree. For example, *A. aethiopicus* forms a side branch with *A. africanus* evolving from the common ancestor that existed at point X (this took place about 3 mya).
- Progression up the 'trunk of the tree' represents a movement in time from the past to the present. This shows the relationships between the hominids through time. Hominids that share a recent common ancestor are the most closely related to each other. For example, *P. robustus* shares a most recent common ancestor with *P. boisei*, namely *A. africanus*.

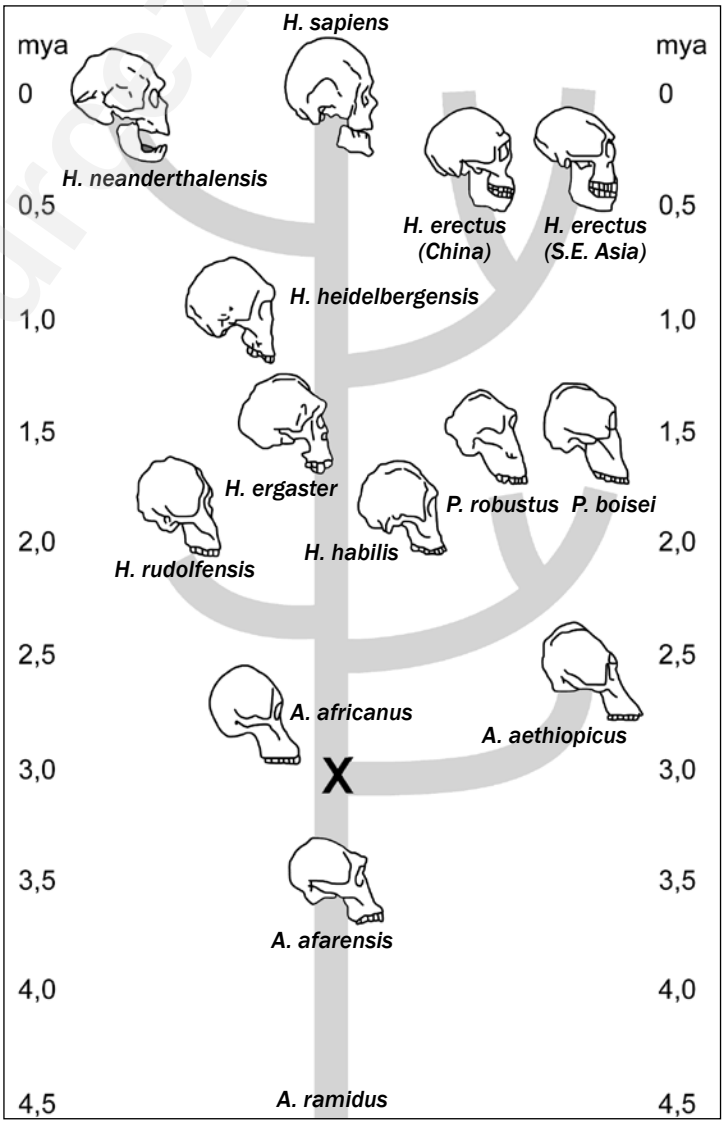


Figure 10.10 A phylogenetic tree

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Questions

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

1. Give the common ancestor of *H. neanderthalensis* and *H. sapiens*. (1)
2. How long ago did *H. rudolfensis* split from its common ancestor? (2)
3. Name the direct ancestor of *H. ergaster*. (1)
4. How long has it taken *H. heidelbergensis* to evolve from *A. afarensis*? (3)
5. Give the common ancestor of all the hominids. (1) **[8]**

Answers

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

Activity 5

Study the phylogenetic tree in Figure 10.11 below and answer the questions based on it.

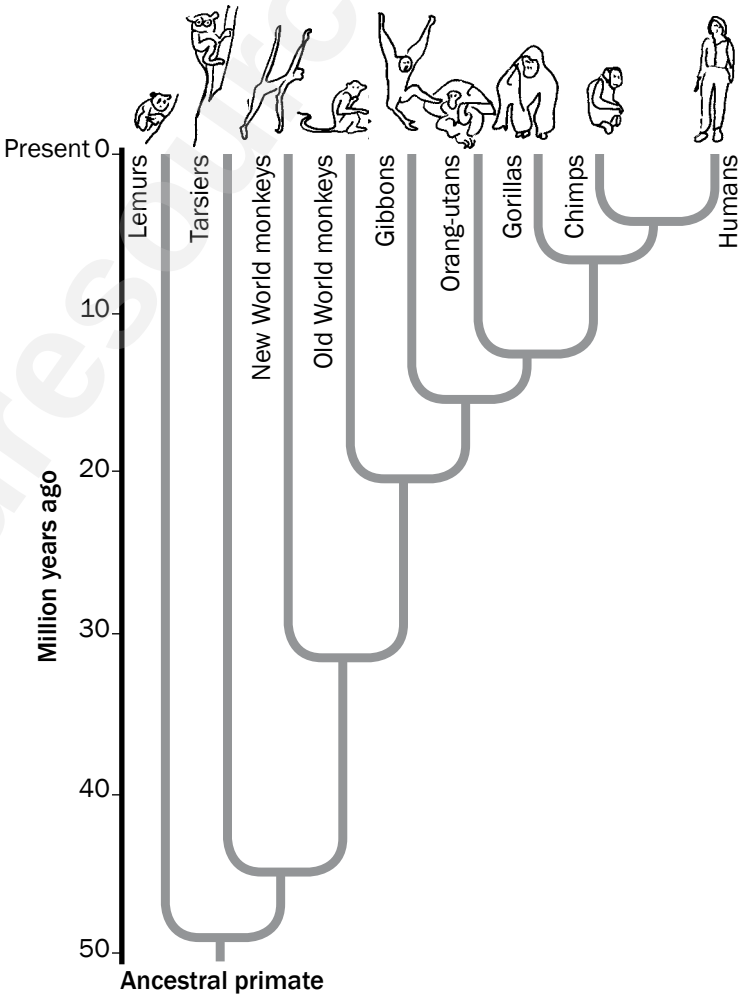

Figure 10.11 Phylogenetic tree

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Questions

1. How long ago did the ancestral primate live on earth? (2)
2. Name the organism that shares the most distant common ancestor with humans. (1)
3. Name the organism that is most closely related to humans. (1)
4. How many years ago did the New World monkeys split from the common ancestor that gave rise to the Old World monkeys? (2)
5. For how long did the common ancestor that evolved into the gibbons exist? Show your working. (3)
6. Humans and gorillas share many common characteristics with primates. List THREE of these common characteristics. (3)

[12]

exams

For more questions on **phylogenetic trees**, refer to these National Life Sciences examination papers:

- Life Sciences Paper 2 November 2009 – Question 1.5 on page 7.
- Life Sciences Paper 2 March 2009 – Question 3.4 on page 11.
- Life Sciences Paper 2 March 2010 – Question 1.4 on page 6.
- Life Sciences Paper 2 March 2011 – Question 1.4 on page 5.
- Life Sciences Paper 1 March 2012: Version 1 – Question 1.4 on page 8.

Answers to activity 5

1. 50✓ million years ago✓/mya (2)
2. Lemurs✓ (1)
3. Chimpanzee✓ (1)
4. 33✓ million years ago✓/mya (2)
5. 22 million years – 15 million years✓ = 7✓million years✓ (3)
6.
   - Large brain✓
   - Eyes in front✓
   - Freely rotating arms✓
   - Long upper arms✓
   - Rotation around elbow joints✓
   - Bare fingertips or nails instead of claws✓
   - Opposable thumb✓
   - Upright posture✓ (any 3) (3)

[12]

Activity 6

Question 1

Give the correct biological term for each of the following descriptions. Write only the term next to the question number (1.1 to 1.17).

1.1 The development of new species from existing species.

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

1.3 Similar structures in different organisms indicating common ancestry.

1.4 Having a pointed face because of projecting jaws and nose.

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

1.6 A group of organisms of the same species that occupy a particular habitat.

1.7 Only organisms with favourable characteristics survive.

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

[17]

Answers to activity 6

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

[17]

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Chapter 11

Human impact on the environment

Organisms interact with other organisms and with the environment. When we, as humans, interact with the environment to satisfy our needs, we may have many negative impacts on the environment through our activities. We may pollute the land, the water and the atmosphere. We also make demands on the earth to ensure our food security. In doing all of this we may impact negatively on the biodiversity of our planet.

11.1 The atmosphere and climate change

Introduction

Climate refers to the long-term weather conditions of an area. The atmosphere is made up of nitrogen, oxygen and other gases, which include the greenhouse gases such as carbon dioxide and methane. Greenhouse gases absorb infrared (long wave radiation) long wave radiation emitted from the Earth and prevent it from escaping back into the atmosphere. This is known as the 'greenhouse effect'.

The greenhouse effect is important in keeping the Earth warm so that it can sustain life. However, an increase in the concentration of greenhouse gases leads to the 'enhanced greenhouse effect'. As a result, there may be a significant rise in the average temperature of the surface of the Earth over a period of time. This is known as 'global warming'.

Increased concentration of carbon dioxide in the atmosphere is due mainly to:

- **Burning of fossil fuels (for electricity, to power vehicles and for industrial processes):** Combustion of carbon-rich fuels such as coal or plants (wood) releases carbon that was stored in them, as carbon dioxide.
- **Deforestation:** Cutting down trees and removing vegetation from the land decreases the amount of carbon dioxide taken up by plants during photosynthesis. This increases the amount of carbon dioxide available in the atmosphere.

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Increased concentration of the methane in the atmosphere is due mainly to:

- **The increased number of landfills:** decaying organic matter in waterlogged soils such as landfills releases methane.
- **The increased number of livestock:** ruminants such as cows release methane gas through their digestive tracts.
- Mining of coal.

Increased temperatures may lead to:

- More evaporation of water which can lead to increased precipitation which eventually increases the potential for flooding.
- Rising sea levels caused by melting ice in the glaciers which can eventually increase the potential for flooding.
- Increased wildfires that increase the chances of soil erosion and eventually desertification.
- Increased loss of biodiversity, as species are unable to cope with rapidly rising temperatures, eventually leading to desertification.
- Increased droughts in some areas leading to desertification and food insecurity.

Carbon footprint

This is a measure of the total amount of carbon dioxide emissions of an individual, a defined population or a company per year.

Strategies to reduce the carbon footprint include the following:

- **Reuse and recycle:** less fossil fuels burnt in the production of some of the material.
- **Drive less:** by using public transport, walking, bicycles.
- **Reduce the need for heating:** insulating walls and building energy efficient homes.
- **Carbon offsetting:** by using alternative energy (solar and wind) and reforestation to act as a carbon reservoir.
- **Technological developments:** decrease the amount of energy needed for production/decreasing the dependency on carbon emitting fuels.

Destruction of the ozone layer

Ozone is a greenhouse gas that is found at low concentrations 15 – 50 km above the Earth's surface. It absorbs the ultraviolet rays from the sun. The ultraviolet rays damage the DNA and cause skin cancer. Measurements in certain areas have shown a significant decrease in the amount of ozone layer. The damage to the ozone layer is caused mainly by chemicals called CFCs (chlorofluorocarbons), released by refrigerators, aerosol sprays and fast-food packaging.

If the measures to reduce the destruction of ozone layer fail:

- There will be a significant increase in the number of skin cancer cases.
- Ultraviolet rays reaching the Earth's surface may cause permanent damage to our eyes.

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Activity 1

Questions

1. Figure 11.1 below shows the averages of carbon dioxide concentration in the atmosphere since January 2009, as measured at the Mauna Loa Observatory in Hawaii.

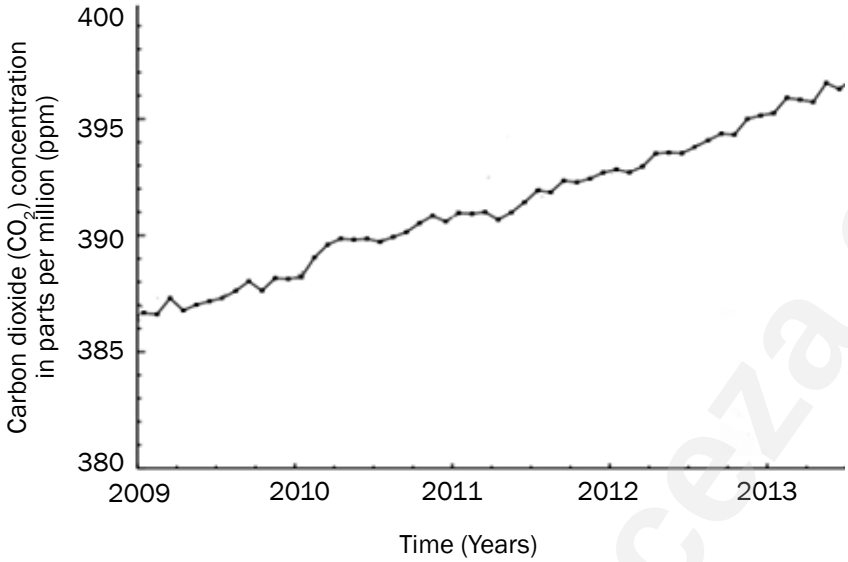

Figure 11.1: Average carbon dioxide concentration in the atmosphere since January 2009, at Mauna in Hawaii

1.1 Describe how deforestation could lead to an increase in the carbon dioxide concentration in the atmosphere. (2)

1.2 Mention ONE human activity that might have led to the increase in carbon dioxide concentration as seen in the graph. (1)

1.3 What was the carbon dioxide concentration in the atmosphere in July 2012? (2)

1.4 What is the dependent variable in this investigation? (1)

1.5 Explain how the excess carbon dioxide in the atmosphere could lead to climate change. (4)

1.6 Mention ONE way in which humans can reduce the amount of carbon dioxide released into the atmosphere. (1)

[11]

Answers to activity 1

1. **1.1** Cutting down of trees decreases the amount of carbon dioxide✓ taken up by the plants during photosynthesis✓ (2)

   1.2 Burning of fossil fuels✓ (1)

   1.3 393,5✓ ppm✓ (2)

   1.4 Carbon dioxide concentration in ppm✓ (1)

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Answers to activity 1 (continued)

1.5
- Carbon dioxide is a greenhouse gas✓
- which absorbs long wave radiation emitted from the Earth✓
- and prevents it from escaping back into the atmosphere✓.
- An increase in the concentration of carbon dioxide leads to an increase in the greenhouse effect✓,
- which may result in global warming✓. (any 4)

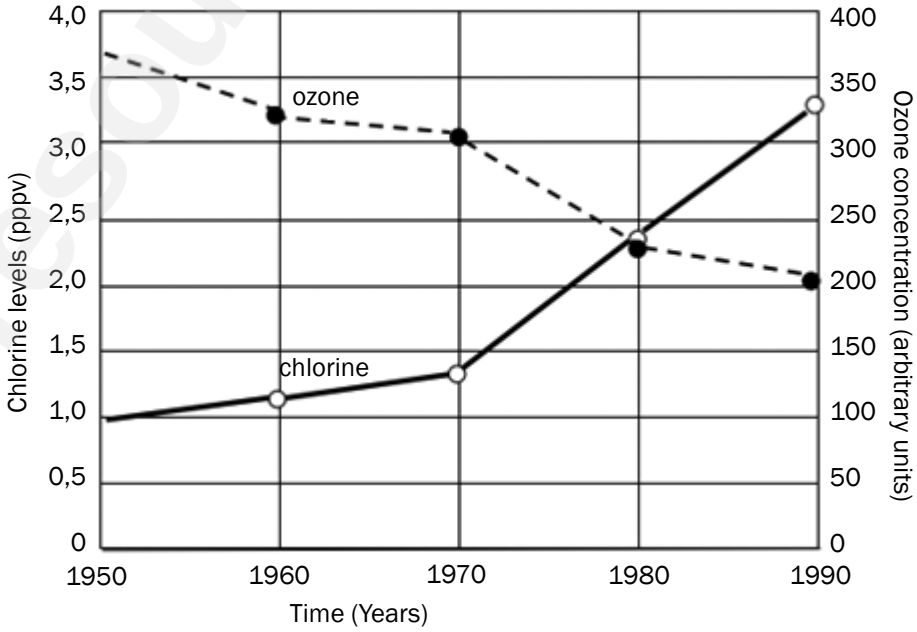
1.6
- Drive less✓/use public transport, walking, bicycle more
- Reduce the need for heating by insulating walls✓
- Building energy efficient homes✓
- Use alternative energy sources✓ (solar and wind)
- Reforestation✓to act as carbon reservoir
- Reuse and recycle✓ (any 1)

[11]

Activity 2

Questions

1. An investigation to measure the ozone concentration and the chlorine levels has been done in Antarctica since 1950 and the results are shown in the graph below:



1.1 Give a caption for the graph. (2)

1.2 What is the relationship between the levels of chlorine and the concentration of ozone? (2)

1.3 Name the dependent variable(s) in the investigation. (2)

1.4 In which 10-year period was the ozone depletion the greatest? (1)

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1.5 In 1987 the Montreal Protocol was signed to lay down targets to reduce the use of CFCs by countries. Give TWO reasons why, despite a reduction in the use of CFCs, there was still a decline in the ozone layer. (2)

1.6 Name ONE item that humans were using which contained CFCs. (1)

1.7 Explain why the ozone layer is important for humans. (2)

[12]

Answers to activity 2

1. **1.1** Changes in the levels of chlorine and ozone concentration✓ from 1950 to 1990✓ (2)

1.2 An increase in the level of chlorine ✓leads to a decrease in the ozone concentration✓ (2)

1.3 Chlorine levels✓
Ozone concentration✓ (2)

1.4 Between 1970 and 1980✓ (1)

1.5 CFCs might persist for a long time in the atmosphere✓
Other countries might have taken longer to implement the protocol✓
Households were still using existing items with CFCs✓
(any)(2)

1.6 Aerosols✓
Refrigerators✓
Food packaging✓ (any)(1)

1.7 The ozone layer provides protection against ultraviolet rays✓, thus reducing the chances of getting skin cancer✓ (2)

[12]

11.2 Water quality and water availability

It is estimated that as many as 2 billion people won't have sufficient access to clean water by 2050. This figure is expected to rise to 3.2 billion by 2080 — almost three times the number of people who now do without water. There are many efforts directed towards making good quality water available.

11.2.1 Availability of water

The availability of water may be influenced by the following factors:

Construction of Dams

- The construction of additional dams plays a major role in increasing the quantity of water stored and made available for later use by people and in agriculture.

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Destruction of wetlands

- Wetlands should not be destroyed because they influence both the availability and quality of water.

Water wastage

- A large amount of water used for irrigation is lost due to poor farming practices. Open drain irrigation leads to loss of water by evaporation. The use of water for irrigation further up a river decreases the availability of water for other users lower down the river.
- Availability is also affected by wastage of water through leaking taps and toilets and faulty pipelines.
- Wastage of water can be reduced by reducing the pressure in the pipes, by educating people to use water wisely and by maintaining all plumbing in good condition.

Cost of water

- The cost of water is influenced by costs involved in increasing the availability and quality of water.
- The cost per kilolitre (kl) of water increases with the increased use of water. This is meant to discourage over-use of water, thus allowing for its sustained use.
- A certain amount of water is available free to all citizens to ensure that water is available to the poorest.

Poor farming practices

- Contamination of water sources by fertilizers and pesticides has decreased the amount of clean water available, thus increasing the costs involved in purification.
- Over-grazing leads to soil erosion. On land that is eroded, water runs off rapidly rather than soaking into the ground, and is thus wasted.

Droughts and floods

- During periods of drought, water availability decreases. Water used from dams during the drought periods cannot be easily replaced.
- Natural vegetation can hold back water from floods. If the natural vegetation is removed, flood waters are lost.

Boreholes and their effect on aquifers

- Boreholes have been used to increase water availability in areas that do not have direct access to other sources of water.
- Constant use of boreholes eventually leads to the drying up of aquifers (the source of borehole water) thus decreasing water availability in the future.

Water recycling

- The availability of water can be increased if existing water is used for more than one purpose. For example, some water used in the household can be used for the garden. Sewage water can be treated and used again.

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Exotic plantations and the depletion of the water table

- Some exotic plants use a large quantity of water from the ground. As a result, this decreases the level of the water table, making less water available to other vegetation in the area.

11.2.2 Quality of water

The quality of water may be influenced by the following factors:

Eutrophication and algal bloom

- Water used for agriculture may contain pesticides, herbicides and fertilizers which pollute the water in rivers, dams and lakes, causing eutrophication. The added nutrients lead to an increase in algal growth (algal bloom). These algae over-use and thus deplete the oxygen in the water, thus reducing the potential for life in such water.

Thermal pollution

- Thermal pollution refers to the heating of water caused by the use of water for cooling in power-stations and industries.
- The quality of water is affected because heated water has a lower oxygen content, making it difficult to support life.

Pollution of water through domestic, agricultural and industrial use

- After water is used for domestic purposes it may contain detergents (such as from washing) and pathogenic bacteria (such as in sewage). This polluted water has to be treated before it can be used again.
- After water is used for industrial purposes it may contain many heavy metals, oil, heat and fertilizers. This adversely affects the quality of the water and all life that depends on it.
- Fertilisers and pesticides may run off into rivers, ponds and dams and pollute the water.

Mining

- Water returned to the environment from mines is generally acidic and toxic. This water is hot and thus also contributes to thermal pollution.

Alien Plants

- Alien invasive water plants block the waterways, reducing light to other aquatic plants. These plants eventually die and decompose. Bacteria that decompose these plants eventually deplete the oxygen supply in the water.

Water purification

- The quality of water is improved through purification methods. Undrinkable water can be made drinkable.

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Activity 3

Questions

1. A group of learners conducted an investigation to determine the average amount of water used by a household for different purposes. They collected data on water-use from 5 families in their neighbourhood. The results are shown below.

Purpose for which water is used	Average amount of water used (%)
Toilet flushing	30
Baths and showers	25
Gardening	15
Washing clothes and dishes	20
Cooking and drinking water	10

1.1 Identify the:

a) Dependent variable (1)

b) Independent variable (1)

1.2 State TWO ways in which the reliability of the results can be improved. (2)

1.3 Draw a pie-chart to represent the data in the table. Show all calculations. (7)

1.4 Describe ONE advantage of making the results of the survey available to the various households that participated. (2)

[13]

Answers to activity 3

1.1 a) Average amount of water used✓ (1)

b) Purpose for which water is used✓ (1)

1.2
- Repeat the investigation✓
- Select the households randomly✓
- Increase the number of households involved in the investigation✓ (any 2)

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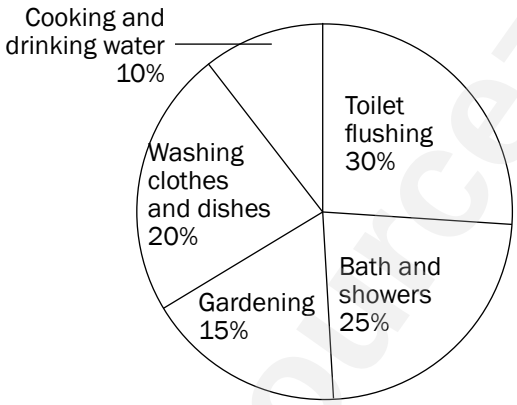
Answers to activity 3 (continued)

1.3 Calculations for proportions of slices in the pie-chart

Purpose for which water was used	Working	Proportion (degrees)
Toilet flushing	$\frac{30}{100} \times 360$	108
Baths and showers	$\frac{25}{100} \times 360$	90
Gardening	$\frac{15}{100} \times 360$	54
Washing clothes and dishes	$\frac{20}{100} \times 360$	72
Cooking and drinking water	$\frac{10}{100} \times 360$	36

Average amount of water used by a household for different purposes



(7)

1.4 Owners can identify the areas of greatest water use✓ to allow them to then develop strategies to reduce water use in that area✓ (2)

[13]

Activity 4

Questions

1. Describe how alien plants may reduce both the availability and quality of water. (4)
2. Describe how poor farming practices may reduce both the availability and quality of water. (4)

[8]

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Answers to activity 4

1. • Alien invasive plants may use water excessively✓ and thus reduce the amount of water available for the natural vegetation✓ of an area (2)
   • Alien invasive water plants block the waterways, reducing light to other aquatic plants✓. These plants eventually die and decompose✓. Bacteria that decompose these plants eventually deplete the oxygen supply in the water✓. (any) (2)
2. • Over-grazing leads to soil erosion✓. On land that is eroded, water runs off rapidly rather than soaking into the ground✓, and is thus wasted. (2)
   • The use of fertilizers and pesticides may pollute nearby dams, ponds and rivers✓ thus reducing the quality of water available✓ (2)

[8]

Activity 5

Questions

1. Read the article below entitled 'Durban to Recycle Sewage water into Drinking Water'.

Durban to Recycle Sewage water into Drinking Water

Durban plans to become the first SA city to purify and recycle sewage water into drinking-quality tap water. The city is also carrying out a feasibility study on purifying seawater.

Water is going astray in Durban because of leaks and theft. The city recently spent millions of rand replacing large sections of old, leaky pipes and reduced pressure levels in several areas to curb leaking. Although a large new dam, Spring Grove, was being built near Mooi River, this would not relieve the water supply risk to an acceptable level in the short term.

Windhoek had been partially reliant on recycled sewage-to-tap water since 1968. 'Crucial to this public acceptance is Windhoek's 42-year record of no waterborne disease outbreaks and no negative health effects attributable to drinking reclaimed water.'

According to eThekwini's water department, there would be at least three safety barriers to ensure the quality of treated effluent. The semi-treated clear water would be pumped at high pressure through ultra-filtration membranes that removed suspended and dissolved solids, and bacteria. This water would then be filtered through tiny pores. The final stage involved ultra-violet light disinfection.

As a further safeguard, all purified effluents from the two new Durban plants would be stored for at least 12 hours after treatment so that final samples could be taken for testing before the water was released into tap supplies.

The Mercury – 15 March 2012

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1.1 List FIVE different strategies referred to in the article intended to increase the availability of clean drinking water. (5)

1.2 Describe THREE arguments used in the article to convince the reader about the safety of recycled sewage water. (6)

1.3 List THREE processes that will be used to ensure that the recycled sewage water will be fit for human consumption. (3)

[14]

Answers to activity 5

1.1
- Recycling sewage water✓
- Purifying sea water✓
- Replacing old, leaky pipes✓
- Reducing water pressure✓
- Building new dams✓ (5)

1.2
- No outbreak of water-borne diseases✓ in Windhoek for 42 years✓
- 3 safety barriers✓ to ensure the quality✓ of treated effluent
- Stored for at least 12 hours✓ allowing sufficient time for repeated testing✓ (6)

1.3
- Pumped at high pressure through ultra-filtration membranes✓ to remove suspended and dissolved solids and bacteria
- Filtration through tiny pores✓
- Ultra-violet disinfection✓ (3)

[14]

11.3 Food security

Food security refers to the access, by all people at all times, to adequate, safe and nutritious food for a healthy and productive life. Food security may be influenced by the following factors:

Exponential growth of the human population

- The world's population is growing at an exponential rate (very rapidly) and as a result some countries cannot produce enough food to feed their growing population. Food production needs to increase as rapidly as the world population; otherwise many countries will experience food insecurity.

Droughts and floods

- Climate change has led to more frequent and severe droughts and floods. Droughts result in crop losses and livestock death which reduce the food available in an area. Floods cause extensive damage in a short period of time and decrease the amount of farmland available to grow crops. People also usually lose their homes, possessions and economic security during floods, further impacting on food security.

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Poor farming practices – monoculture, pest control, loss of topsoil and the need for fertilizers

- **Monoculture** is the growing of one type of crop over large areas of land year after year. Monoculture depletes nutrients and water supplies and therefore impacts negatively on the quality of the topsoil.
- **Pest control** involves the use of pesticides (chemicals) to kill pests that compete with humans for food. Pesticides may kill or get into the tissues of healthy plants. This may reduce crop production and, since pesticides are expensive, increase the cost of food and thus reduce access to poor consumers. Many farmers now use biological control, which uses a natural predator/parasite to get rid of the pest instead of using expensive pesticides.
- **Topsoil** is the top 1.5 metres of soil that contain the nutrients that plants require for growth. The tilling of the soil between plantings and heavy rainfall cause much of the topsoil to be lost, leading to the loss of valuable nutrients over time, reducing crop yields.
- **The use of fertilizers**, both inorganic (chemical) and organic (compost and manure) can increase the nutrients in the soil and keep soil fertile. This replaces nutrients in the soil that are lost when crop plants absorb them. Fertilizers can be expensive, contributing to the high cost of food, thus reducing access to poor consumers.

Alien plants and reduction of agricultural land

- Alien plants deplete the topsoil of water and nutrients. These alien plants out-compete indigenous plants because they have no natural predators, grow rapidly and invade land that could be used to grow crops.

The loss of wild varieties and the impact on gene pools

- Crop plants have replaced wild varieties. The preservation of wild varieties is important because, if changing environmental conditions destroy the present crop plants, then wild varieties could be used as alternative sources of food. If wild varieties are wiped out, it will reduce the genetic diversity and thus the gene pool.

Genetically engineered food

- Genetically engineered food is produced from genetically modified organisms (GMOs). Genetic engineering involves the inserting of a gene (with a desired characteristic) from one organism into another organism to increase the yield. For example, a gene for drought resistance could be inserted into a crop plant that grows in areas where water is scarce.

Food wastage

- Wastage could occur during the storage, production and processing of food. Wastage includes food thrown away and food not eaten. Wastage increases the prices of food to consumers and could reduce food security in a country.

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Activity 6

Questions

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

Country/Region	Total (kg)	Developed/ Developing Regions	Food loss and waste per person per year	
			At the production and retail stages(kg)	By consumers (kg)
Europe	280	Developed	190	90
North America and Oceania	295	Developed	185	110
Industrialized Asia	240	Developed	160	80
Sub-Saharan Africa	160	Developing	155	5
North Africa, West and Central Asia	215	Developing	180	35
South and Southeast Asia	125	Developing	110	15
Latin America	225	Developing	200	25

Adapted from *CUP Biology: Jones and Jones, 2010*

1.1 For Sub-Saharan Africa, calculate the food wastage by consumers as a percentage of the total food waste. (3)

1.2 Suggest a reason for this low percentage calculated in QUESTION 1.1 above. (2)

1.3 Explain the differences in the pattern of food wastage in developed and developing regions. (4)

1.4 State TWO possible ways of preventing the high levels of food waste that are found in the developed countries. (2)

[11]

2. The following questions relate to the factors that threaten food security in a country.

2.1 Give ONE reason why there has been an increase in the demand for food over the years. (1)

2.2 State one way in which the use of each of the following helps to increase food productivity:

a) Pesticides (1)

b) Fertilizers (1)

2.3 Describe how the use of pesticides could destroy food chains. (2)

2.4 Explain why GMOs may be considered a threat to food security. (3)

[8]

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Answers to activity 6

1. **1.1** Food Wastage in Sub-Saharan Africa
   5/160✓ × 100✓ = 3.1%✓ (3)

   1.2 Access to food is scarce and the food that is available is either provided by international aid agencies or subsistence farming✓. Very little food is bought and even less is bought from supermarkets.✓ There is no food left over to waste.✓ (any 2)

   1.3 In developed regions: buy food from markets, shops and supermarkets, often in excess of their requirements and will throw unused food away.✓ The markets, shops and supermarkets will also throw away unsold food.✓
   In developing regions: people will depend more on small, local sources of food,✓ have less food security and will not have food in excess of their needs.✓ (4)

   1.4 Possible ways to reduce food waste include:
   - Prevention – prevent consumers from throwing away food or stop them from producing/buying more food than they need✓
   - Plan what you need before you shop and reduce impulse and spontaneous buying✓
   - Understand how to store and preserve food✓
   - Ensure that unused food is used in some way – e.g. give to the poor, animal feed, compost heaps.✓
   - Education✓ (any 2)

   [11]

2. **2.1** There has been a rapid increase in the human population✓ (1)

   2.2 a) Pesticides kill the pests which destroy the crops✓ (1)
   b) Fertilizers increase nutrient content in the soil✓ (1)

   2.3 Secondary consumers e.g. birds can eat the pests with the poison✓, which can kill the birds✓ thereby decreasing the population size of birds✓
   OR
   The pest can become extinct✓, and the population size of the secondary consumer feeding on the pest will also decrease✓ (any 1 × 2) (2)

   2.4
   - Loss of flora and fauna biodiversity by inbreeding of GMOs✓
   - Entire species could be wiped out✓ if exposed to diseases✓ (no variation in the population)/GMOs will have no resistance to the diseases (3)

   [8]

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11.4 Loss of biodiversity

Biodiversity refers to the variety of plant and animal species on Earth. Biodiversity ensures that we have food, fresh water, medicines and fuel that we obtain from our environment. It also ensures that the climate is regulated, floods are controlled (wetlands), diseases are kept in check (predators eat the sick animals) and water is purified (filtering by wetlands). Biodiversity ensures that seeds are dispersed, nutrients are cycled (e.g. nitrogen and phosphorus) and oxygen and soil continue to form. It also helps improve our quality of life by providing us with forms of recreation and ecotourism. As biodiversity declines, these things do not occur as they should and the survival of humans becomes threatened.

11.4.1 Factors that reduce our biodiversity

Habitat destruction through:

Farming methods

Monoculture: Monoculture is the growing of one type of crop over large areas of land year after year. Monoculture replaces indigenous plants and reduces biodiversity. Insects that specialise in feeding on one type of crop spread rapidly because there are no natural enemies or barriers to stop them. This means the farmer needs to use more pesticides to kill them. Intensive use of agrochemicals such as fertilisers and pesticides often end up in rivers, streams and groundwater, poisoning species in the area and causing eutrophication. This results in a large loss of biodiversity.

Overgrazing: It occurs when livestock such as sheep or cattle are kept in an area for too long; the vegetation is grazed to a point where it will not grow back. It causes soil erosion by removing the plants that bind the soil together with their roots. Topsoil is lost during rainstorms. This can lead to the extensive destruction of land through desertification which results in loss of biodiversity. Sometimes overgrazed land becomes subject to alien plant invaders which destroy habitats by taking over the land.

Golf Estates

Developments such as golf estates are a form of monoculture that requires large amounts of water, pesticides and fertilisers which may runoff and poison aquatic ecosystems. Housing associated with golf developments replaces large areas of natural vegetation.

Mining

Mining alters the environment and can negatively affect the biodiversity in an area. Pollutants in the form of dust and smoke may be released into the air while vegetation is removed and replaced with rock and waste dumps. Underground water may be poisoned because of sulphates and heavy metals released into them.

Urbanisation

The growth of large cities (urbanisation) also negatively impacts on biodiversity. Surfaces are covered with concrete, and natural habitats are

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destroyed to build houses and businesses. Habitat fragmentation causes the loss of biodiversity, as natural plants are replaced by exotic trees and plants.

Deforestation

Deforestation is the permanent destruction of indigenous forest and woodland areas. Deforestation is caused by human activities such as agriculture, logging, and using trees as firewood. Deforestation leads to the destruction of the habitats of other organisms, like frogs and insects, and this leads to the loss of biodiversity.

Loss of wetlands and grasslands

Grasslands and wetlands have unique plant and wildlife and provide many ecological services to humans. Destruction of these habitats will lead to the loss of species.

Poaching

Poaching refers to the illegal hunting of animals, either for food or because certain body parts can be sold for money. 'Poaching' may also be applied to plants that are removed and sold for profit e.g. medicinal plants. Some wild animals are hunted for food ('bush meat') and are on the verge of extinction. Elephants are poached for their tusks to make carvings and jewellery and rhinos are hunted for their horns which are used in the Far East for medicinal reasons.

Alien plant invasions

These plants are species that have been introduced into an area and which compete with the natural plants in the area. They can outcompete indigenous plants, thus reducing the biodiversity.

11.4.2 Ways in which our biodiversity can be maintained

Control of alien plant invasions

Alien invasive species may be controlled by mechanical, chemical and biological methods. Mechanical methods involve chopping down plants or physically removing them by hand and is very time consuming. Chemical control involves spraying herbicides onto the plants; this can pollute the environment and is expensive. Biological methods involve introducing a natural enemy from the alien plant's environment and allowing it to reproduce and feed on the invasive plant.

Sustainable use of the environment

Sustainable use of the environment means using resources without harming the ability of future generations to use that resource. Substances from indigenous plants such as the African potato, Hoodia, rooibos and Devil's claw all have economic and medicinal value. These indigenous plants can be used sustainably by encouraging traditional healers to grow their own plants and through improving education of the women who generally gather the plants in the wild. Encouraging traditional healers to

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be part of formal medical programmes would encourage training to be on-going and help establish sustainable use of medicinal plants. Legislation should be passed to limit the numbers of plants that can be harvested at one time and seeds of medicinal plants could be collected and distributed to increase plant numbers.

Activity 7

Questions

1. Study the following table showing a summary of the rhino poaching incidents in South Africa from 2006 – 2010.

Province	2006	2007	2008	2009	2010	Total
Kruger National Park (part of Limpopo)	17	10	36	50	109	**222**
Gauteng	0	0	0	7	15	**22**
Limpopo	0	0	23	16	37	**76**
Mpumalanga	2	3	2	6	12	**25**
North West	0	0	7	10	44	**61**
Eastern Cape	0	0	1	3	2	**6**
Free State	0	0	0	2	3	**5**
KwaZulu-Natal	5	0	14	28	23	**70**
Northern Cape	0	0	0	0	2	**2**
Total Illegally hunted	**24**	**13**	**83**	**122**	**247**	**489**

1.1 How many rhinos were illegally hunted in 2009? (1)

1.2 Suggest THREE ways in which the poaching of rhinos can be stopped. (3)

1.3 Describe the general trend observed in the table. (2)

1.4 By what percentage did the poaching of rhino incidents increase in North West from 2008 to 2010? Show all working. (3)

1.5 Use the data in the table and draw a bar graph to show the number of rhinos poached each year from 2006 to 2010 in South Africa. (7)

[16]

2. Read the following passage on Rooibos (*Aspalanthus linearis*) and answer the questions that follow.

> *The Rooibos plant is used to make herbal tea. South Africa is the only commercial grower of Rooibos plants in the world. Rooibos tea is a caffeine-free beverage with health and medicinal benefits. Some of the benefits of drinking Rooibos tea are: it has a calming effect, it helps with digestion problems and it helps with infant colic.*

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2.1 Describe TWO ways in which over-exploitation of plants, such as Rooibos, impacts on other life forms and the environment. (2)

2.2 Describe THREE strategies that could be used to prevent the over-exploitation of plants such as Rooibos. (3)

[5]

Answers to activity 7

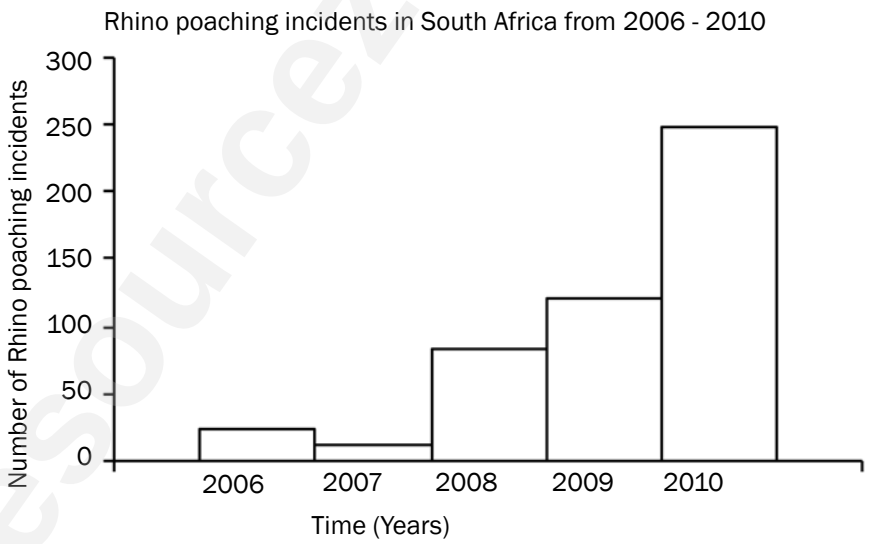
1. **1.1** 122 ✓ (1)

1.2
- Rhino horns must be sawn off ✓
- Implant a 'Pro Tag Device' to monitor movement of the rhino ✓
- Institute heavy penalties like imprisonment instead of fines ✓ (3)

1.3 Rhino poaching ✓ has increased ✓ from 2008 to 2010 (2)

1.4 $\frac{44}{7}$ ✓ × $\frac{100}{1}$ ✓ = 628,53% ✓ (3)

1.5



(7)

[16]

2.

2.1
- Plants can become extinct ✓/leads to loss of biodiversity
- Food chains/webs can be destroyed ✓
- Could lead to degradation of the environment ✓
- Erosion of ground surface if too many plants are removed ✓
- Increase run-off of water ✓
- Alien plant invasion ✓in the habitats from which the plants are removed
- Upset the balance of oxygen and carbon dioxide ✓/global warming if too many plants are removed (any 2)

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Answers to activity 7 (continued)

2.2
- Sustainable harvesting ✓
- Impose quotas ✓/limit numbers
- Limit area ✓where plants are harvested
- Limit size of plants harvested ✓
- Limit time/seasons of collection ✓
- Research done to look at reproductive cycle ✓/alternative source of active ingredient/cloning
- Legislation to control harvesting ✓
- Permits to control harvesting ✓
- Monitoring of harvest ✓
- Penalties ✓for breaking legislation
- Education ✓/campaign on the impact and consequences of over-exploitation
- Establish nurseries ✓/seed banks – to replace plants harvested
- Establish more nature reserves ✓ to conserve indigenous plants (any 3)

(5)

11.5 Solid-waste disposal

Solid waste is any solid material that is of no use to humans and which needs to be disposed of in a safe and environmentally friendly way.

Managing dumpsites for rehabilitation and prevention of soil and water pollution

The simplest and most cost effective way of disposing of solid waste is to bury it in landfill sites. A landfill site is a hole where solid waste is dumped and then covered by soil. However, this way of disposing of solid waste contributes to soil and groundwater pollution because rain seeps through the waste to produce a toxic substance called leachate. To prevent the toxic leachate from reaching the groundwater, a plastic liner is placed under the dumpsite area.

Rehabilitation of landfill sites occurs before they are closed down. This involves the covering of the old landfill site with clay soil, which is impermeable to water, and then it is covered with topsoil. Grass or other vegetation is then planted on the old landfill site. The growth of the plants stabilises the area and the old landfill site may be used as a recreational area such as a park or a golf course.

The need for recycling

Various methods may be used to manage solid waste, they include the reduction of waste, re-using waste and recycling of waste.

- Re-using waste products includes re-using plastic shopping bags, re-using glass and plastic containers – this helps to reduce the waste produced.
- Recycling is a process whereby used materials/waste products are recycled to make new products, for example plastic, glass, tin and

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paper. The advantage of recycling is that it provides employment, reduces the use of raw materials and energy, and reduces air, ground and water pollution.

Using methane from dumpsites for domestic use: heating and lighting

Methane is a gas produced as a result of the decomposition of organic waste. The methane gas can be used as a fuel. Methane can be collected from landfill sites and used to generate electricity for domestic use – heat for cooking and electricity for lighting.

Safe disposal of nuclear waste

South Africa also uses radioactive material such as uranium to power its nuclear power station at Koeberg in the Western Cape. Unfortunately, a by-product of using uranium is nuclear waste that is still radioactive and therefore dangerous to living organisms. The nuclear waste is stored in thick steel drums and buried in trenches at special protected sites.

Activity 8

Questions

1. State FOUR strategies you would use to manage solid waste if you were appointed as the head of the waste disposal division of your town. (4)
2. The following table shows the total amount of solid waste and the amount of recyclable material dumped in a South African city landfill site over a number of years.

YEAR	TOTAL AMOUNT OF SOLID WASTE (MILLIONS OF TONS)	AMOUNT OF RECYCLABLE MATERIAL IN SOLID WASTE (MILLIONS OF TONS)
2003	1,49	0,78
2004	1,59	0,82
2005	1,80	1,20
2006	1,93	1,30

2.1 Describe the general trend in the total amount of waste produced and the amount of recyclable materials dumped from 2003 to 2006. (2)

2.2 Explain TWO advantages of recycling. (4)

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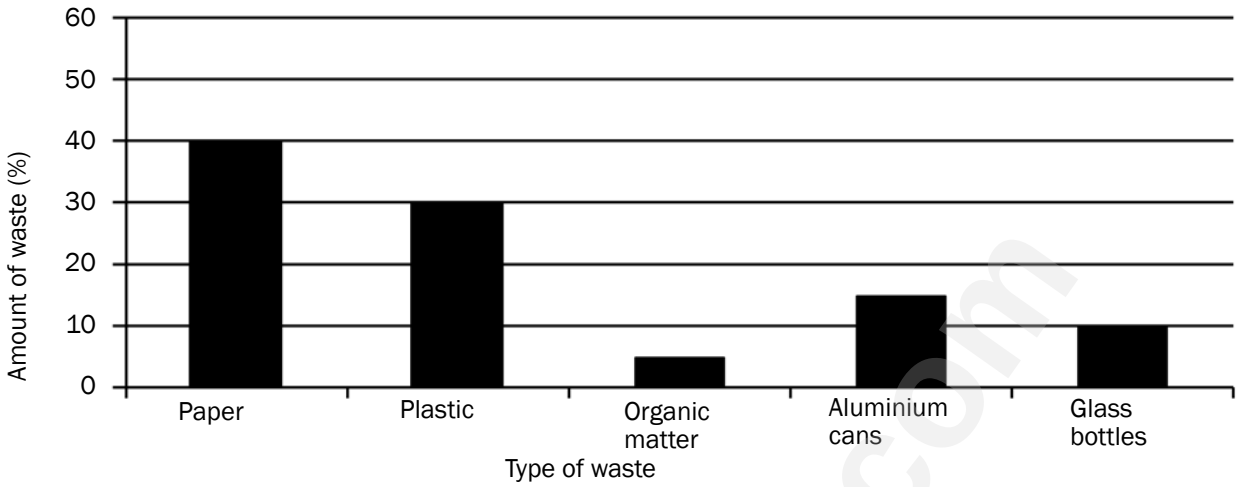
3. The graph below shows the percentages of various types of waste found on the grounds of a school.



3.1 Draw a table to illustrate the percentages of waste shown in the graph above. (5)

3.2 The school wants to manage the large amount of waste generated on a daily basis. They decide to recycle the waste.

3.2.1 Define 'recycling'. (2)

3.2.2 Give TWO reasons why the recycling of waste is advantageous. (2)

[19]

Answers to activity 8

1.
- Investigate methods to collect and utilise methane gas as a fuel ✓
- Encourage citizens of the city to sort their waste ✓ into different waste containers
- Partner with recycling companies for improved collection of different wastes ✓
- Institute fines ✓ for people that do not separate the waste into different bins
- Educate people to use organic waste ✓ for example to make compost
- Encourage recycling ✓of items such as papers, tins, glass
- Encourage citizens to reuse ✓ items such as glass
- Penalties/charge people extra if they generate more waste ✓

(any 4)

2. **2.1** Both ✓ the total amount of waste produced and the amount of recyclable material increased ✓ from 2003 to 2006 (2)

2.2
- People collect and sell waste at buy-back centres ✓ and therefore benefit economically ✓/create own jobs
- People who collect waste and take it to recycling depots✓ contribute to sustainable use of materials ✓
- Recycling saves energy ✓ and therefore reduces the amount of energy used to make new products ✓(any 2 × 2)

[4]

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Answers to activity 8 (continued)

3.

3.1 Percentages/amount of each type of waste on the school grounds

Type of waste	Percentages (%)
Paper	40
Plastic	30
Organic matter	5
Aluminium cans	15
Glass bottles	10

(5)

3.2

3.2.1 The process by which waste materials✓ are treated in such a way that they can be used again✓/ reused (2)

3.2.2
- To avoid over-exploitation of the limited natural resources✓
- To save/raise money✓/(create jobs)
- To reduce the amount of waste material✓/cleaner environment
- Less energy✓used/Reduce carbon footprint
- Fewer landfill sites✓ (any 2) (2)

[19]

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Chapter 12

Skills

12.1 Drawing graphs

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

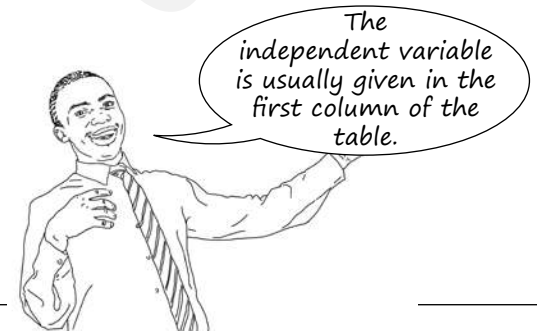
1. **Line graphs** show the relationship between two types of information where the independent variable is continuous. Line graphs are useful in showing trends over time and are often used for biological data.
2. **Bar graphs** show different categories of data and are used when the independent variable is not a set of continuous numbers or continuous groups (discontinuous data). They are best used to compare values across categories.
3. **Histograms** have connected bars displaying continuous data. They are used when the values of the independent variables are continuous but fit into categories or groups that follow on after each other.
4. **Pie charts** are circular charts used to compare parts of the whole. They are divided into sectors that are equal in size to the quantity represented. They are used for discontinuous data.

12.1.1 How to draw a line graph

Step 1

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

- **Dependent:** This is the variable or factor that is being measured, i.e. the temperature in degrees Celsius in this example.
- **Independent:** This is the variable that the investigator can change. The dependent variable changes as the independent variable changes, i.e. the time in hours in this example.



Time (hours)	Temperature (°C)
0	16
5	24
9	28
13	26
17	21
20	19
24	17

Table 12.1 Air temperature recorded over a 24 hour period

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Step 2

Draw a **set of axes** and label the X and Y axes. The dependent variable goes on the Y-axis and the independent variable on the X-axis. Include the unit in each label, e.g. temperature in °C and time in **hours**. Do **NOT** forget to label the axes.

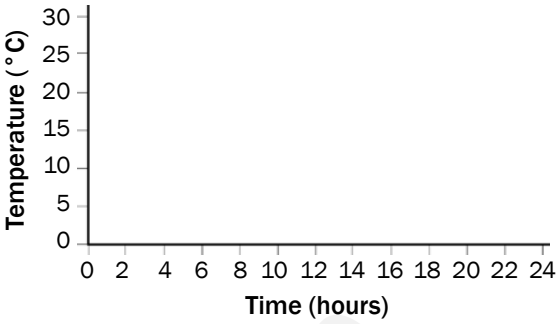
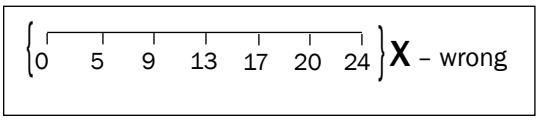


Figure 12.2 Draw the axes and choose a scale

Step 3

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



Step 4

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

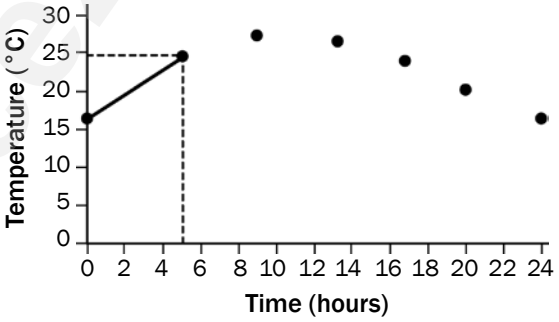


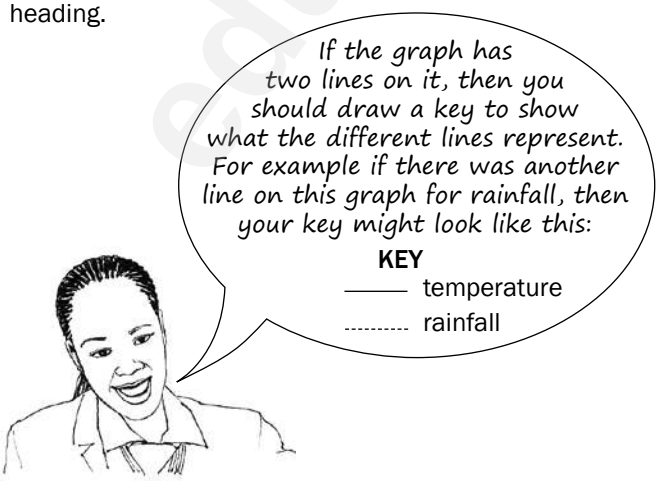
Figure 12.3 Plot the points on the graph and join them

Step 5

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

Step 6

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



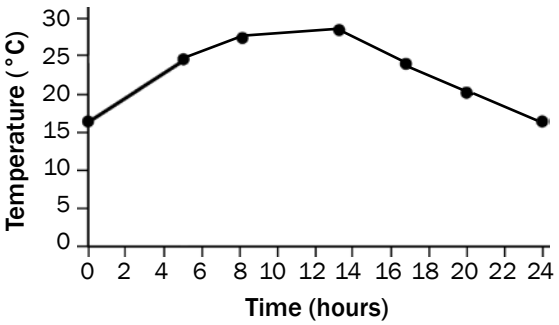


Figure 12.4 Final line graph with heading

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12.1.2 How to draw a bar graph

Steps 1 to 3

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

Point number	Number of organisms
1	10
2	12
3	8
4	8
5	4

Table 12.2 Number of organisms found in the water at different points along a river

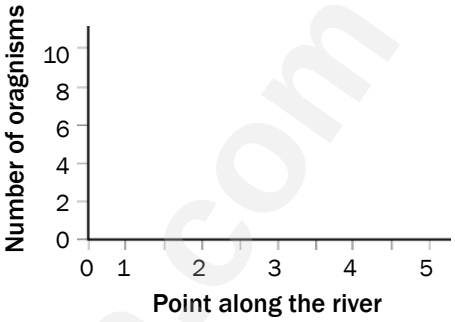

Figure 12.5 Draw the axes and choose a scale

Step 4

Draw a bar to show that 10 organisms were found at point number 1 on the river. Then draw bars to represent the number of organisms found at each of the points along the river.

Since this is a bar graph, the **bars should not touch** as the points along the river have **no direct relationship** with each other.

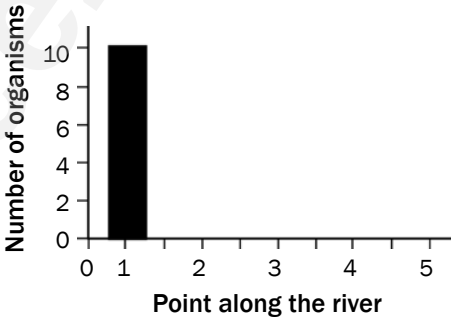

Figure 12.6 Draw the first bar

Step 5

Give the graph a heading or caption. See step 6 under the line graph for instructions how to give your graph a heading or caption.

Bar graph to show the number of organisms at different points along a river

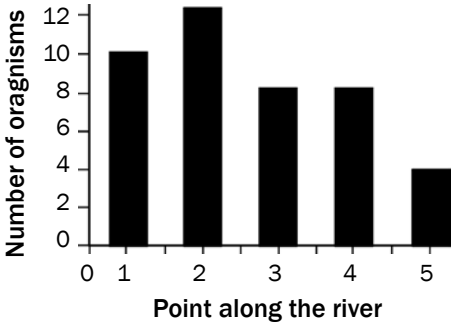

Figure 12.7 Final bar graph with heading

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12.1.3 How to draw a histogram

A histogram is drawn in exactly the same way as a bar graph. The only difference is that a histogram is used when the independent variable is groups of information along a continuous scale. Note that in a histogram, the bars are drawn **without any spaces** between them. Use the information in Table 12.3 below to draw a histogram. Your graph should look like the one in Figure 12.8 below.

Range (%)	Number of pupils
0–19	0
20–39	5
40–59	11
60–79	16
80–100	3

Table 12.3 Number of learners with a particular percentage (%) score

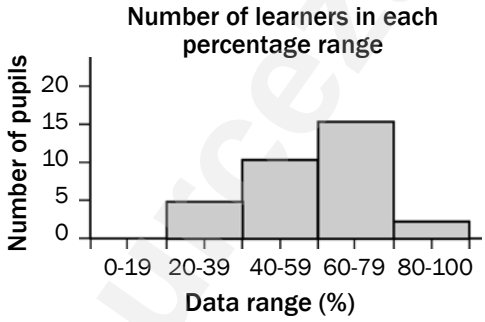

Figure 12.8 Final histogram with heading

NOTE:

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

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

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12.1.4 How to draw a pie chart

Step 1

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

34 + 38 + 22 + 30 + 76 = 200

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

Contraceptive	Number of women
Sterilisation	34
Pill	38
Condom	22
Rhythm method	30
None	76

Table 12.4 Table of contraceptive use by a sample group of women

Step 2

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

$\frac{34}{200} \times 360 = 61{,}2°$ (round down to 61°)

$\frac{38}{200} \times 360 = 68{,}4°$ (round down to 68°)

$\frac{22}{200} \times 360 = 39{,}6°$ (round up to 40°)

$\frac{30}{200} \times 360 = 54°$

$\frac{76}{200} \times 360 = 136{,}8$ (round up to 137°)

NB

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

61° + 68° + 40° + 54° + 137° = 360°

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

Step 3

Use a mathematical compass to draw a circle.

Step 4

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

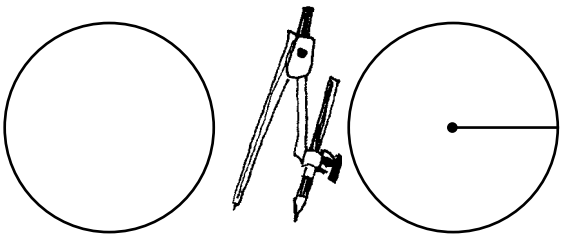

Figure 12.9 Draw a circle and then draw a radius

Step 5

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

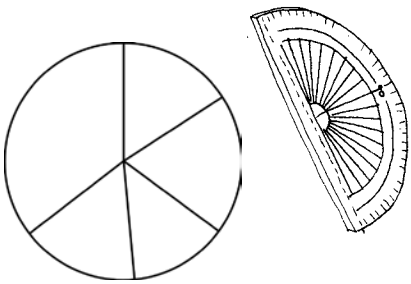

Figure 12.10 Measure out the sectors

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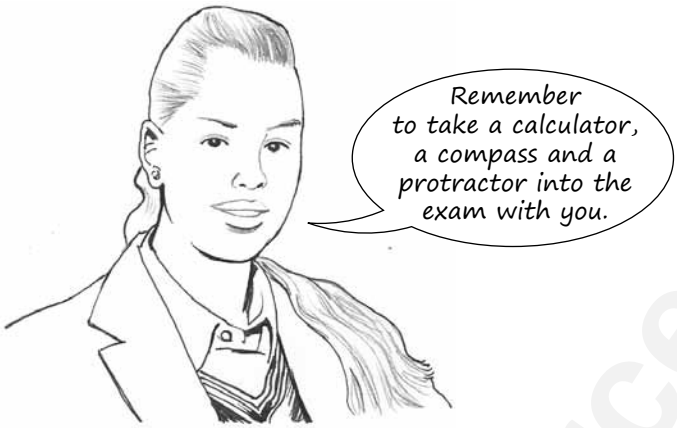
Step 6

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

Step 7

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



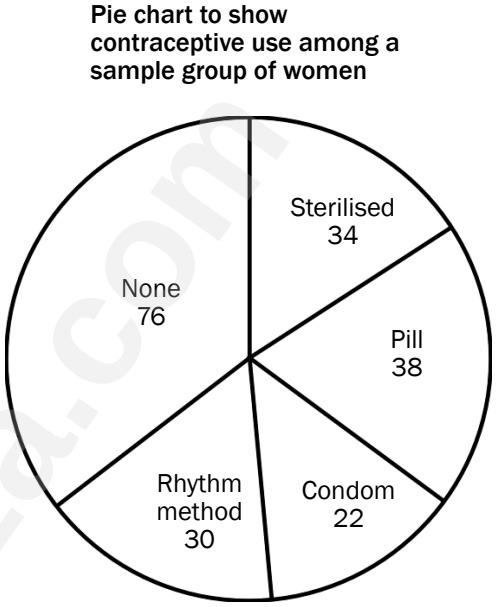


Figure 12.11 Final pie chart with heading

12.2 Answering essay questions

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

> **Describe** the role of the hypothalamus and the adrenal glands in bringing about changes to the blood vessels of the human skin and **explain** why these changes take place.
>
> Content (17)
> Synthesis (3)
> **(20)**

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Step 1

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

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

Step 2

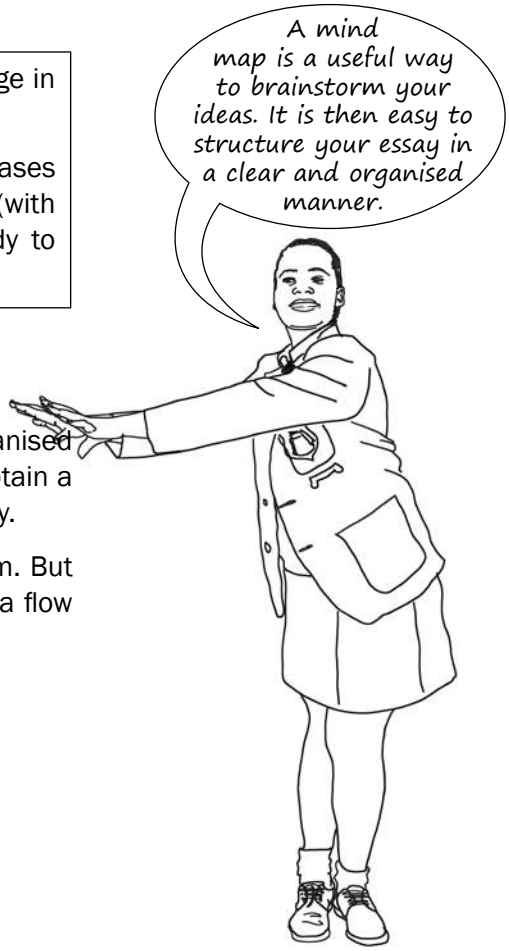
Interpret and analyse the essay question. Identify the **aspects or processes** that are required from each of the topics identified. You may need to read the question more than once to enable you to do this.

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

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

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

Hypothalamus – controls body temperature by stimulating a change in the diameter of the blood vessels of the skin. Adrenal glands secrete adrenalin into the bloodstream, which decreases the diameter of the blood vessels of the skin so that more blood (with oxygen and glucose) can be directed to other parts of the body to prepare for an emergency.



Step 3

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

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

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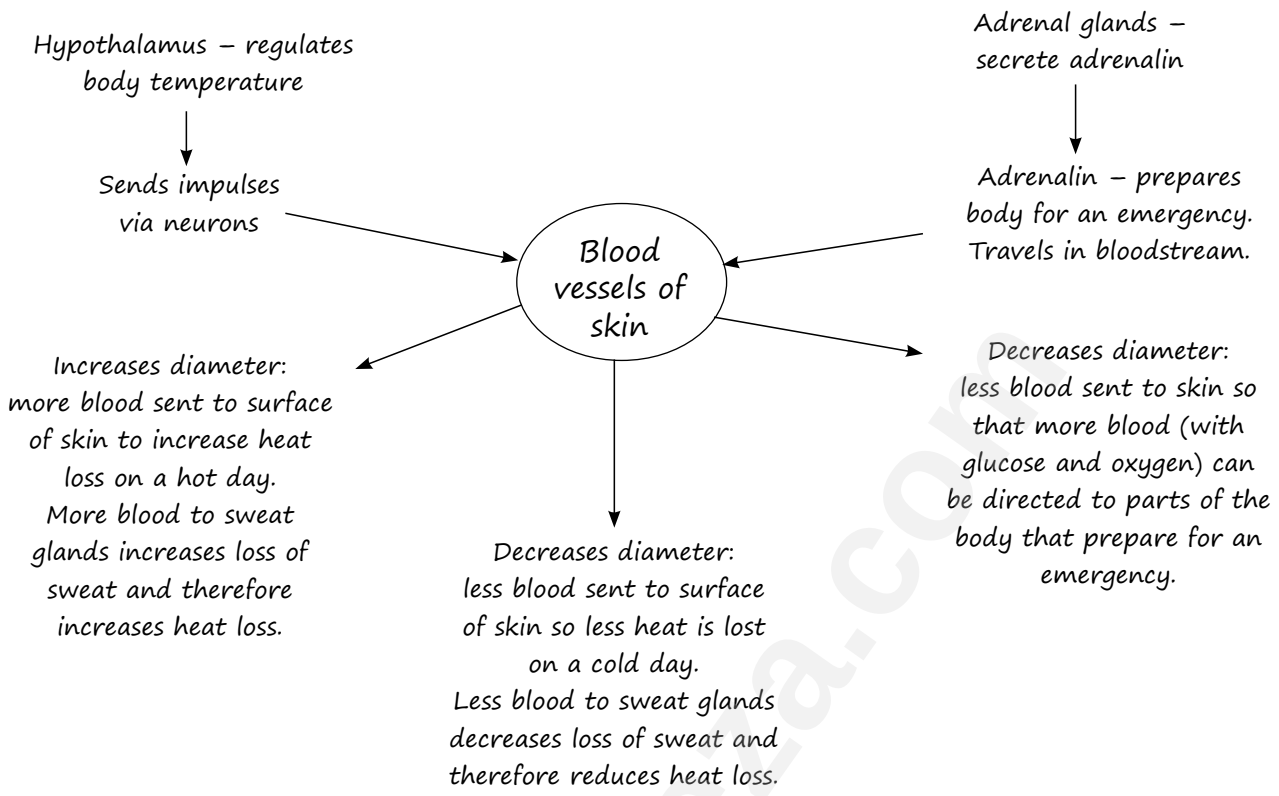
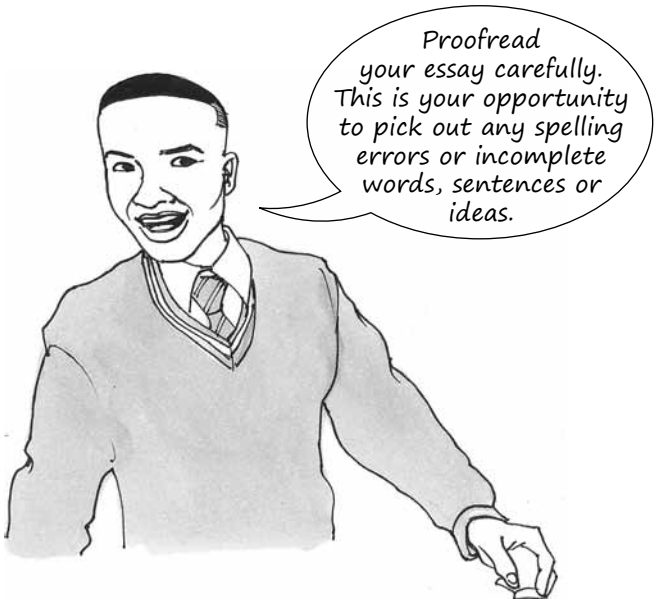


Step 4

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

Step 5

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



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12.3 Line drawings

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

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

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

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Appendix 1: Blank drawings

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

1. You can use them to practise your drawing and labelling skills. You may be asked to draw a diagram in the exam, so make sure you follow the guidelines set out on page 113 when you redraw and label a diagram.
2. These diagrams are a valuable study aid. They summarise key information and important processes in Life Sciences. If you can label all these diagrams correctly on your own, without looking at them in the text, you'll be well prepared for the exam.

The following diagrams are included:

Topic 1: DNA: The code of life
Nucleotide
DNA
RNA
Replication of DNA
Protein synthesis

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

Topic 3: Reproduction
Male reproductive system
Sperm cell
Female reproductive system
Hormonal control of the menstrual cycle
Fertilisation and gestation

Topic 4: Responding to the environment: humans
Brain
Neuron
Reflex arc
Eye
Accommodation
Pupillary mechanism
Ear

Topic 5: Human endocrine system
Name, position and functions of glands

Topic 6: Homeostasis in humans
Skin regulating temperature on a hot and cold day

Topic 7: Evolution
Characteristics we share with the African apes
Characteristics that make us different from the African apes

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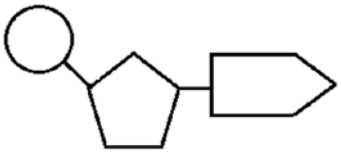
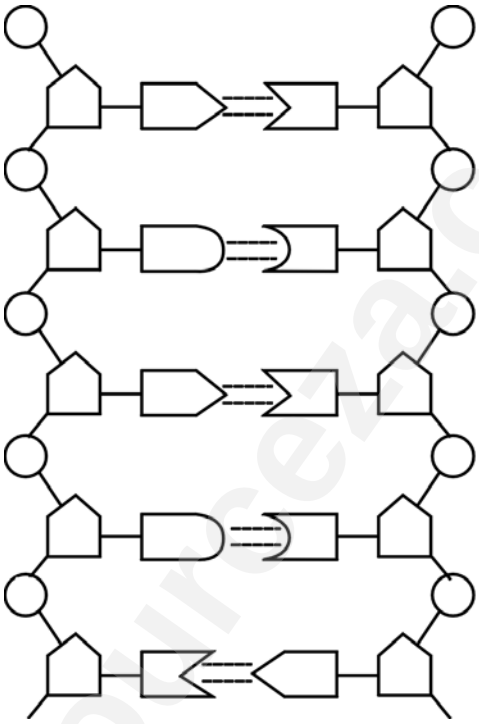
Topic 1: DNA: The code of life

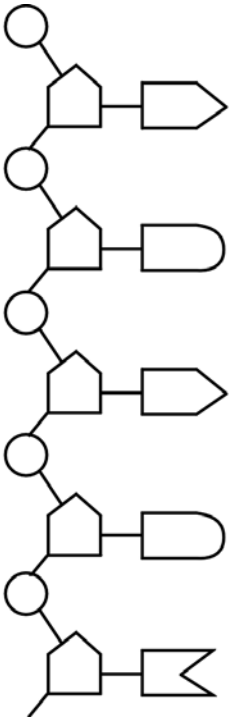
1. **Nucleotide**



2. **DNA**



3. **RNA**



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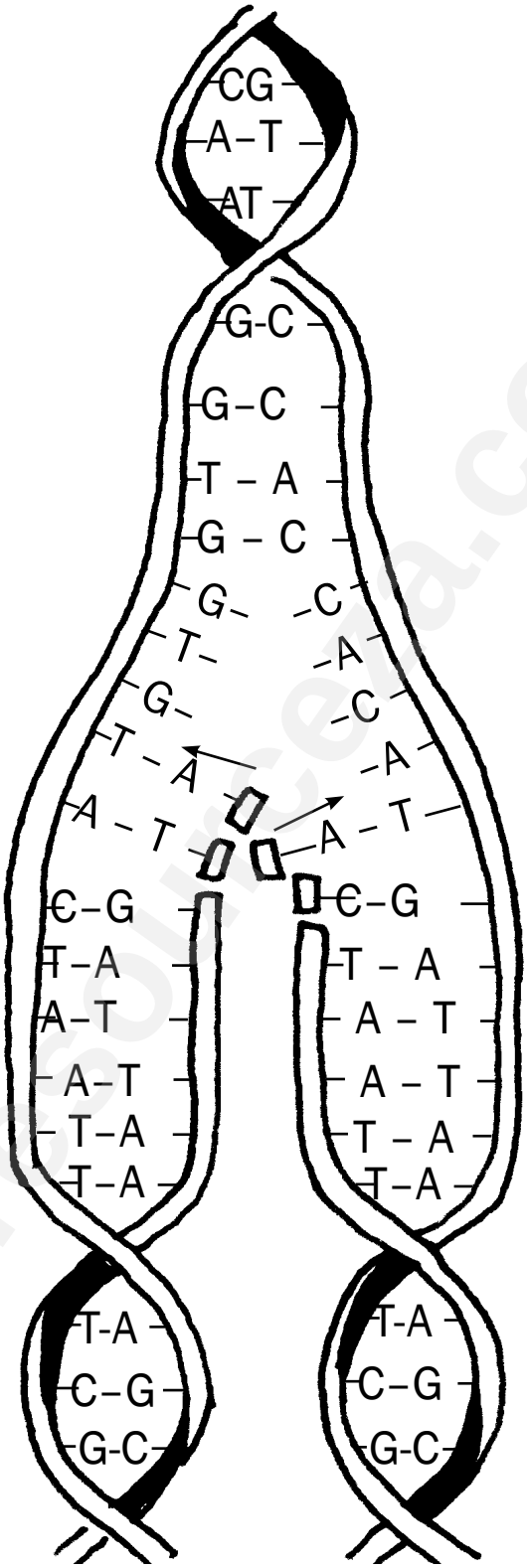
4. Replication of DNA



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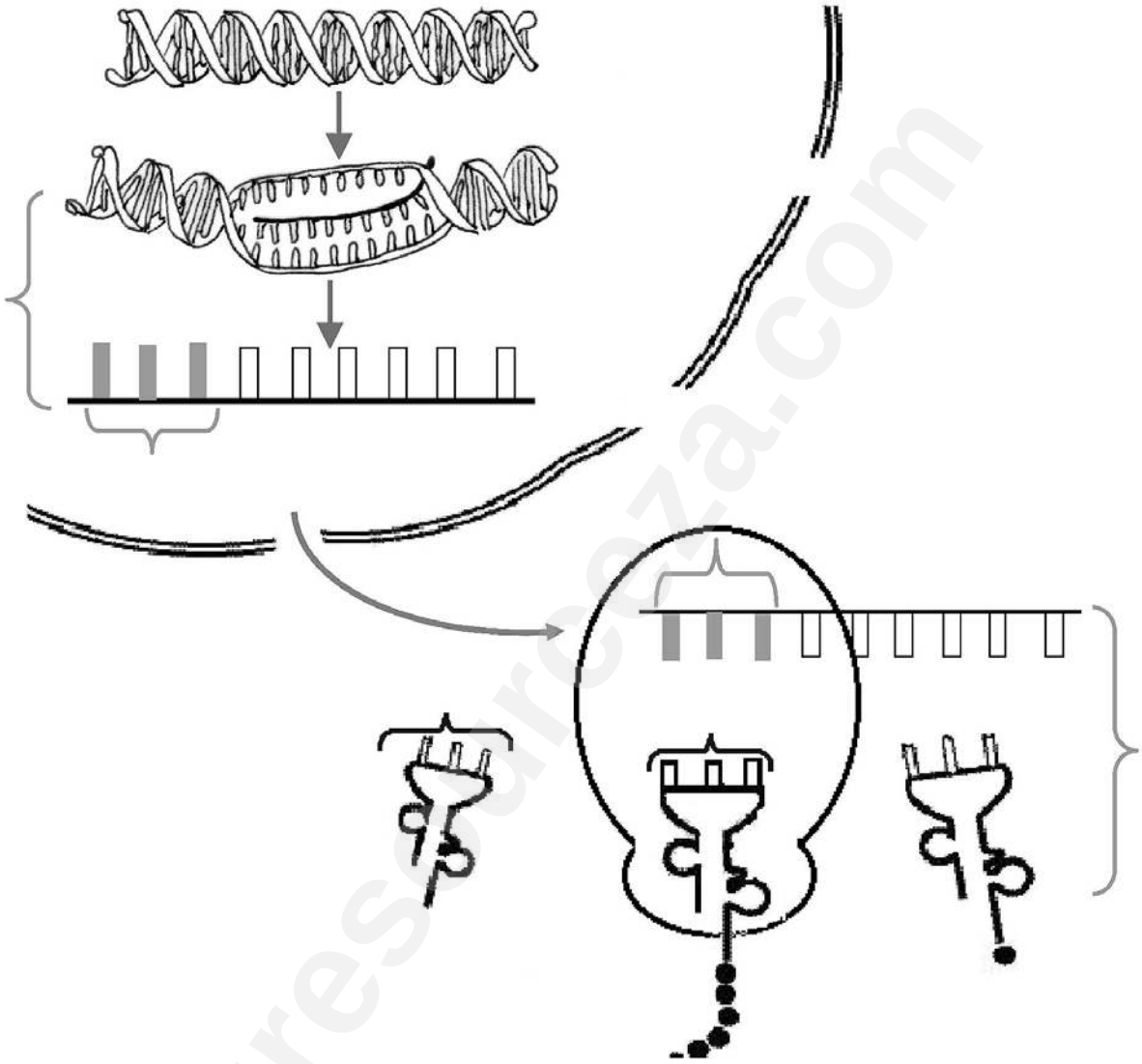
5. **Protein synthesis**



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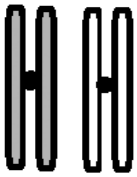
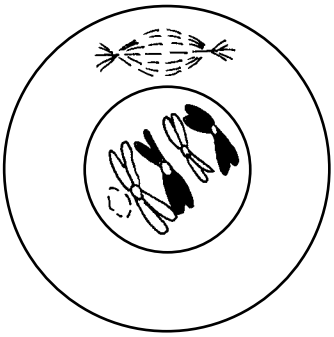
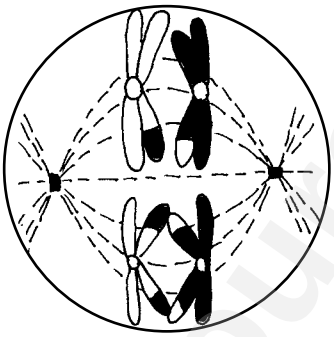
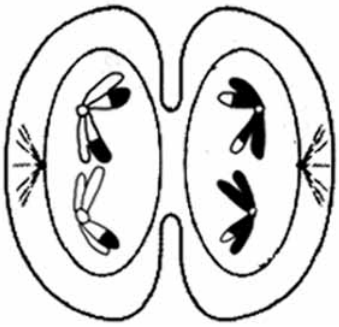
Topic 2: Meiosis

1. Homologous chromosomes



2. Meiosis I

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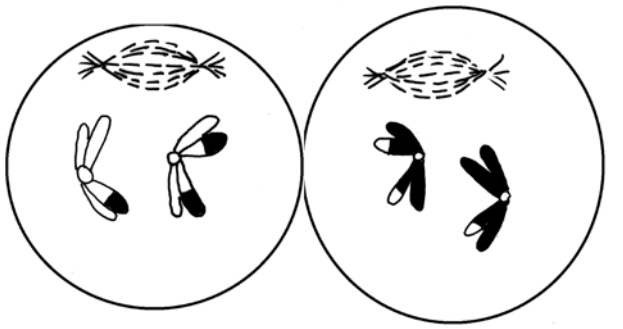
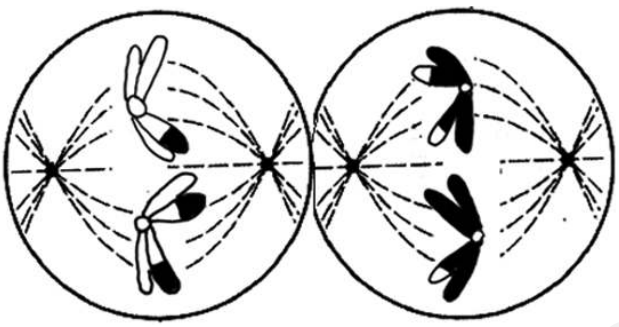
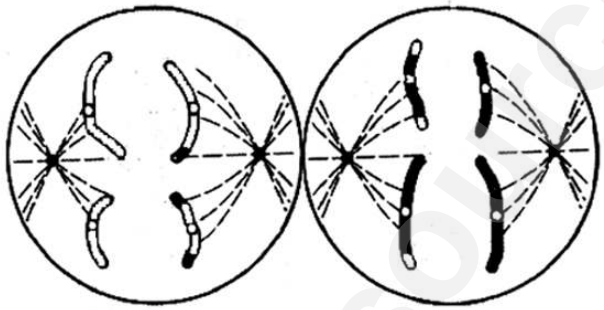
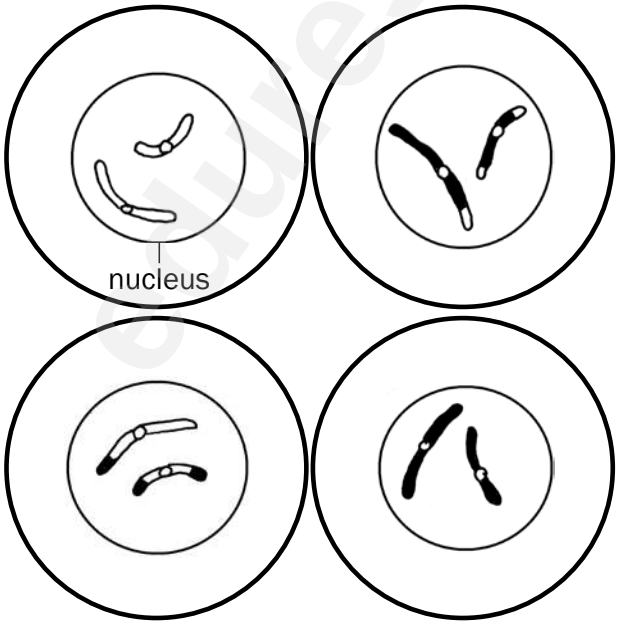
3. **Meiosis II**

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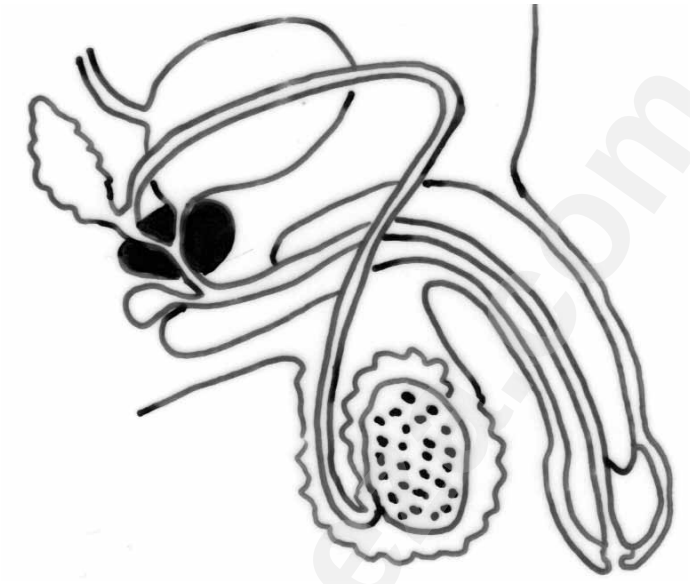
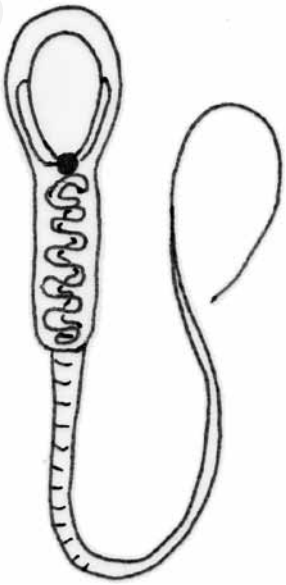
Topic 3: Human reproduction

1. Male reproductive system



2. Sperm cell



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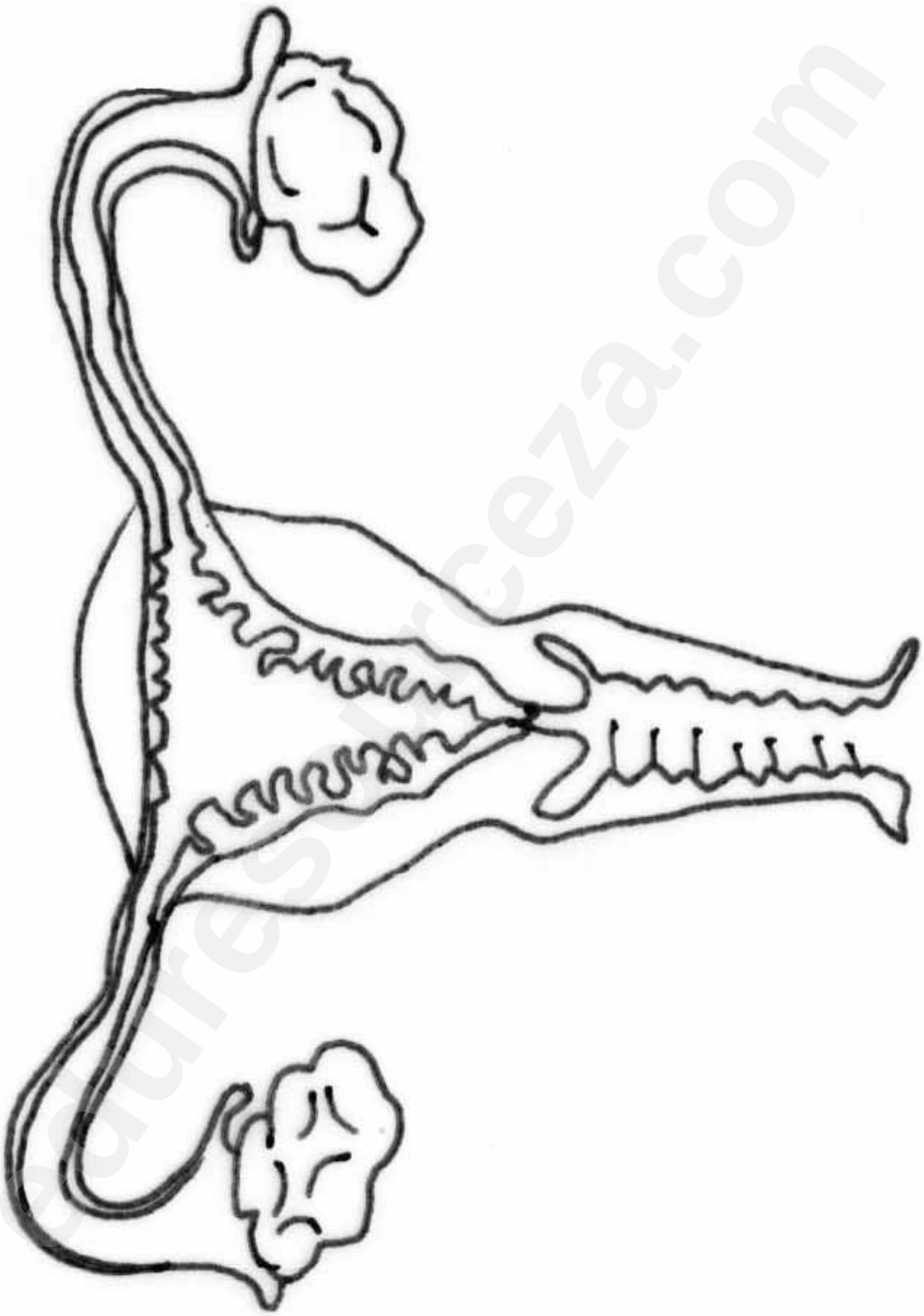

3. Female reproductive system

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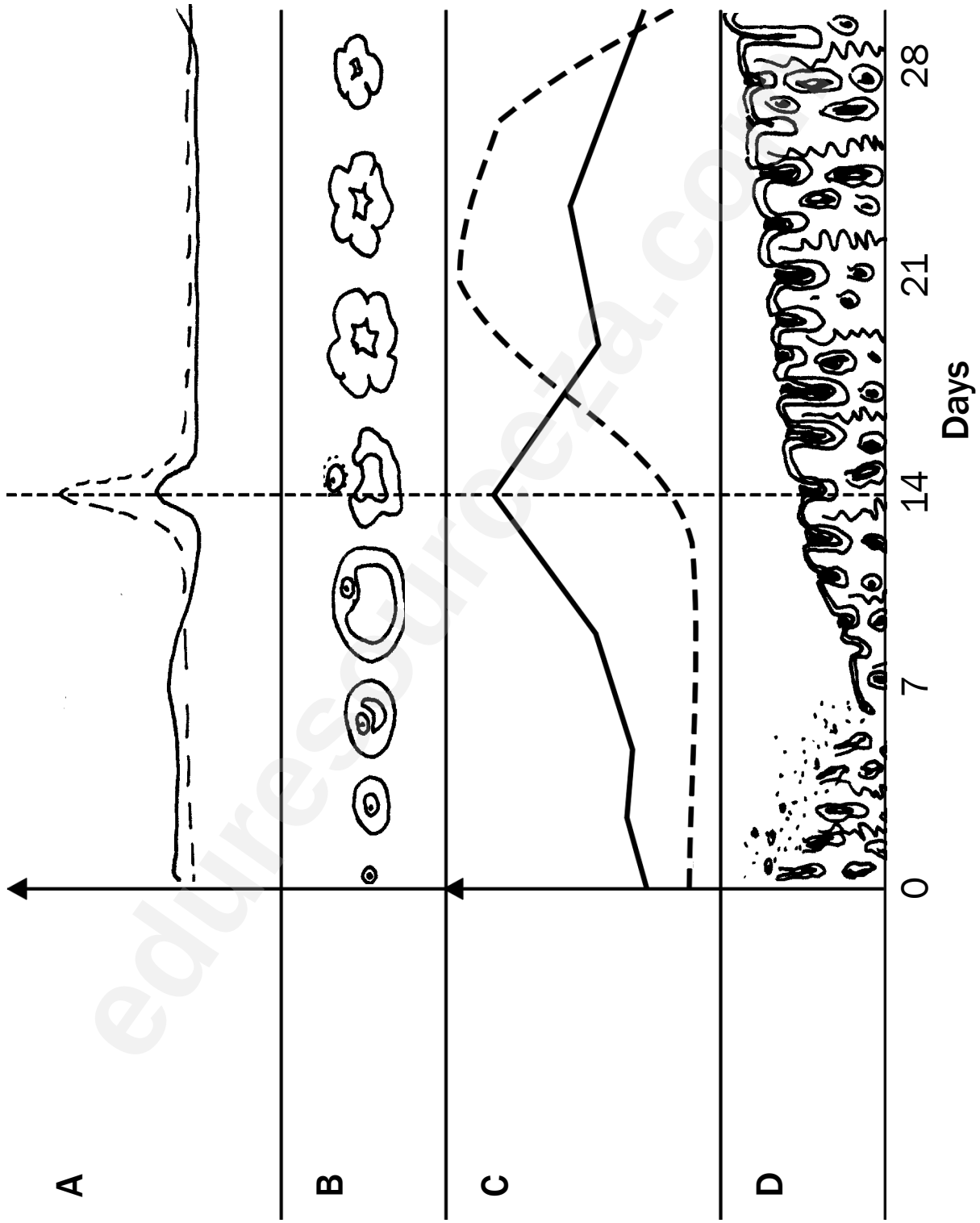
4. Hormonal control of the menstrual cycle



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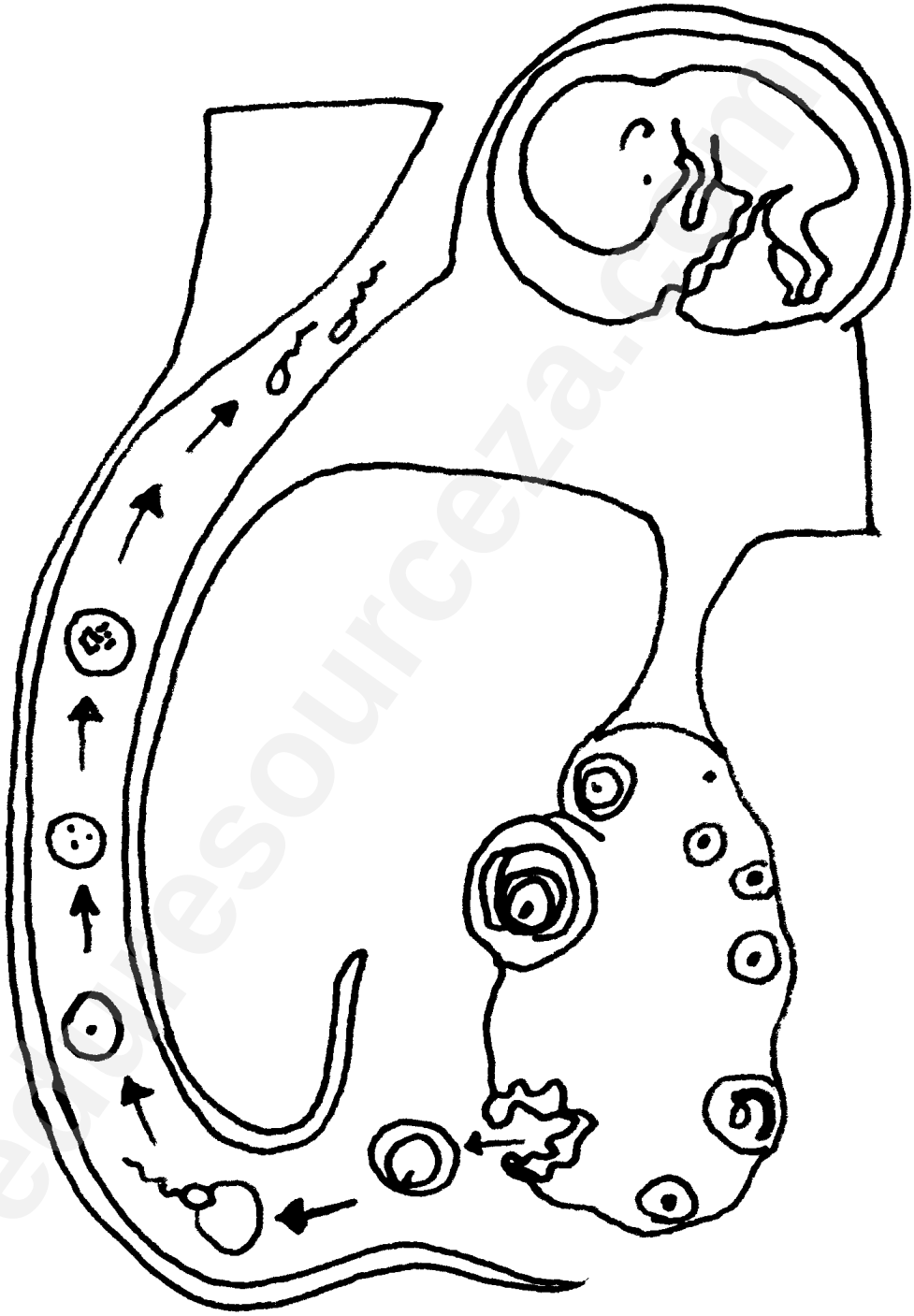
5. Fertilisation and gestation



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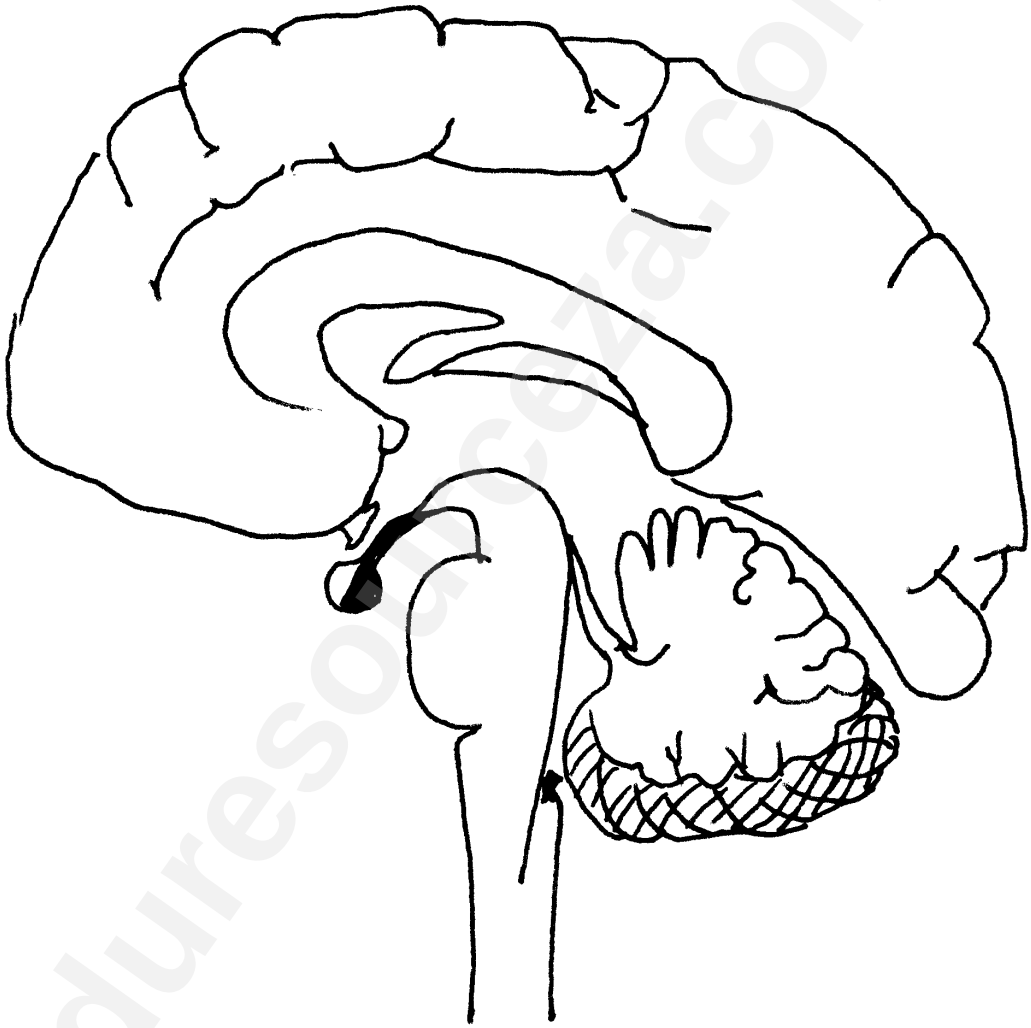
Topic 4: Responding to the environment – humans

1. Brain



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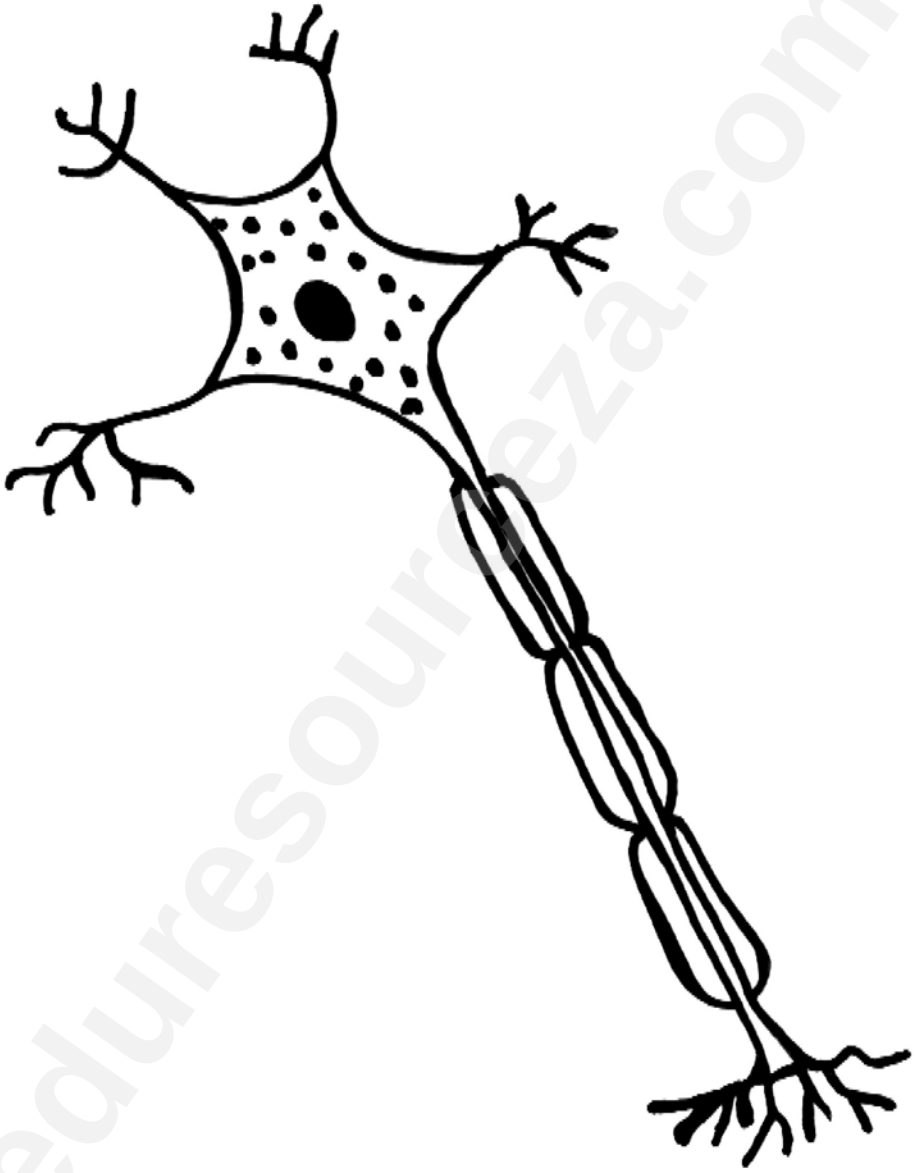
2. Neuron



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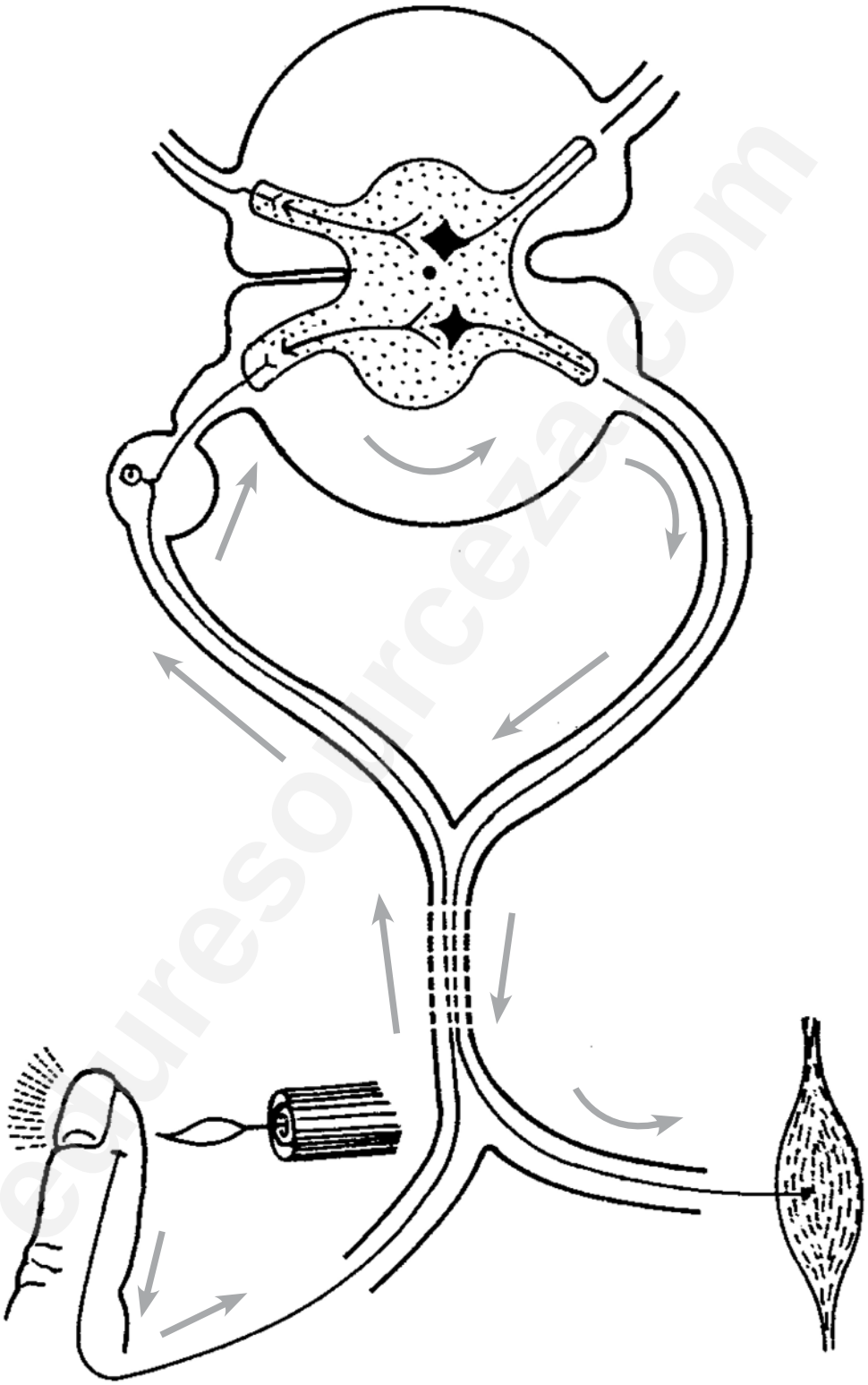

3. Reflex arc

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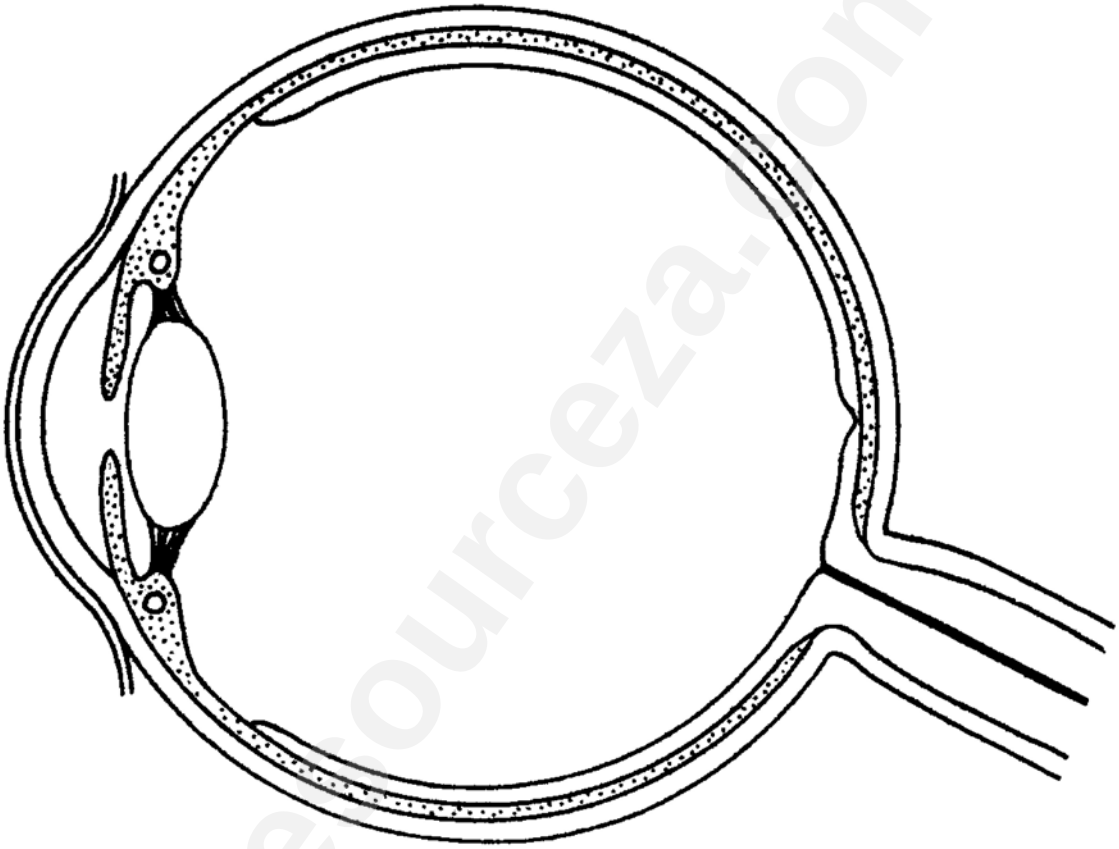
4. Eye



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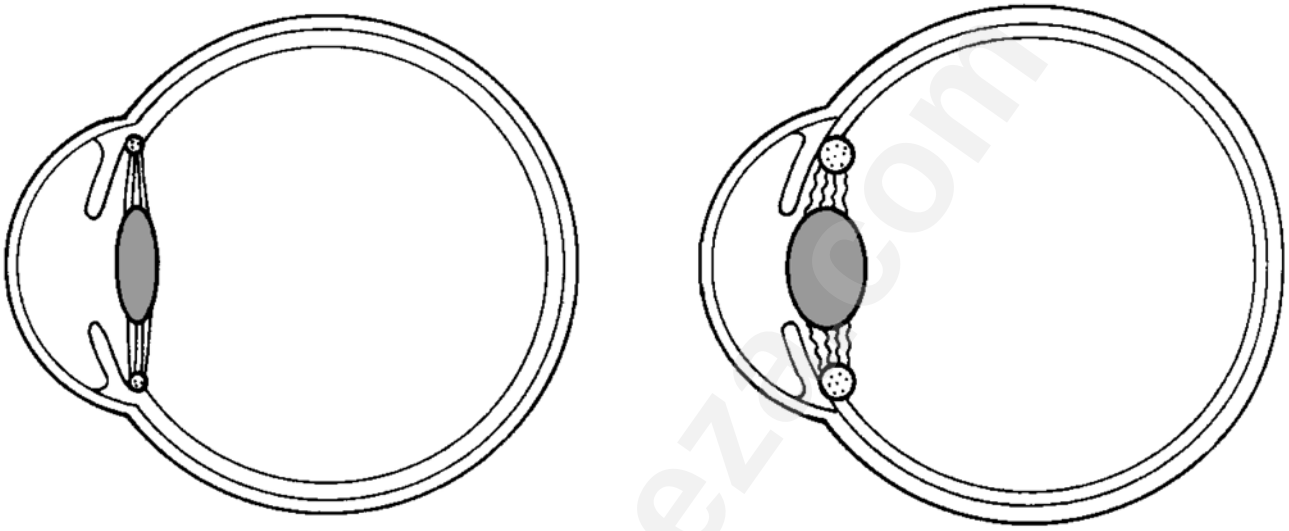
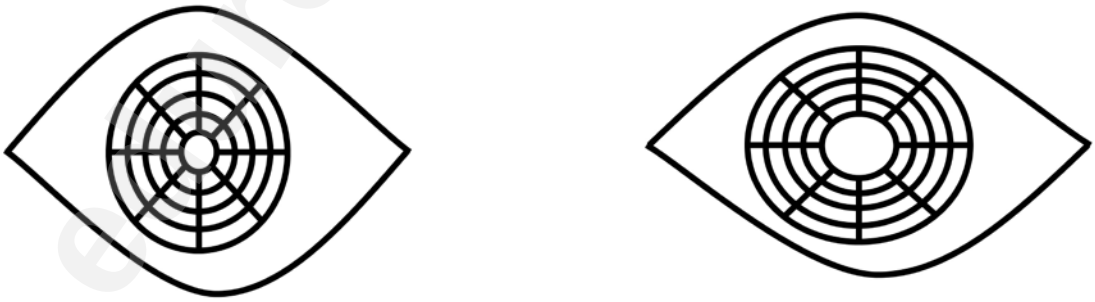
5. Accommodation



6. Pupillary mechanism



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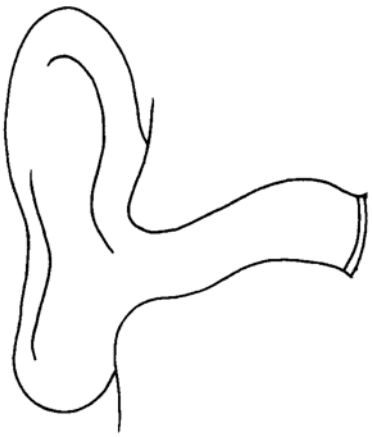
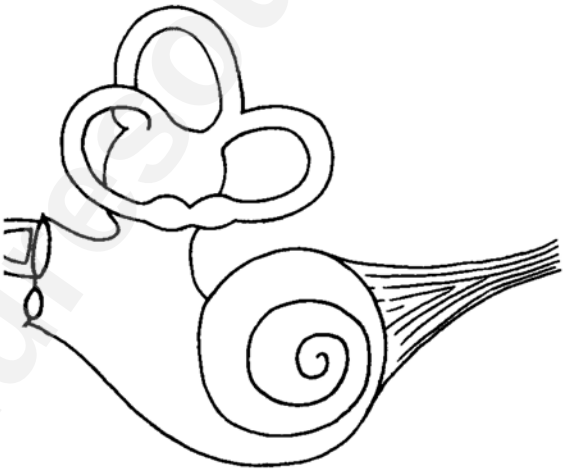
7. Ear





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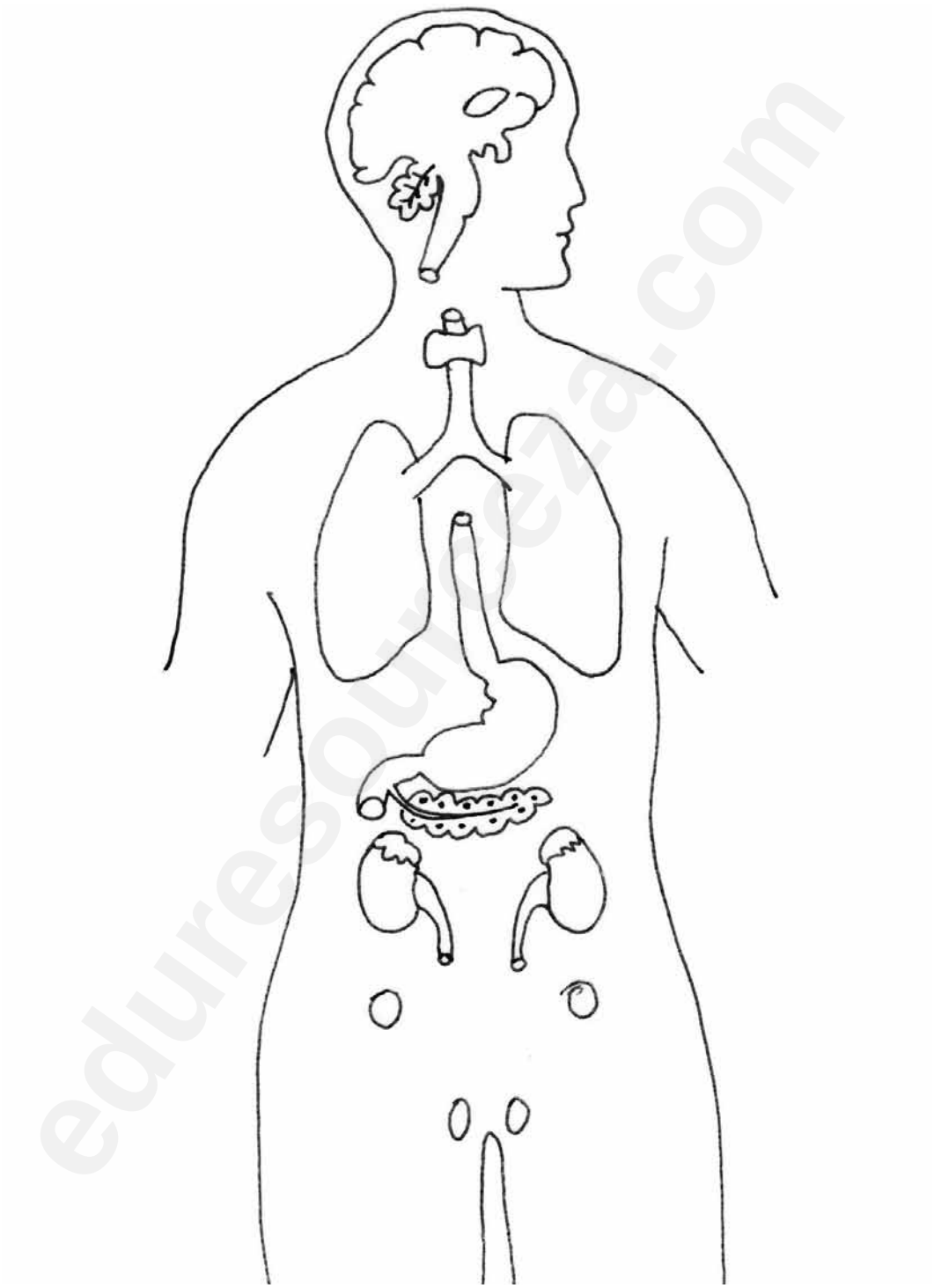
Topic 5: Human endocrine system

1. Name, position and functions of glands



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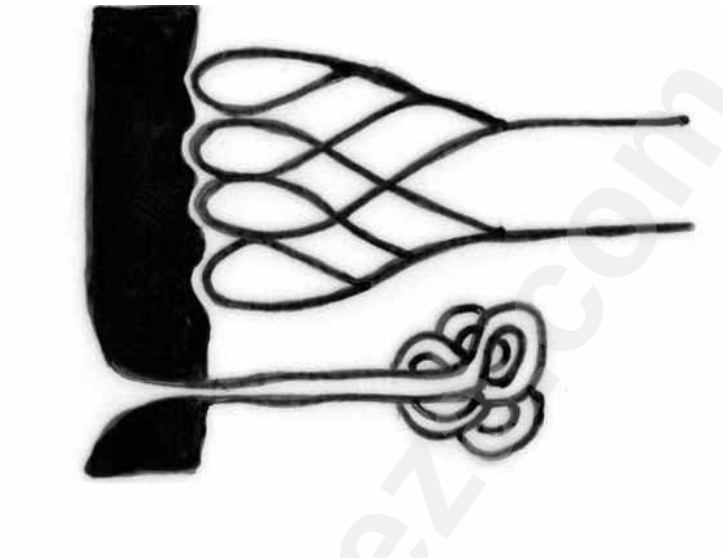
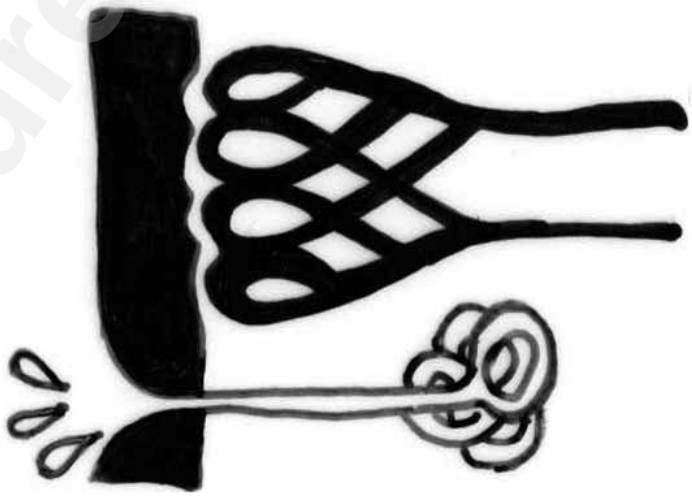
Topic 6: Homeostasis in humans

1. Skin regulating temperature on a hot and cold day





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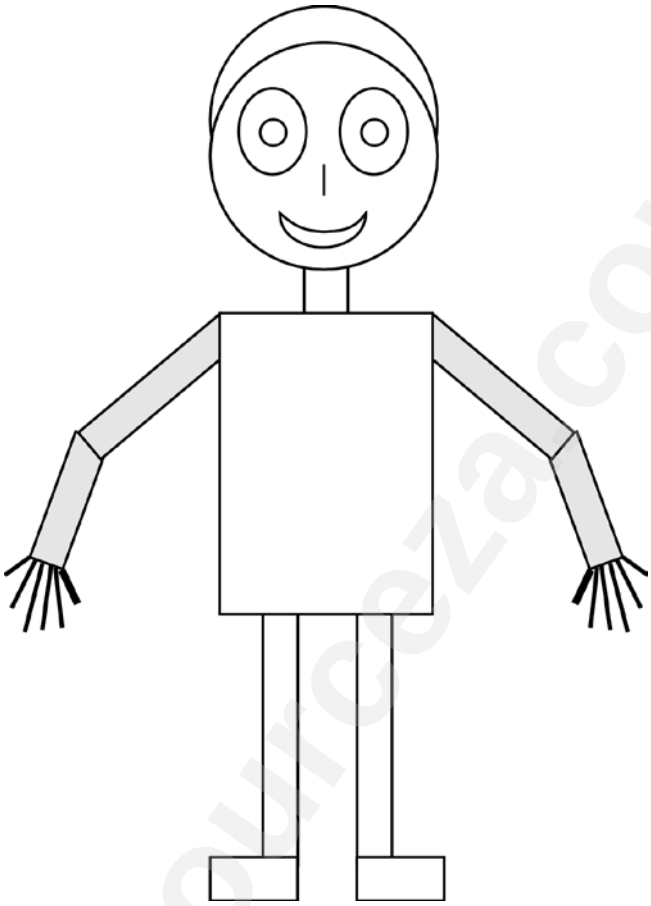
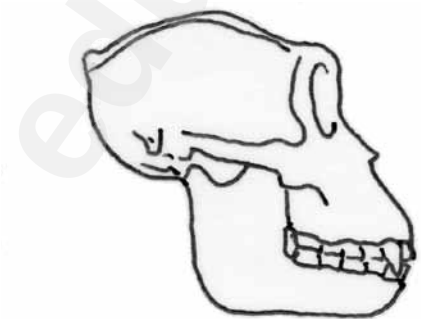
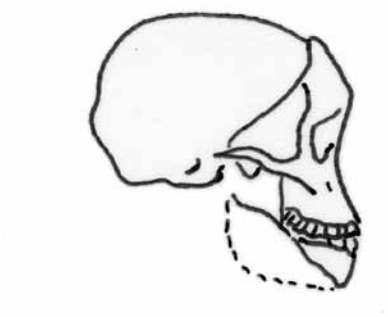
Topic 7: Evolution

1. Characteristics we share with African apes



2. Characteristics that make us different from the African apes





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Appendix 2: Exemplar exam paper

The 2014 Life Sciences exams have a new format in line with CAPS. The Department of Basic Education has offered an example of Life Sciences Paper 1 and Paper 2 with marking memoranda.

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

1. **Answer the questions** in Life Sciences Paper 1. Make sure you take a break before doing the same with Paper 2. Treat them as "real" exams by preparing yourself as if these were real exams, so have the paper, pens, pencils, eraser and other materials that you need. **Time yourself** so you complete each paper within the 2 ½ hours that is allocated to them. This exercise is meant to test your own knowledge – so **don't cheat** yourself by looking up the answers in the memo before you've finished each exam.
2. Use the memoranda to **check whether or not your answers are correct**. Note where you have got answers wrong – these are the sections of the curriculum that you need to do more work on. Go back to your textbooks and to the relevant sections of this study guide, and **spend time learning** the sections for which you got the lowest marks.

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basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

LIFE SCIENCES P1

EXEMPLAR 2014

MARKS: 150

TIME: 2½ hours

This question paper consists of 17 pages.

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INSTRUCTIONS AND INFORMATION

Read the following instructions carefully before answering the questions.

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

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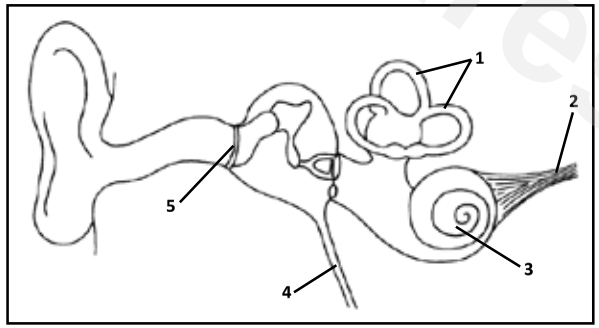
SECTION A

QUESTION 1

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

QUESTIONS 1.1.1 AND 1.1.2 REFER TO THE DIAGRAM BELOW SHOWING THE STRUCTURE OF THE HUMAN EAR.



1.1.1 Which part sends vibrations to the ossicles?
A 3
B 1
C 4
D 5

1.1.2 Which part maintains equal pressure on either side of the tympanic membrane?

A 4
B 3
C 2
D 1

1.1.3 Below is a set of events following fertilisation in humans.

1. The embryo is embedded in the uterine wall in humans.
2. A zygote is formed in the Fallopian tube.
3. Cell division occurs to form a ball of several hundred cells.
4. The blastocyst remains free for several days in the uterus.

Which ONE of the following represents the correct order in which the above events occur?

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

1.1.4 The following are effects of the secretion of different hormones:

1. An increase in the blood glucose level
2. An increase in the heart rate
3. An increase in the amount of digestive enzymes
4. An increase in blood flow to the skeletal muscles

Which ONE of the following combinations of the above effects is due to adrenalin?

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

1.1.5 The control centre in the body that will be activated when an athlete is dehydrated is the …

A cerebellum.
B cerebrum.
C corpus callosum.
D pituitary gland.

1.1.6 The following blood vessels carry blood to or from the placenta in humans:

1. Mother's artery
2. Mother's vein
3. Umbilical artery
4. Umbilical vein

Which blood vessels contain blood with a larger amount of oxygen and nutrients?

A 1 and 3 as compared to 2 and 4
B 1 and 4 as compared to 2 and 3
C 2 and 3 as compared to 1 and 4
D 2 and 4 as compared to 1 and 3

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1.1.7 Which ONE of the following is an advantage of the testes being held in the scrotum, outside the body cavity?

A More sperm can be stored in the scrotum.
B Sperm formation is more efficient at temperatures below the normal body temperature.
C The testes are better protected in the scrotum than in the body cavity.
D There is more time for prostate secretions to be added to the sperm.

1.1.8 Meiosis in a diploid cell results in …

A four identical gametes.
B four haploid gametes.
C two different diploid gametes.
D four gametes having the same chromosome number as the parent cell.

1.1.9 The list below gives some of the stages involved in gamete and zygote formation.

1. Prophase I
2. Prophase II
3. Metaphase I
4. Fertilisation

Which ONE of the following combinations of the above stages contributes to genetic variation?

A 1, 2 and 3
B 1, 3 and 4
C 2 and 3
D 3 and 4 (9 x 2) **(18)**

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

1.2.1 The period of development of an embryo in the uterus between fertilisation and birth

1.2.2 Disease characterised by a lack of insulin production

1.2.3 Tube that connects the pharynx and the middle ear

1.2.4 A process by which nutrients become highly concentrated in a body of water, leading to increased growth of organisms such as algae

1.2.5 A stage in the development of humans in which the embryo consists of a layer of cells surrounding a cavity

1.2.6 The structure at the tip of a sperm cell containing enzymes and which makes contact with the egg cell during fertilisation

1.2.7 The gland in the male reproductive system of humans that produces an alkaline fluid to counteract the acid environment of the vagina

1.2.8 The duct leading from the testis to the urethra in human males

1.2.9 The process by which the ovum is formed through meiosis in the ovary (9 x 1) **(9)**

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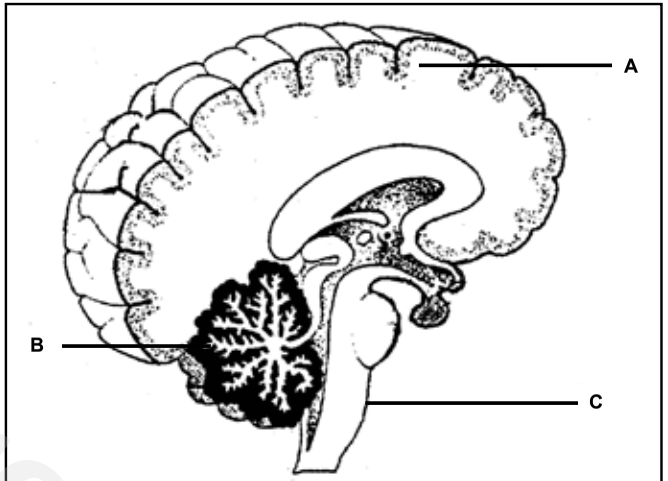
1.3 Indicate whether each of the statements in COLUMN I applies to **A only**, **B only**, **both A and B** or **none** of the items in COLUMN II. Write **A only**, **B only**, **both A and B**, or **none** next to the question number (1.3.1 to 1.3.6) in the ANSWER BOOK.

COLUMN I	COLUMN II
1.3.1 Type of development resulting in offspring that are capable of moving around soon after hatching	A Precocial B Altricial
1.3.2 Converts glucose to glycogen	A Glucagon B Adrenalin
1.3.3 Factors affecting water availability	A Destruction of wetlands B Poor farming practices
1.3.4 Provides greater chances for the fusion of sperm and egg	A External fertilisation B Internal fertilisation
1.3.5 Characteristic of vivipary	A Placenta is formed B Live offspring is born
1.3.6 Examples of greenhouse gases	A Carbon dioxide B Methane

(6 x 2) **(12)**

1.4 The diagram below represents a portion of the central nervous system of humans.



Portion of the central nervous system of a human

Write down the LETTER ONLY of the part which:

1.4.1 Regulates heartbeat and breathing rate (1)

1.4.2 Coordinates movement while walking (1)

1.4.3 Interprets what you see (1)

1.4.4 Has its hemispheres connected by the corpus callosum (1)

1.4.5 Controls balance and equilibrium (1)
(5)

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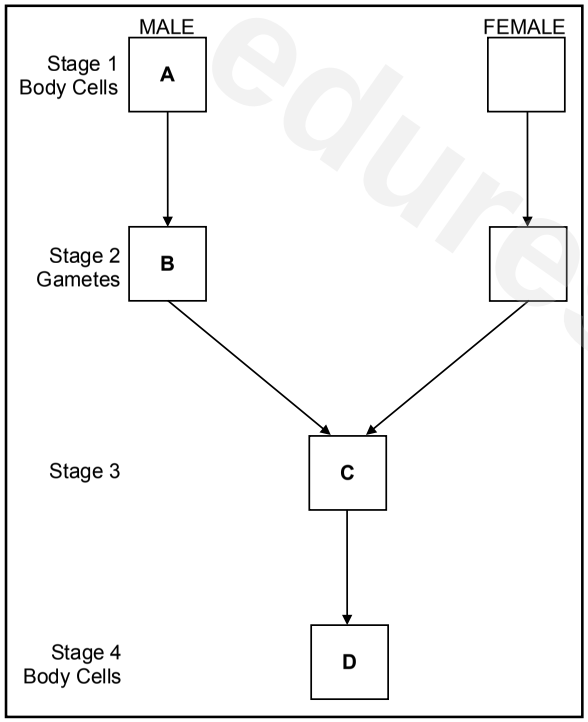
1.5 The diagram below shows the various stages in the life cycle of a human.



1.5.1 State the chromosome number of the cells represented by **A**, **B** and **C**. (3)

1.5.2 Name the structure at Stage **3**. (1)

1.5.3 Between which two consecutive stages does meiosis occur in the life cycle? (1)

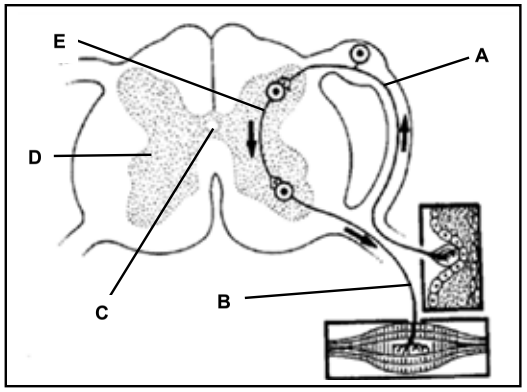
1.5.4 Between which two consecutive stages does mitosis occur in the life cycle? (1)
(6)

TOTAL SECTION A: 50

SECTION B

QUESTION 2

2.1 Study the diagram below, which shows a reflex arc.



2.1.1 Give labels for each of the following:

(a) Region **D** (1)

(b) Neuron **E** (1)

2.1.2 Write down the LETTER of the part which:

(a) Transmits impulses to the central nervous system (1)

(b) Contains cerebrospinal fluid (1)

2.1.3 Explain the effect on the reflex action if part **B** was damaged. (2)

2.1.4 The nerve pathway in the above response is about 1,5 metres in length. A nerve impulse travels at 75 m s^{-1}.

Use this information to calculate the time taken for this reflex action to occur. Show all working. (3)

2.1.5 Explain the significance of a reflex action. (2)
(11)

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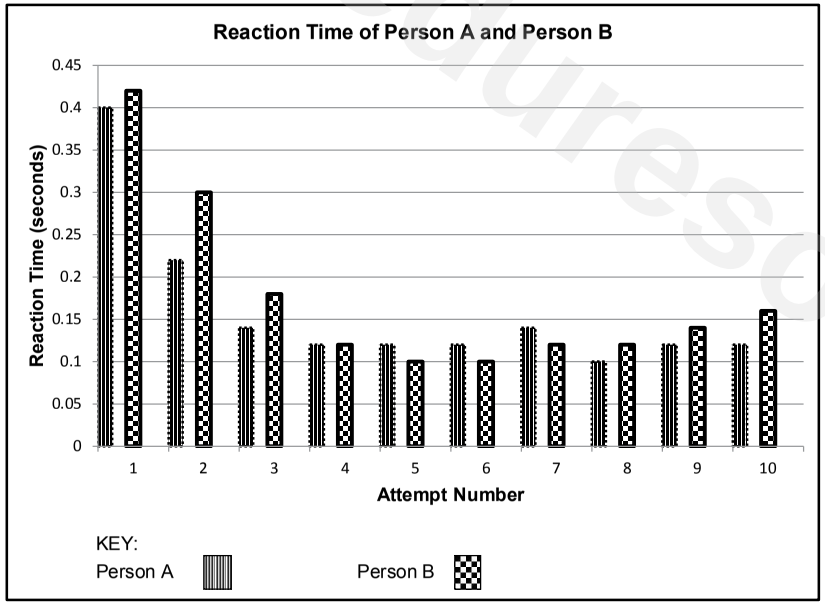
2.2 A learner carried out an investigation to measure the reaction time of two people (A and B). Each person had to ring a bell when a light flashed on. The time taken for each person to react was recorded and plotted on the bar graph below. The test was carried out 10 times.



2.2.1 What was the slowest reaction time? (1)

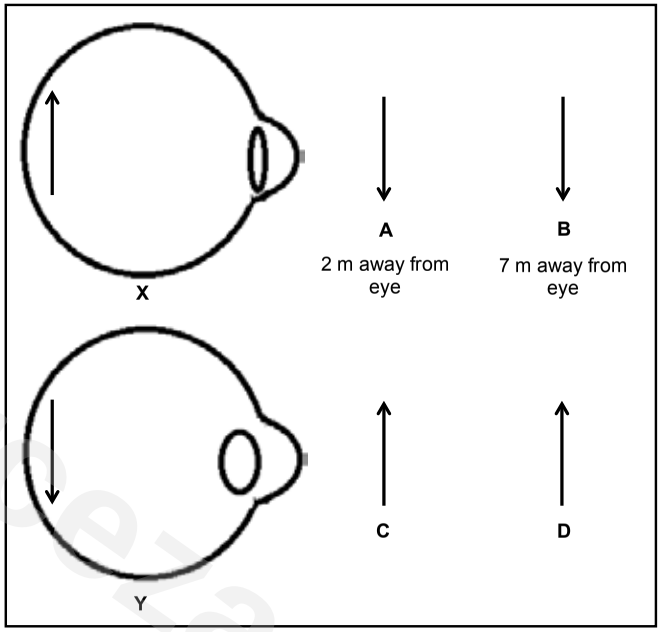
2.2.2 Describe how the reaction time of Person **B** changed over the 10 attempts. (3)

2.2.3 Suggest a possible reason for the trend described in QUESTION 2.2.2. (2)

2.2.4 What was the stimulus in this investigation? (1)

2.2.5 How would the reaction time of Person **A** have differed if he/she had been under the influence of drugs during the experiment? (1)
(8)

2.3 The diagram shows two eyes (**X** and **Y**) focused on objects (represented by arrows) at different distances from the eye. Objects **A** and **C** were 2 metres away from the eye. Objects **B** and **D** were 7 metres away from the eye.



2.3.1 Write down the LETTER ONLY of the object that:

(a) Eye **X** is focused on (2)

(b) Eye **Y** is focused on (2)

2.3.2 Name and describe the process that allows eye **Y** to form a clear image on the retina. (5)
(9)

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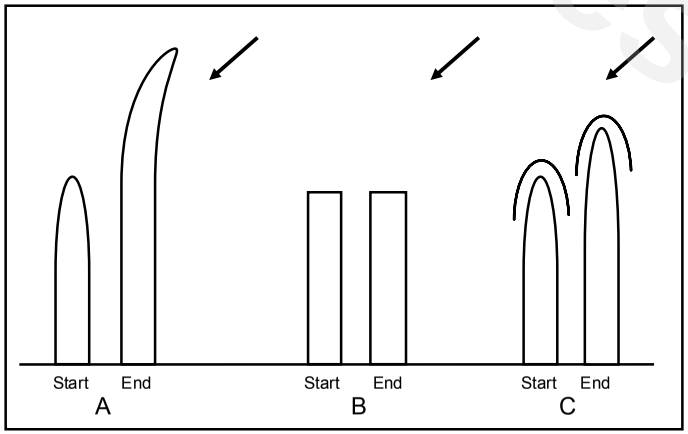
2.4 A Grade 12 learner performed an investigation to determine the effect of light on the growth of plant shoots. The learner divided the plants that were used into three groups as follows:

Group A – The tip of the shoot was intact.
Group B – The tip of the shoot was removed.
Group C – The tip of the shoot was covered by a cap that does not allow light to pass through.

The diagram below shows each shoot at the start of the investigation and next to each, the same shoot at the end of the investigation.

The arrows indicate the direction of light in each investigation.



2.4.1 Name the dependent variable in this investigation. (1)

2.4.2 State TWO factors that must be kept constant in this investigation. (2)

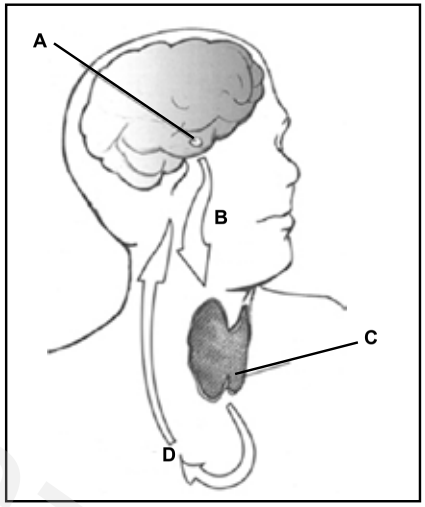
2.4.3 The influence of which plant hormone is being investigated? (1)

2.4.4 Explain the results observed in investigations **A** and **C**, as illustrated in the diagram above. (6)

2.4.5 State TWO ways in which the learner could improve the reliability of this investigation. (2)
(12)
[40]

QUESTION 3

3.1 The diagram below represents the interaction between two important endocrine glands. The gland labelled **A** is found at the base of the brain, while the gland labelled **C** is present towards the front of the neck.



3.1.1 Give a label for gland **A**. (1)

3.1.2 Name hormone **B**. (1)

3.1.3 State TWO functions of hormone **D**. (2)

3.1.4 Describe the *negative feedback mechanism* that operates when the level of hormone **D** is higher than normal in the blood. (5)
(9)

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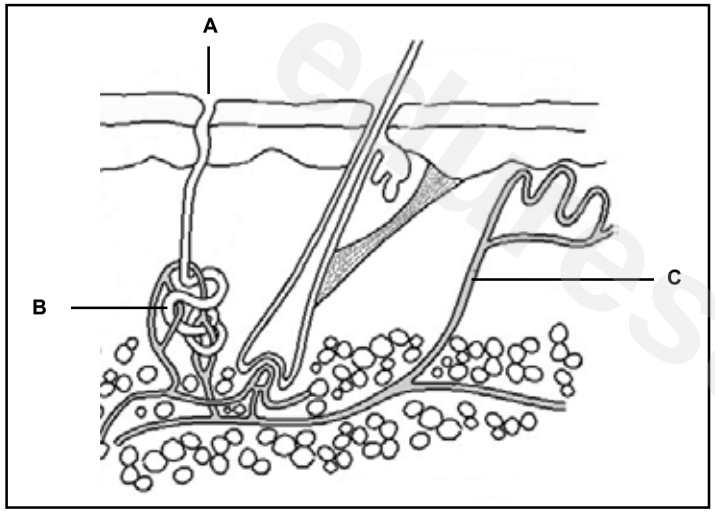
3.2 The diagram below shows a section through the mammalian skin.



3.2.1 Give labels for parts **A**, **B** and **C**. (3)

3.2.2 Describe how parts **B** and **C** play a role in reducing the body temperature back to normal when it increases above the normal level. (6)
(9)

3.3 The Human Sciences Research Council (HSRC) conducted a survey on food security across the provinces. The results showed that the overall percentage of food-secure households in South Africa is 45,6% as opposed to 48% in 2008.

The results, indicating the percentage of food-insecure households in each province according to the latest survey, are shown in the table below.

PROVINCE	FOOD-INSECURE HOUSEHOLDS (%)
Eastern Cape	36
Limpopo	31
Mpumalanga	30
Free State	29
KwaZulu-Natal	28
Northern Cape	21
Gauteng	19
Western Cape	16

3.3.1 What is meant by *food security*? (2)

3.3.2 Use the data in the table to draw a bar graph for the four provinces that have the highest percentage of food-insecure households. (7)

3.3.3 State how the use of fertilisers by farmers can:

(a) Increase food security for a country (1)

(b) Decrease food security for a country (1)

3.3.4 State how the use of pesticides by farmers can:

(a) Increase food security for a country (1)

(b) Decrease food security for a country (1)

3.3.5 State TWO factors, other than the use of fertilisers and pesticides, which may have led to a decrease in the percentage of food-secure households in South Africa since 2008. (2)
(15)

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3.4 The carbon dioxide concentration in the atmosphere was recorded at 400 parts per million (ppm) in May 2013 compared to 316 parts per million (ppm) in 1958. This change is due to an increase in the use of fossil fuels as well as an increase in deforestation.

3.4.1 Describe how deforestation contributes to the high carbon dioxide concentration in the atmosphere. (2)

3.4.2 State ONE other impact of deforestation on the environment. (1)

3.4.3 Explain why we should be concerned about the rising carbon dioxide levels. (3)

3.4.4 Suggest ONE way in which the government can reduce carbon emissions caused by the generation of electricity. (1)
(7)
[40]

TOTAL SECTION B: 80

SECTION C

QUESTION 4

Name the hormones produced by the testes and ovaries and describe the role of each hormone in human reproduction.

Content: (17)
Synthesis: (3)
(20)

NOTE: NO marks will be awarded for answers in the form of flow charts or diagrams.

TOTAL SECTION C: 20
GRAND TOTAL: 150

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Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

LIFE SCIENCES P1

EXEMPLAR 2014

MEMORANDUM

MARKS: 150

This memorandum consists of 11 pages.

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PRINCIPLES RELATED TO MARKING LIFE SCIENCES

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

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

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

4. **If comparisons are asked for but descriptions are given**
   Accept if the differences/similarities are clear.

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

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

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

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

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

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

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

12. **Spelling errors**
    If recognisable, accept the answer, provided it does not mean something else in Life Sciences or if it is out of context.

13. **If common names are given in terminology**
    Accept, provided it was accepted at the national memo discussion meeting.

14. **If only the letter is asked for but only the name is given (and vice versa)**
    Do not credit.

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

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

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

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

19. **Changes to the memorandum**
No changes must be made to the memoranda without consulting the provincial internal moderator who in turn will consult with the national internal moderator (and the Umalusi moderators where necessary).

20. **Official memoranda**
Only memoranda bearing the signatures of the national internal moderator and the Umalusi moderators and distributed by the National Department of Basic Education via the provinces must be used.

SECTION A

QUESTION 1

1.1	1.1.1	D✓✓		
	1.1.2	A✓✓		
	1.1.3	A✓✓		
	1.1.4	C✓✓		
	1.1.5	D✓✓		
	1.1.6	B✓✓		
	1.1.7	B✓✓		
	1.1.8	B✓✓		
	1.1.9	B✓✓		
			(9 x 2)	**(18)**
1.2	1.2.1	Gestation✓		
	1.2.2	Diabetes mellitus✓		
	1.2.3	Eustachian✓ tube		
	1.2.4	Eutrophication✓		
	1.2.5	Blastocyst✓		
	1.2.6	Acrosome✓		
	1.2.7	Prostate✓		
	1.2.8	Sperm duct✓/vas deferens		
	1.2.9	Oogenesis✓	(9 x 1)	**(9)**
1.3	1.3.1	A only ✓✓		
	1.3.2	None ✓✓		
	1.3.3	Both A and B ✓✓		
	1.3.4	B only✓✓		
	1.3.5	Both A and B✓✓		
	1.3.6	Both A and B✓✓	(6 x 2)	**(12)**
1.4	1.4.1	C✓		(1)
	1.4.2	B✓		(1)
	1.4.3	A✓		(1)
	1.4.4	A✓		(1)
	1.4.5	B✓		(1)
				(5)
1.5	1.5.1	A – 46✓ B – 23✓ C – 46✓		(3)
	1.5.2	Zygote✓		(1)
	1.5.3	Stages 1 and 2✓		(1)
	1.5.4	Stages 3 and 4✓		(1) **(6)**
			TOTAL SECTION A:	**50**

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SECTION B

QUESTION 2

2.1	2.1.1	(a) Grey matter✓	(1)
		(b) Interneuron✓/connector neuron	(1)
	2.1.2	(a) A✓	(1)
		(b) C✓	(1)
	2.1.3	Sensation would be felt✓ but there would be no response✓	(2)
	2.1.4	1,5 m ÷ 75 $m.s^{-1}$✓ = 0,02✓ s✓	(3)
	2.1.5	Helps to protect the body✓by reacting quickly✓	(2) **(11)**
2.2	2.2.1	0,42 seconds✓	(1)
	2.2.2	– It decreased first✓ – then levelled off✓ – and finally increased again.✓	(3)
	2.2.3	Practice makes reaction time faster✓ but later, tiredness slows down the reaction time.✓	(2)
	2.2.4	Light✓	(1)
	2.2.5	Reaction time would probably increase✓	(1) **(8)**
2.3	2.3.1	(a) B✓✓	(2)
		(b) C✓✓	(2)
	2.3.2	Accommodation✓ (1) – Ciliary muscles contract✓ – Suspensory ligaments slacken✓ – Tension on lens decreases✓ – Lens becomes more convex✓ – Refractive power of lens increases✓ – A clear image now forms on the retina (any 4)	(5) **(9)**

2.4	2.4.1	Growth of plant shoots✓	(1)
	2.4.2	– Same environment in which the shoots are placed✓ – Same type of shoot used✓ **(Mark first TWO only)**	(2)
	2.4.3	Auxins✓	(1)
	2.4.4	**In investigation A:** – Light from the right✓ – caused auxins to move to shaded side of the shoot✓ – leading to increased cell elongation and division✓ – There was therefore greater growth on the shaded side✓ – thus bending the shoot in the direction of the source of light✓ (any 4) **In investigation C:** – Light has no influence on the distribution of auxins✓ – therefore the shoot grew upright✓ (2)	(6)
	2.4.5	– Repeat the investigation✓ – Use more than one plant for each treatment✓ **(Mark first TWO only)**	(2) **(12)** **[40]**

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QUESTION 3

3.1 3.1.1 Pituitary gland/hypophysis✓ (1)

3.1.2 B – TSH/thyroid-stimulating hormone✓ (1)

3.1.3
- Controls metabolism✓
- Influences heart rate✓
- Influences functioning of central nervous system✓
(Mark first TWO only) (any 2) (2)

3.1.4
- High levels of thyroxin is detected✓by the hypophysis
- which leads to a decrease✓
- in the secretion of TSH✓
- Activity of thyroid is slowed down✓ /less thyroxin produced
- Thyroxin level drops✓ to normal (5)
(9)

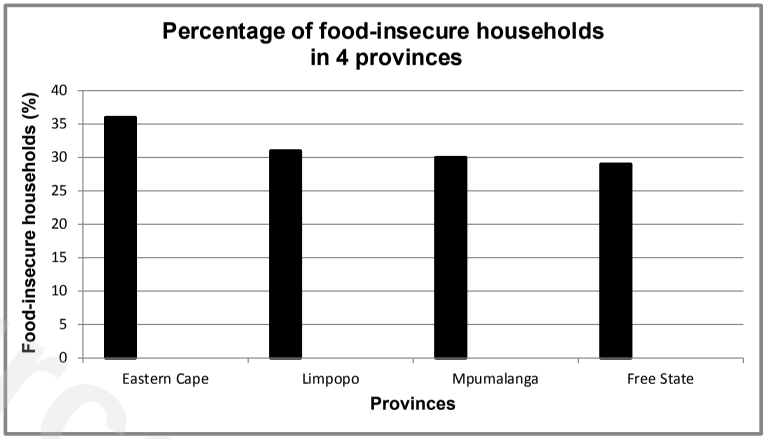
3.2 3.2.1
A – Sweat pore✓
B – Sweat gland✓
C – Blood vessel✓ (3)

3.2.2
- Impulses sent from hypothalamus✓to C (blood vessels)
- Blood vessels dilate✓/vasodilation occurs
- More blood carrying heat comes to the skin surface✓
- and therefore more heat is lost from the body✓
(any 3)

- B (Sweat glands) produce more sweat✓
- When sweat evaporates from the skin surface ✓
- More heat is lost from the skin✓
- leading to a drop in the body temperature✓ (any 3) (6)
(9)

3.3 3.3.1 Having access to enough food✓on a daily basis, so as to ensure healthy living✓ (2)

3.3.2



Mark allocation for the graph

Criterion	Elaboration	Mark
Type of graph	Bar graph drawn	1
Data used	Graph drawn for four provinces only (EC, LIM, MPU and FS)	1
Caption	Includes both variables: 'Provinces' and 'Percentage food-insecure households'	1
X-axis	Appropriate width of bars and intervals between bars AND Correct label: Provinces	1
Y-axis	Appropriate scale AND Correct label and unit: Food-insecure households (%)	1
Plotting of points	1–3 bars plotted correctly – 1 mark All 4 bars plotted correctly – 2 marks	2

(7)

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3.3.3 (a) Fertilisers provide nutrients that increase crop growth✓ (1)

(b) Fertilisers are expensive – causes food prices to increase✓/ over-use of fertilisers can cause oxygen deprivation in soil which will eventually reduce crop production (1)

3.3.4 (a) Pesticides ensure that pests do not cause large-scale damage to crops✓ (1)

(b) Pesticides could kill pests as well as their predators – hence more pesticides would have to be used, raising the cost of food✓ (1)

3.3.5
- Massive unemployment in the country✓
- Increase in the size of the human population✓
- Farms destroyed for development✓
- Decrease in subsistence farming ✓
- Prolonged unfavourable environmental conditions✓

(Mark first TWO only) (any 2 x 1) (2)
(15)

3.4 3.4.1
- There will be less trees✓
- so less carbon dioxide will be used from the atmosphere for photosynthesis✓ (2)

3.4.2
- Can lead to the loss of biodiversity✓/habitat destruction/soil erosion

(Mark first ONE only) (1)

3.4.3
- Increased carbon dioxide levels lead to the enhanced greenhouse effect✓
- which causes an increase in the global temperatures✓
- This could lead to rise in sea levels because of melting ice✓/ floods/change in climate
- which can lead to the extinction of some organisms✓.

(any 3) (3)

3.4.4 Use alternate sources of energy✓
(Mark first ONE only) (1)
(7)
[40]

TOTAL SECTION B: 80

SECTION C

QUESTION 4

Testosterone✓

Produced by seminiferous tubules✓ in the testes

During puberty testosterone stimulates:

- The deepening of the voice as vocal cords elongate in the larynx✓
- The development of muscles✓
- The growth of facial, pubic and body hair✓
- Development of the penis and testes✓
- The production of sperm in the testes✓ max (5)

Oestrogen✓

Produced by the Graafian follicles✓ in the ovaries

- Causes the lining of the uterus✓/endometrium
- to become thicker/more vascular ✓
- in preparation for a possible implantation of the embryo and development of the foetus✓

During puberty oestrogen stimulates:

- The widening of the pelvis/hips✓
- The growth and development of the breasts✓
- The growth of the female sex organs✓
- The start of the menstrual cycle, ovulation and menstruation✓ max (7)

Progesterone✓

Produced by the corpus luteum✓ and placenta✓

- Progesterone causes further thickening of the endometrium✓
- so that it is ready for implantation of the embryo should fertilisation occur✓
- High levels of progesterone✓
- inhibits the secretion of FSH✓
- by the pituitary gland✓
- which in turn prevents the further development of any new ovum in the ovary✓ max (5)

Content (17)
Synthesis (3)
(20)

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ASSESSING THE PRESENTATION OF THE ESSAY

Criterion	Elaboration	Mark
Relevance	No other hormones except testosterone, oestrogen and progesterone are mentioned.	1
Logical sequence	Each hormone named is linked to its correct role.	1
Comprehensive	All THREE correct hormones mentioned with at least THREE roles described for each hormone.	1

TOTAL SECTION C: 20
GRAND TOTAL: 150

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GRADE 12

LIFE SCIENCES P2

EXEMPLAR 2014

MARKS: 150

TIME: 2½ hours

This question paper consists of 14 pages.

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INSTRUCTIONS AND INFORMATION

Read the following instructions carefully before answering the questions.

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

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SECTION A

QUESTION 1

1.1 Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A to D) next to the question number (1.1.1 to 1.1.10) in the ANSWER BOOK, for example 1.1.11 D.

1.1.1 Which ONE of the following serves as evidence of cultural evolution in early *Homo* species?

A Drawings and carvings on rocks
B Animal remains close to a *Homo* skeleton
C Male and female skeletons in the same area
D More than one *Homo* skeleton in an area

1.1.2 A father has blood type A. He has 4 children with the following blood types:

Child 1 – A
Child 2 – O
Child 3 – AB
Child 4 – B

What is the blood type of the mother of the above children?

A A
B B
C O
D AB

1.1.3 New alleles arise in a sexually reproducing population through ...

A mutations in DNA sequences prior to meiosis.
B random fertilisation of gametes during reproduction.
C random assortment of homologous chromosomes during meiosis.
D exchange of chromatid segments between homologous chromosomes during meiosis.

1.1.4 A tall pea plant was crossed repeatedly with a short pea plant. In each of these crosses, they produced only tall offspring. It is reasonable to conclude that the …

A tall pea plant involved in the cross is homozygous.
B tall pea plant involved in the cross is heterozygous.
C offspring are all heterozygous for height.
D short pea plant involved in the cross is heterozygous.

1.1.5 The table below shows a section of the mitochondrial DNA (mtDNA) sequence for a modern human, a chimpanzee and three hominid species. The letter 'X' in the chimpanzee and the hominid sequences means that the DNA base was the same as that found in the modern human sequence.

ORGANISM	SECTION OF mtDNA SEQUENCE
Modern human	AAT-TCC-CCG-ACT-GCA-ATT-CAC-CTT
Chimpanzee	XXX-XXX-TXA-TTX-XXX-XAC-TGA-AAA
Hominid species 1	GGX-CTT-TTA-TTC-XTC-TCC-GTA-TAG
Hominid species 2	GGX-XGX-XXA-TTC-XTC-CCC-TGT-AAG
Hominid species 3	XTA-XXX-XXA-TTX-ATC-CXC-TGT-TCC

From the data in the table above it is possible to conclude that …

A chimpanzees are more closely related to hominid species 3 than they are to modern humans.
B hominid species 1 is probably the most recent common ancestor of chimpanzees and modern humans.
C modern humans are more closely related to hominid species 2 than to hominid species 3.
D modern humans are more closely related to hominid species 3 than to hominid species 2.

1.1.6 The following data represents a small section of a sequence of nucleic acid bases taken from an animal cell:

A G C U C G U U

From this data it is reasonable to conclude that …

A this portion of nucleic acid will code for a chain of eight amino acids.
B the sequence given will be complementary to the sequence C T C G T G C T T.
C the nucleic acid shown contains the sugar ribose.
D the nucleic acid shown is DNA.

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1.1.7 The list below provides information relating to the replication of DNA:

1. Complementary nucleotides bind to each of the two strands.
2. Sugar phosphate bonds form between the nucleotides.
3. The newly formed DNA molecules are identical to each other.
4. After unwinding, the DNA molecule forms two single strands.

The correct order of these events as they occur in DNA replication is …

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

1.1.8 Which ONE of the following accounts for gametes having a single allele only for a particular characteristic, instead of two?

A The chromosome number is halved during Meiosis II
B Mendel's principle of segregation
C Mendel's principle of independent assortment
D The 'law' of dominance

1.1.9 In multiple alleles …

A more than one gene controls a trait or characteristic.
B there are more than two different alleles for the same gene.
C the different alleles for the same characteristic are at different positions.
D there are only two alleles for a particular gene.

1.1.10 In a situation where a characteristic is expressed more frequently in males than in females in humans, we can conclude that …

A one allele is dominant over the other.
B the alleles for the characteristic are located on the X chromosomes.
C the alleles for the characteristic are located on the autosomes.
D the alleles for the characteristic are located on the Y chromosomes. (10 x 2) **(20)**

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 1.2.6) in the ANSWER BOOK.

1.2.1 An allele that does not influence the phenotype when found in the heterozygous condition

1.2.2 The position of a gene on a chromosome

1.2.3 The physical and functional expression of a gene

1.2.4 Chromosomes that are not responsible for sex determination

1.2.5 The process of finding a desirable gene, isolating it and then moving it into the cells of another organism

1.2.6 The two parts of a chromosome held together by a centromere (6 x 1) **(6)**

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 1.3.8) in the ANSWER BOOK.

	COLUMN I	COLUMN II
1.3.1	Discovered the double helical structure of DNA	A Francis Crick B James Watson
1.3.2	Describes evolution as consisting of long phases of little change alternating with short phases of rapid change	A punctuated equilibrium B Darwinism
1.3.3	Variation within a population in which there is a range of intermediate phenotypes	A discontinuous variation B continuous variation
1.3.4	Evidence for evolution	A mitochondrial DNA B cladogram
1.3.5	Chromosome condition of a cell that has a single set of chromosomes	A diploid B haploid
1.3.6	Two alleles of a gene that are equally dominant	A codominance B complete dominance
1.3.7	The full complement of genes present in an organism	A karyotype B phenotype
1.3.8	Bonds that hold amino acids together in a protein molecule	A hydrogen bonds B peptide bonds

(8 x 2) **(16)**

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1.4 In pea plants the allele for round seeds (R) is dominant over the allele for wrinkled seeds (r). The allele for yellow seeds (Y) is dominant over the allele for green seeds (y).

Plant A, heterozygous for both seed shape and seed colour, was crossed with plant B, which had wrinkled, green seeds.

1.4.1 Write down the genotype of:

(a) Plant A (1)

(b) Plant B (1)

1.4.2 Write down ALL the possible genotypes of the gametes of plant A. (2)

1.4.3 State the phenotype of an offspring having the genotype:

(a) rrYy (1)

(b) RrYy (1)

1.4.4 When plant B was crossed with plant C, all the offspring had round yellow seeds.

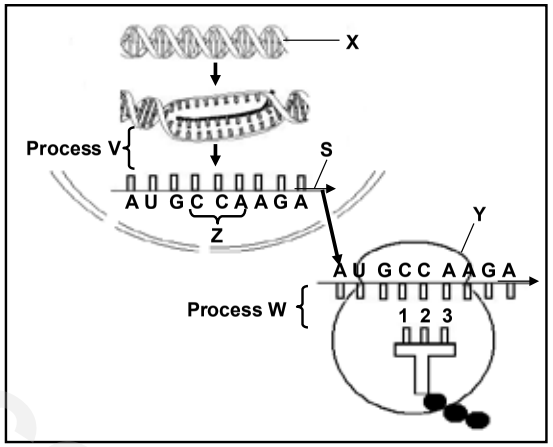
Use this information and write down the genotype of plant C. (2)
(8)

TOTAL SECTION A: 50

SECTION B

QUESTION 2

2.1 The diagram below shows the process of protein synthesis.



2.1.1 Identify the following:

(a) Molecule **X** (1)

(b) Organelle **Y** (1)

2.1.2 Identify the nitrogenous base labelled:

(a) 1 (1)

(b) 3 (1)

2.1.3 Describe the role of DNA during transcription. (3)

2.1.4 Describe the part of protein synthesis shown as process **W**, which occurs at organelle **Y**. (4)

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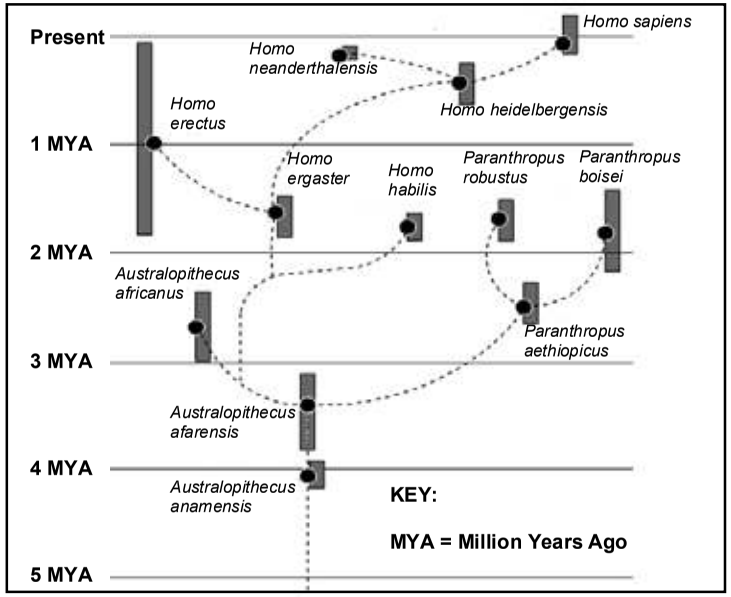
2.1.5 The table below shows the amino acids that correspond with different DNA codes.

AMINO ACID	DNA CODE
Arginine	TCT
Methionine	TAC
Glycine	GGT

Write down the correct sequence of amino acids coded for by structure **S** in the diagram on the previous page. (3)
(14)

2.2 The phylogenetic tree below shows one interpretation of the origin of humans. The dotted lines indicate the possible evolutionary relationships, and the vertical bars show the period during which the organisms are believed to have existed on earth.



2.2.1 Use the diagram to identify ONE organism that may have competed with *Homo heidelbergensis* for resources. (1)

2.2.2 Identify the common ancestor that gave rise to both *Paranthropus* and *Homo*. (1)

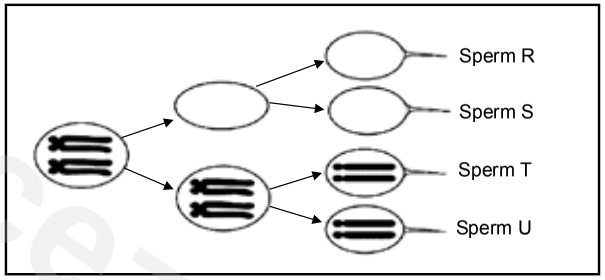
2.2.3 (a) For what period of time did *A. africanus* exist on Earth? Show all working. (3)

(b) Name ONE piece of evidence that could be used to prove that *A. africanus* existed during the time period calculated in QUESTION 2.2.3(a). (1)

2.2.4 (a) Which organism, *H. ergaster* or *H. neanderthalensis*, is more closely related to modern-day humans? (1)

(b) Explain your answer to QUESTION 2.2.4(a) using information in the diagram. (2)
(9)

2.3 The diagram below shows the result of abnormal meiosis, starting with a cell showing chromosome pair 21.



2.3.1 Explain the number of chromosomes present in sperm **R** and sperm **T**. (3)

2.3.2 How many copies of chromosome 21 would you expect in a normal gamete? (1)

2.3.3 What genetic disorder will result if sperm **U** fertilises a normal ovum? (1)

2.3.4 Describe TWO ways in which meiosis contributes to genetic variation. (7)
(12)

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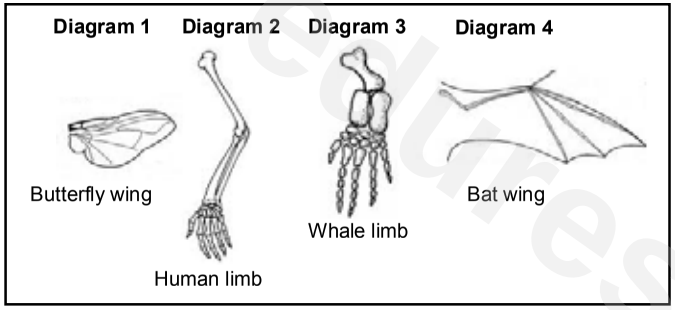
2.4 Study the diagrams below showing structures of different organisms.



2.4.1 Which diagram represents a structure that is analogous to the structure in Diagram 4? (1)

2.4.2 Write down the numbers of any TWO diagrams that represent homologous structures. (2)

2.4.3 What information do analogous and homologous structures provide about evolution? (2)
(5)
[40]

QUESTION 3

3.1 Scientists investigated the resistance of mosquitos to DDT.

The following steps were followed:
- They captured a sample of mosquitos from the environment.
- The mosquitos were then exposed to a standard dose of DDT (4% DDT for 1 hour) in the laboratory.
- The number of mosquitos that died was counted.
- Those that survived were left to reproduce.
- A sample was taken from this population every two months and the same procedure was followed for a period of 16 months.

The results are shown in the table below.

TIME (IN MONTHS)	MORTALITY OF MOSQUITOES (%)
0	95
2	87
4	80
6	69
8	60
10	54
12	35
14	27
16	22

3.1.1 Identify the:

(a) Independent variable (1)

(b) Dependent variable (1)

3.1.2 Formulate a hypothesis for this investigation. (3)

3.1.3 Draw a line graph to show how the mortality of mosquitoes changed over the period of the investigation due to the application of DDT. (6)

3.1.4 State TWO factors, other than those mentioned, that should be controlled in this investigation. (2)

3.1.5 State TWO ways in which the scientists could improve the reliability of their results. (2)

3.1.6 Explain, in terms of natural selection, how mosquitoes may develop resistance to DDT. (8)
(23)

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3.2 Study the table below, which indicates some of the hominid fossils found in different parts of the world.

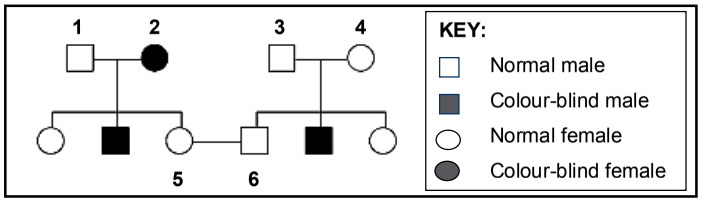
SPECIES	AREA WHERE IT WAS FOUND	PERIOD OF EXISTENCE
Australopithecus afarensis	Eastern Africa	3,4–2,8 mya
Australopithecus africanus	Southern Africa	2,1–2,8 mya
Australopithecus sediba	Southern Africa	2,0–1,9 mya
Homo habilis	Sub-Saharan (Africa)	2,3–1,4 mya
Homo erectus	Africa, Europe, Asia	1,5–0,2 mya
Homo heidelbergensis	Europe, China	0,6–0,35 mya
Homo neanderthalensis	Europe, Western Asia	0,35–0,03 mya
Homo sapiens	Worldwide	0,2 mya–present

[Adapted from *The Evolutionary Road*, Jamie Shreeve, *National Geographic*, July 2010]

3.2.1 Explain why the information in the table supports the 'Out of Africa' hypothesis. (2)

3.2.2 Describe how the analysis of mitochondrial DNA is used to support the 'Out of Africa' hypothesis. (3)
(5)

3.3 The pedigree diagram below shows the inheritance of Daltonism in a family. Daltonism (red-green colour-blindness) is sex-linked. The allele for Daltonism is recessive to the allele for normal colour vision.



3.3.1 Use the symbols X^D, X^d and Y to state the genotype of the following:

(a) Individual **2** (2)

(b) Individual **3** (2)

3.3.2 How many family members not affected by Daltonism are definitely carriers? (2)

3.3.3 Use a genetic cross to determine the possible genotypes and phenotypes of the offspring that may be formed by individuals **5** and **6**. (6)
(12)
[40]

TOTAL SECTION B: 80

SECTION C

QUESTION 4

It is thought that modern humans evolved gradually from ape-like beings over millions of years through speciation.

Describe how a single species can form new species, and explain how the differences in the skulls and other parts of the skeleton of primitive ape-like beings and modern humans support the idea that the general trend in human evolution has been towards bipedalism and a change in diet from raw food to cooked food.

Content: (17)
Synthesis: (3)
(20)

NOTE: NO marks will be awarded for answers in the form of flow charts or diagrams.

TOTAL SECTION C: 20
GRAND TOTAL: 150

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basic education

Department:
Basic Education
REPUBLIC OF SOUTH AFRICA

NATIONAL SENIOR CERTIFICATE

GRADE 12

LIFE SCIENCES P2

EXEMPLAR 2014

MEMORANDUM

MARKS: 150

This memorandum consists of 11 pages.

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PRINCIPLES RELATED TO MARKING LIFE SCIENCES

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

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

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

4. **If comparisons are asked for but descriptions are given**
   Accept if the differences/similarities are clear.

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

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

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

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

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

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

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

12. **Spelling errors**
    If recognisable, accept the answer, provided it does not mean something else in Life Sciences or if it is out of context.

13. **If common names are given in terminology**
    Accept, provided it was accepted at the national memo discussion meeting.

14. **If only the letter is asked for but only the name is given (and vice versa)**
    Do not credit.

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

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

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

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

19. **Changes to the memorandum**
No changes must be made to the memoranda without consulting the provincial internal moderator who in turn will consult with the national internal moderator (and the Umalusi moderators where necessary).

20. **Official memoranda**
Only memoranda bearing the signatures of the national internal moderator and the Umalusi moderators and distributed by the National Department of Basic Education via the provinces must be used.

SECTION A

QUESTION 1

1.1	1.1.1	A✓✓		
	1.1.2	B✓✓		
	1.1.3	A✓✓		
	1.1.4	A✓✓		
	1.1.5	D✓✓		
	1.1.6	C✓✓		
	1.1.7	D✓✓		
	1.1.8	B✓✓		
	1.1.9	B✓✓		
	1.1.10	B✓✓		
			(10 x 2)	**(20)**
1.2	1.2.1	Recessive✓		
	1.2.2	Locus✓		
	1.2.3	Phenotype✓		
	1.2.4	Autosomes✓		
	1.2.5	Genetic engineering✓/DNA manipulation/ Biotechnology/DNA recombination		
	1.2.6	Chromatids✓	(6 x 1)	**(6)**
1.3	1.3.1	Both A and B✓✓		
	1.3.2	A only✓✓		
	1.3.3	B only✓✓		
	1.3.4	A only✓✓		
	1.3.5	B only✓✓		
	1.3.6	A only✓✓		
	1.3.7	None✓✓		
	1.3.8	B only✓✓	(8 x 2)	**(16)**
1.4	1.4.1	(a) RrYy✓		(1)
		(b) rryy✓		(1)
	1.4.2	RY, Ry, rY, ry✓✓		(2)
	1.4.3	(a) Wrinkled, yellow✓ seeds		(1)
		(b) Round, yellow✓ seeds		(1)
	1.4.4	RRYY✓✓		(2)
				(8)
				[50]

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QUESTION 2

2.1	2.1.1	(a) DNA✓ (b) Ribosome✓	(1) (1)
	2.1.2	(a) G✓ (b) U✓	(1) (1)
	2.1.3	– DNA codes for a particular protein✓ but cannot leave nucleus – One strand of DNA is used as a template✓ – to form mRNA✓	(3)
	2.1.4	– According to the codons on mRNA✓ – tRNA molecules with matching anticodons✓ – bring the required amino acids to the ribosome✓ – This is called translation✓ – The amino acids become attached by peptide bonds✓ – to form the required protein✓ (any 4)	(4)
	2.1.5	Methionine, ✓ Glycine, ✓ Arginine✓ (in the correct order)	(3) **(14)**
2.2	2.2.1	*H. erectus*✓	(1)
	2.2.2	*A. afarensis*✓	(1)
	2.2.3	(a) 3 mya – 2,4✓ mya = 0,6✓ my✓ OR 3 mya – 2,3✓ mya = 0,7✓ my✓	(3)
		(b) Fossils✓	(1)
	2.2.4	(a) *H. neanderthalensis*✓	(1)
		(b) *H. neanderthalensis* and *H. sapiens* share a common✓ ancestor✓ OR Both evolved✓ from *H heidelbergensis*✓	(2) (2) **(9)**

2.3	2.3.1	– The homologous chromosome pair ✓ – does not separate✓/non-disjunction – during anaphase 1✓	(3)
	2.3.2	1✓	(1)
	2.3.3	Down syndrome✓	(1)
	2.3.4	– During crossing over✓ – in Prophase 1✓ – segments of chromatids of homologous chromosomes✓ – are exchanged✓ – leading to each gamete having a mix of genetic material from both parents✓ (any 4) – During Metaphase I✓/II – each pair of homologous chromosomes✓/each chromosome – may line up in different ways✓ on the equator of the spindle – allowing the gametes to have different combinations of maternal and paternal chromosomes ✓ (any 3)	(7) **(12)**
2.4	2.4.1	Diagram 1✓	(1)
	2.4.2	Diagrams 2 & 3✓✓/ 2 & 4/ 3 & 4	(2)
	2.4.3	Analogous structures show that two organisms evolved independently of each other✓ Homologous structures show that two organisms have a common ancestor✓.	(2) **(5)** **[40]**

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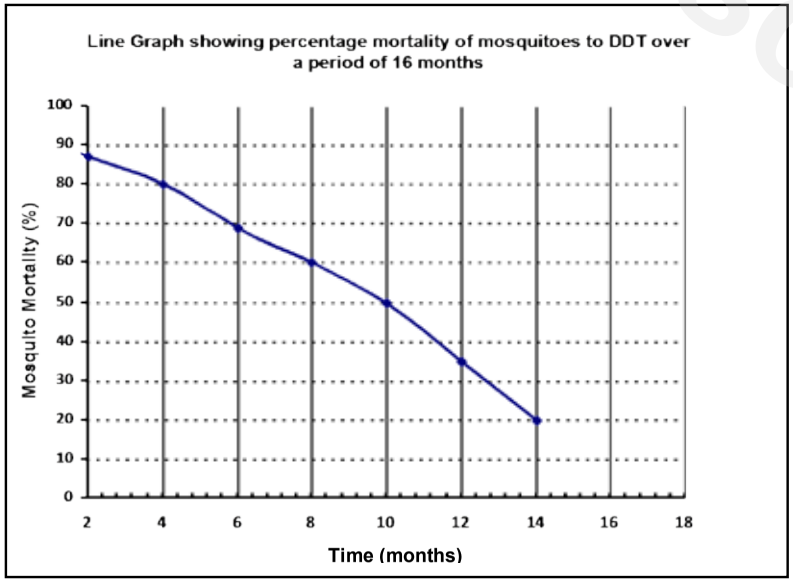
QUESTION 3

3.1 3.1.1 (a) Time ✓ (1)

(b) Mortality of mosquitoes ✓ (1)

3.1.2 Mosquito Mortality due to DDT✓/Resistance of mosquitos to DDT will decrease ✓ over time✓
OR
Mosquito Mortality due to DDT✓/Resistance of mosquitos to DDT will increase ✓ over time✓
OR
Mosquito Mortality due to DDT✓/Resistance of mosquitos to DDT will remain the same ✓ over time✓ (3)

3.1.3



NOTE:

If the wrong type of graph is drawn:
- Marks will be lost for 'correct type of graph'

If axes are transposed:
- Marks will be lost for labelling of X-axis and Y-axis

Mark allocation for the graph

Criterion	Elaboration	Mark
Type of graph	Line graph drawn	1
Caption	Includes both variables: 'Percentage mortality of mosquitoes' and 'Time'	1
X-axis	Appropriate scale AND Correct label and units for X-axis: Time (months)	1
Y-axis	Appropriate scale AND Correct label and units for Y-axis: Mortality of mosquitoes (%)	1
Plotting of points	1–8 points plotted correctly – 1 mark All 9 points plotted correctly – 2 marks	2

(6)

3.1.4
- Same species of mosquito✓
- Identical laboratory conditions for the full period of the investigation ✓
- The same scientist must be used for the full period of the investigation ✓
- Mosquitos should not be hurt for the full period of the investigation ✓

(Mark first TWO only) (any 2) (2)

3.1.5
- Use a larger sample of mosquitoes✓
- Repeat the investigation✓
- Take many samples each time and calculate the average mortality✓

(Mark first TWO only) (any 2) (2)

3.1.6
- More mosquitoes are produced than can survive.✓
- There is genetic variation✓ amongst the mosquitoes.
- Some mosquitoes may be naturally resistant to DDT.✓
- When DDT is applied✓
- those that are resistant survive✓
- and they then reproduce,✓
- passing the allele for resistance to the offspring.✓
- Those that are not resistant, die✓
- and their alleles are lost from the population.✓
- The number of DDT-resistant mosquitoes therefore increases over the generations✓. (any 8) (8)

(23)

3.2 3.2.1 The oldest fossils of human ancestors✓ were only found in Africa✓ (2)

3.2.2
- Mitochondrial DNA is passed down from mother to child✓
- mutations✓ on the mitochondrial DNA
- were traced to an ancestral female that existed in Africa✓ (3)

(5)

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3.3 3.3.1 (a) X^dX^d✓ (2)

(b) X^DY✓ (2)

3.3.2 3✓ (2)

3.3.3 **P_1** phenotype Normal female x Normal male ✓
genotype X^DX^d x X^DY ✓

Meiosis

G_1 X^D , X^d x X^D , Y ✓

Fertilisation

X^DX^D, X^DX^d, X^DY, X^dY ✓

F_1 genotype 2 normal females 1 normal male 1 colour-blind male ✓
phenotype

Parents and offspring✓/P_1 & F_1
Meiosis and fertilisation✓ (any 6)

OR

P_1/parent phenotype Grey bodied x grey bodied✓
genotype Gg x Gg ✓

Meiosis

Fertilisation

gametes	X^D	X^d
X^D	X^DX^D	X^DX^d
Y	X^DY	X^dY

1 mark for correct gametes✓
1 mark for correct genotypes✓

F_1 genotype 2 normal females 1 normal male 1 colour-blind male
phenotype

Parents and offspring✓/P_1 & F_1
Meiosis and fertilisation✓ (any 6) (6)
(12)
[40]

TOTAL SECTION B: 80

SECTION C

QUESTION 4

The development of a new species

- If a population splits into two populations✓.
- There is now no gene flow between the two populations. ✓
- Since each population may be exposed to different environmental conditions✓,
- Natural selection occurs independently in each of the two populations✓
- such that the individuals of the two populations become very different from each other✓
- genotypically and phenotypically✓.
- Even if the two populations were to mix again✓,
- they will not be able to reproduce with each other✓, thus becoming different species (any 5) (5)

The development of bipedalism

- The backward position of the foramen magnum on the skull✓,
- the narrow pelvis✓
- and the less-curved spine✓
- indicates that the ape-like beings were quadripedal✓ (any 3)

- The forward position of the foramen magnum on the skull✓,
- the wider pelvis✓
- and the curved spine✓
- indicates that modern humans are bipedal✓ (any 3) (6)

Change in the diet from raw food to cooked food

- The large teeth, especially the canines✓
- as well as the large and long jaws✓
- which makes the skull prognathous✓
- as well as cranial/brow ridges associated with large muscles that operate the jaws✓
- indicate that the ape-like beings ate raw food that required a great amount of processing✓/tearing, biting and chewing. (any 3)

- The smaller teeth, including the canines✓
- as well as the smaller jaw size✓
- which makes the skull less prognathous✓
- as well as the absence of cranial/brow ridges due to the presence of smaller muscles for chewing✓
- indicate that modern humans rely on a diet of cooked food that does not require the same amount of processing✓/tearing, biting and chewing. (any 3) (6)

Content: (17)
Synthesis: (3)
(20)

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ASSESSING THE PRESENTATION OF THE ESSAY

Relevance	Logical sequence	Comprehension
Only information regarding development of a new species, the development of bipedalism and change in diet is given (no irrelevant information).	Generally, the development of a new species, the development of bipedalism and change in diet are explained logically.	All three aspects of the question are described correctly.

TOTAL SECTION C: 20
GRAND TOTAL: 150

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