Life Sciences
Part 2

CLASS TEXT & STUDY GUIDE

Liesl Sterrenberg, Helena Fouché & Grace Elliott

GRADE
12
CAPS

3-in-1

THE ANSWER SERIES *Your Key to Exam Success*

Grade 12 Life Sciences 3-in-1 Part 2 CAPS

CLASS TEXT & STUDY GUIDE

This book is PART 2 of a SET of 2 Life Sciences study guides comprehensively covering the Grade 12 CAPS curriculum.

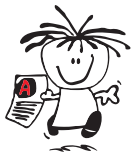
It contains the 2 Knowledge Areas examined in Paper 2 (National final exam):

- Life at the Molecular, Cellular and Tissue level
- Diversity, Change and Continuity

Key Features:

- Comprehensive, accessible notes per module
- Carefully selected, graded questions and answers per module
- 'Rapid-fire' questions for key concepts and terms
- Clear, explanatory diagrams
- Up-to-date, relevant material

As you work methodically through this study guide, you will become increasingly prepared to achieve excellent results in your exams.



THE ANSWER SERIES *Your Key to Exam Success*

GRADE

12

CAPS

3-in-1

Life Sciences

Part 2

Liesl Sterrenberg, Helena Fouché & Grace Elliott

Also available

GRADE 12
LIFE SCIENCES
PART 1

Life Processes in Plants and Animals

THIS CLASS TEXT & STUDY GUIDE INCLUDES

ALL the content for PAPER II

1 Notes
- Life at the Molecular, Cellular and Tissue level
- Diversity, Change and Continuity

2 Questions & Rapid Fire Questions

3 Detailed Memos

THE ANSWER SERIES *Your Key to Exam Success*

Printed by novus print
A division of Novus Holdings

eBook available

2014 publication | 2021 edition | ISBN: 978-1-920568-87-0

091123 | NOVUS

CONTENTS

WHAT IS LIFE SCIENCES?

Life Sciences is the scientific study of living things from molecular level to their interaction with one another and the environment.

- Living systems exhibit levels of organisation from molecules to biomes.
- Life on earth is dynamic, with homeostasis maintaining balance at every level of organisation.
- Life is characterised by changes over time.

AIMS IN LIFE SCIENCES

Specific Aim 1: Knowing Life Sciences
(concepts, processes, phenomena, mechanisms, principles, theories, laws, models, etc.)

Specific Aim 2: Investigating phenomena in Life Sciences

Specific Aim 3: Appreciating and Understanding the History, Importance and Applications of Life Sciences in Society.

TRANSCRIPTION OF DNA

- DNA occurs in the nucleoplasm and never leaves the nucleus.
- Protein synthesis occurs outside the nucleus, at the ribosomes in the cytoplasm.
- The code for the synthesis of a specific protein must be transferred from DNA to mRNA which is able to leave the nucleus.
- This process where mRNA obtains the code for protein synthesis from DNA is known as **transcription**.

***Transcription** means 'to rewrite' or 'carry over'.*

Process of transcription

- The particular gene on one of the DNA strands, which codes for a specific protein, serves as a **template** for building mRNA.
- The two strands of DNA unzip in the region where the gene is located. The enzyme **RNA polymerase** controls the transfer of the code from DNA to RNA and causes the weak hydrogen bonds between the base pairs to break.
- Free-floating RNA nucleotides in the nucleoplasm form a complementary mRNA strand on one of the DNA strands (template).
- A single mRNA strand is formed with 3 nitrogenous bases corresponding with each DNA base triplet.
- Each group of three nitrogenous bases on the mRNA is known as a **codon**, and codes for a particular amino acid.
- The sequence of the codons on the mRNA is the **complement** of the sequence of the base triplets on the DNA.
- If the base triplet on the DNA is **CCA**, the codon on the mRNA will be **GGU**.
- Cytosine binds with Guanine, and Uracil (on mRNA) binds with Adenine (on DNA).

***Remember:** In **RNA**, Thymine is replaced by **Uracil**.*

- As the mRNA forms, it moves away from the DNA strand. The two separated DNA strands join and twist together again to form a double helix.
- The mRNA strand leaves the nucleus via pores in the nuclear membrane.
- This newly-formed mRNA takes the code to ribosomes in the cytoplasm.

TRANSLATION OF RNA TO PROTEINS

***Translation** means 'to change something from one form to another'.*

- In protein synthesis, translation is the processing of the code locked in the mRNA strand (as codons) to form a certain amino acid sequence in the synthesis of a particular protein.

Process of translation

- The single mRNA strand that was formed in the nucleus attaches to the ribosome.
- mRNA provides the code for the sequence of the amino acids to form a specific protein.

***NB:** Each codon on the mRNA codes for a particular amino acid.*

- tRNA occurs in the cytoplasm and picks up amino acids from the amino acid pool in the cytoplasm to transfer them to the ribosomes.
- Each tRNA has three exposed nitrogenous bases, known as an **anticodon**, on one of the loops.
- The anticodon determines which amino acid will bind to the tRNA.
- A specific tRNA brings the specific amino acid for which it is coded, to the mRNA template.
- The codons of the mRNA determine which anticodons of tRNA will correspond.
- Codons and anticodons are thus **complementary**.

Example:
An mRNA strand with a **GUC** codon can only receive a tRNA molecule with the **CAG** anticodon. This tRNA picks up the amino acid **Valine** and transfers it to the codon on the mRNA in the ribosome.

Make sure you can distinguish between the three nitrogenous bases on different molecules:
***a base triplet** (DNA), a **codon** (mRNA) and an **anticodon** (tRNA).*

- Amino acids join in sequence determined by the mRNA codons.
- A **peptide bond** forms between two adjacent amino acids to form a **dipeptide**. More than two amino acids **joined by peptide bonds** form a **polypeptide chain**.

- As soon as tRNA places the amino acid in the correct sequence and the amino acid forms a **peptide bond** with the adjacent amino acid in the polypeptide chain, the tRNA breaks the bond with its amino acid and moves away from the ribosome.
- tRNA is now ready to pick up another amino acid of the same type.
- This process proceeds until 50 or more amino acids join to form a **protein**.

*There are certain control mechanisms that initiate and terminate protein synthesis. Three mRNA codons do not code for proteins and are known as **stop codons**. These codons terminate the process of protein synthesis.*

- There is normally more than one codon on mRNA that codes for a specific amino acid.
- There is thus also more than one anticodon (or tRNA) for each amino acid.

***MUTATIONS** may occur in protein synthesis. Mutations are changes in the DNA. A mistake in **one** nitrogenous base may result in changing the protein produced. If the mutated base triplet/codon/anticodon still codes for the same amino acid, the mutation will **not** result in a different/abnormal protein.*

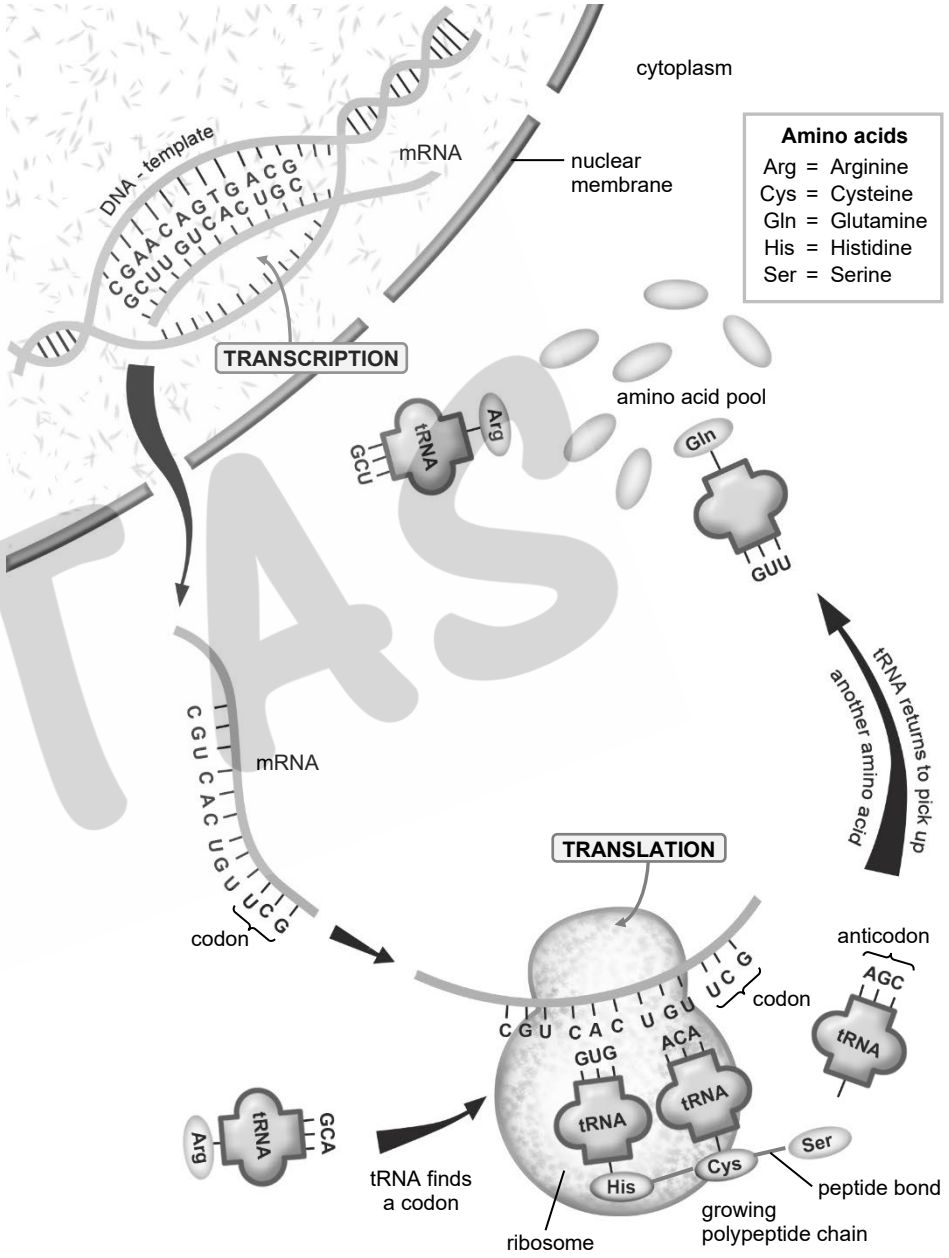
Table to show mRNA codon codes for each amino acid in the genetic code

FIRST LETTER	SECOND LETTER: U	C	A	G	THIRD LETTER
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
	UUA Leu	UCA Ser	UAA Stop	UGA Stop	A
	UUG Leu	UCG Ser	UAG Stop	UGG Trp	G
C	CUU Leu	CCU Pro	CAU His	CGU Arg	U
	CUC Leu	CCC Pro	CAC His	CGC Arg	C
	CUA Leu	CCA Pro	CAA Gln	CGA Arg	A
	CUG Leu	CCG Pro	CAG Gln	CGG Arg	G
A	AUU Ile	ACU Thr	AAU Asn	AGU Ser	U
	AUC Ile	ACC Thr	AAC Asn	AGC Ser	C
	AUA Ile	ACA Thr	AAA Lys	AGA Arg	A
	AUG Met	ACG Thr	AAG Lys	AGG Arg	G
G	GUU Val	GCU Ala	GAU Asp	GGU Gly	U
	GUC Val	GCC Ala	GAC Asp	GGC Gly	C
	GUA Val	GCA Ala	GAA Glu	GGA Gly	A
	GUG Val	GCG Ala	GAG Glu	GGG Gly	G

20 Amino acids

Phe - Phenylalanine
Leu - Leucine
Ile - Isoleucine
Met - Methionine
Val - Valine
Ser - Serine
Pro - Proline
Thr - Threonine
Ala - Alanine
Tyr - Tyrosine
His - Histidine
Gln - Glutamine
Asn - Asparagine
Lys - Lysine
Asp - Aspartic acid
Glu - Glutamic acid
Cys - Cysteine
Trp - Tryptophan
Arg - Arginine
Gly - Glycine

***NB:** You do not need to learn this table or the names of the amino acids. In exam questions, the genetic code will always be provided.*



Representation of the process of protein synthesis

***Hydrogen bonds** occur between **nitrogenous bases**, e.g. G and C.*
***Peptide bonds** occur between adjacent **amino acids** in a polypeptide/protein.*

- Initially, Mendel did his experiments with parent plants that were **true breeding** for a specific characteristic.

*A plant is **true breeding** for a specific characteristic when self-pollination takes place and all the offspring produced have the same characteristic as the parent, e.g. if a tall plant self-pollinates and only produces tall plants, it is a true-breeding plant for the 'tall' characteristic (see 'homozygous' on p. 26).*

Conclusions from Mendel's experiments

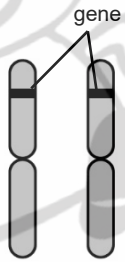
- An inherited characteristic is determined by 'factors' that occur in pairs.
- Pairs of 'factors' separate in the formation of gametes.
- One 'factor' can mask its partner 'factor'.
- 'Factors' are inherited independently of each other.

These 'factors' were only named 'genes' after Mendel's death.

CONCEPTS IN INHERITANCE

Genes and alleles

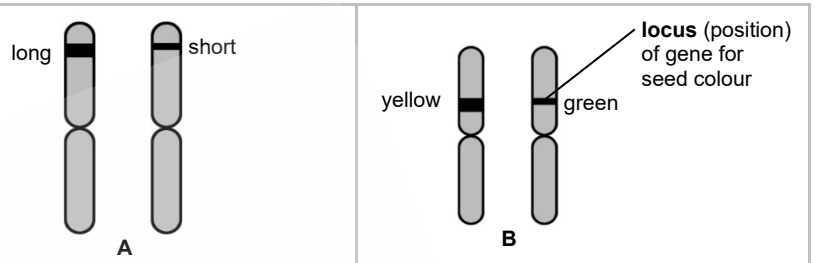
- One gene of the gene pair comes from the individual's mother and the other gene from the father. A gene pair is carried on two chromosomes of a homologous chromosome pair.
- A particular gene occurs in two (sometimes more) different forms that affect the same characteristic in different ways.
- The alternative forms of the same gene are known as **alleles**.
- Different alleles contain different information about the same characteristic/trait.
- For example, in pea plants the **plant length** trait is determined by a gene that results in tall plants and its allele that results in short plants, while the **seed colour** trait is determined by a gene that produces yellow seeds and its allele that produces green seeds.



Homologous chromosomes with two genes of a gene pair that determine a specific hereditary characteristic

*Each gene has a specific position on a chromosome. This is called the **locus** (plural: loci).*

The alleles of a particular gene occur at the same **locus** on a specific homologous chromosome pair:



Two different homologous chromosome pairs (A and B) with different alleles (for plant length and seed colour) at different loci

*In the diagram above the **alleles** for plant length (tall and short) occur at a specific **locus** on **one homologous chromosome pair** (A) and the alleles for seed colour (yellow and green) at a different locus on another homologous chromosome pair (B).*

Dominant and recessive alleles

- One allele of a gene pair can mask another and this is known as the **dominant** allele. The allele that is masked and not visibly expressed in the organism, is called **recessive**.

Mendel's Law of Dominance

If two alleles are different, only the dominant one will be expressed.

Genotype and phenotype

The composition of the gene pair (2 alleles) for a specific trait is known as the **genotype**.

- An organism's genotype is represented by two letters. Each letter represents one allele of the gene that controls the trait.
- Usually the first letter of the dominant allele is used as the symbol to represent the gene.
- A **capital letter** shows the **dominant allele** and a **small letter** the **recessive allele**.
- The dominant allele (capital letter) is always written first.

- The characteristic of **plant length in pea plants** is used as example:
  - Pea plants have two alleles for plant length, i.e. tall and short.
  - Tall is dominant over short.
  - The letter **'T'** is used, from the first letter of the word 'tall'.
  - The symbols for the two alleles are: tall = T
    short = t
  - A plant with the genotype **TT** has two alleles for tall and appears tall.
    A plant with the genotype **tt** has two alleles for short and appears short.
    A plant with the genotype **Tt** has one allele for tall and one allele for short.
    Given that tall is dominant over short, the tall trait dominates and the plant appears tall.

This notation for writing the genotypes of pea plants also applies to other organisms. In the questions section of this module, you will come across various crosses of different organisms and traits.

The observable characteristics (physical appearance) of an organism, as determined by its genotype as well as its environment, is known as its **phenotype**, for example, tall or short pea plants, yellow or green seeds.

Homozygous and heterozygous

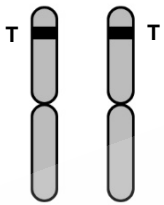
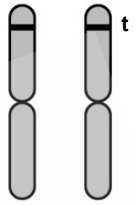
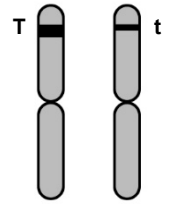
- When two alleles (gene pair) for a particular characteristic on the homologous chromosomes are **the same**, e.g. **TT** or **tt**, the individual is **homozygous** for that specific trait (e.g. plant length). This organism may also be referred to as **true breeding** (see p. 25).
- When two alleles on the homologous chromosomes **differ** from each other, e.g. **Tt**, the individual is **heterozygous** for that particular trait (e.g. plant length).

'homo' = same
'hetero' = different

homozygous vs homologous

homozygous - refers to **genes** where the alleles are identical for a particular characteristic e.g. TT or tt

homologous - refers to pairs of **chromosomes** that are similar in size, shape and genetic composition

Homozygous		Heterozygous
 *homozygous dominant*	 *homozygous recessive*	
Homologous chromosomes with the alleles **TT**	Homologous chromosomes with the alleles **tt**	Homologous chromosomes with the alleles **Tt**

An organism can be homozygous with respect to some traits and heterozygous with respect to others.

- A pea plant can be homozygous with respect to plant length (TT) and heterozygous with respect to seed colour (Gg).

G = yellow
g = green

Multiple alleles

- Sometimes a gene has **more than two possible alleles at the same loci** to control a hereditary characteristic. These are known as **multiple alleles**.
- Only two alleles, however, can occur in a somatic cell at a time. One allele is inherited from the mother and the other from the father.
- **Blood groups** are an example of multiple alleles in humans. There are 3 alleles that control this single characteristic. The letters I and i are used to indicate the dominant and recessive alleles. Possible genotypes are I^AI^A / I^BI^B /I^AI^B / I^Ai / I^Bi /ii . See p. 31 for an explanation of multiple alleles in blood groups.

Polygenic characteristics

- A polygenic characteristic is a hereditary characteristic that is controlled by **more than one gene pair at different loci**. These genes can also have multiple alleles.
- The more alleles that control a specific characteristic, the more possible gene combinations, the greater the diversity of phenotypes.
- A series of phenotypes usually occur over a continuous spectrum, ranging from one extreme to another. This phenomenon is known as **continuous variation**.
- **Skin colour in humans** and **size of flower in plants** are examples of polygenic characteristics controlled by various genes.

3.4 To represent a karyotype, microscope photographs of the chromosomes are taken. The chromosomes are then arranged in pairs (1 to 23).

3.4.1 Do you think these photographs are taken during Interphase or the division phase of a cell? Motivate your answer.

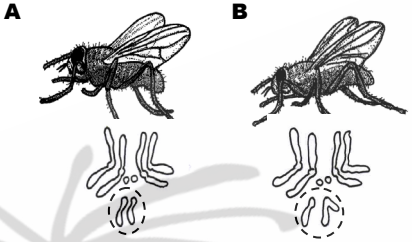
3.4.2 During cell division different phases occur. During which phase were these chromosomes possibly photographed? Explain.

QUESTION 4

Read the following paragraph, study the karyotypes of a male and female fruit fly and answer the questions that follow.

The fruit fly has 4 pairs of chromosomes, of which one pair is the sex chromosomes (gonosomes).

As in humans, the male individuals have XY and the females have XX gonosomes.



4.1 What is the chromosome pair, encircled with the dotted line, called?

4.2 Which one of A or B is the male? Give a reason for your answer.

4.3 What is the chromosome number of the somatic cells of a fruit fly?

4.4 Draw a representation of an egg cell/ovum of a fruit fly in order to indicate the chromosome number.

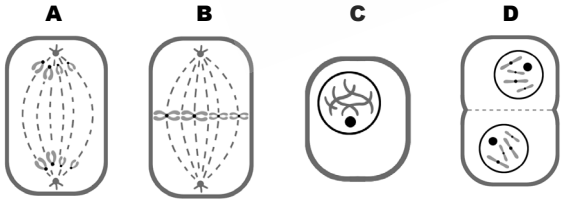
4.5 Which type of cell division is responsible for the formation of eggs?

QUESTION 5

5.1 What type of cell division results in daughter cells with chromosome numbers identical to the mother cell?

5.2 Give THREE reasons why the type of cell division mentioned in Question 5.1 is biologically important.

5.3 Study the representations below and identify the FOUR different phases of the division process mentioned in Question 5.1 by writing down the LETTER and the NAME of the phase in the correct order.

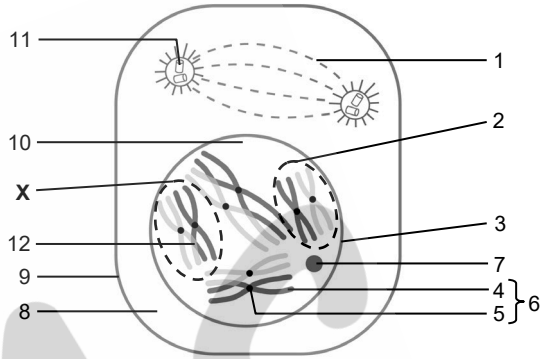


5.4 Do these diagrams illustrate a human somatic cell? Give a reason for your answer.

5.5 If the daughter cells formed in D divide again by mitosis, what would the chromosome number of their daughter cells be?

QUESTION 6

Study the following representation of a phase during cell division and answer the questions that follow.



6.1 Identify the type of cell division that is represented here. Motivate your answer.

6.2 Define the type of cell division mentioned in Question 6.1.

6.3 Identify the phase of cell division that is represented here.

6.4 What is the diploid chromosome number of this cell?

6.5 Identify the parts numbered from 1 to 11.

6.6 Which process takes place at the chromosome pair marked with an X?

6.7 What is the biological importance of the process mentioned in Question 6.6?

6.8 Identify the point indicated at number 12.

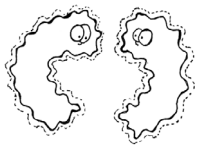
6.9 Make a neat labelled drawing of the phase that will follow the phase represented above. Supply your drawing with a heading.

6.10 Make a neat labelled drawing, with a heading, of the very last phase of this cell division process.

6.11 What is the purpose of this cell division process for organisms?

6.12 In plants like mosses and ferns, the haploid gametophyte generation alternates with the diploid sporophyte generation by one giving rise to the other. What is this phenomenon called?

6.13 Explain the role that alternating mitosis and meiosis have in the life cycles of plants like mosses and ferns.



36.9 Genetically modified organisms (GMOs) bring new hope for medical cures and promises to increase yields in agriculture and have the potential to help solve the world's pollution and resource crisis.

There are also many objections to GMOs, some stating that they are expensive and a threat to our biodiversity.

Give TWO reasons why:

36.9.1 the initial cost of production of GMOs is high

36.9.2 GMOs are considered a threat to biodiversity

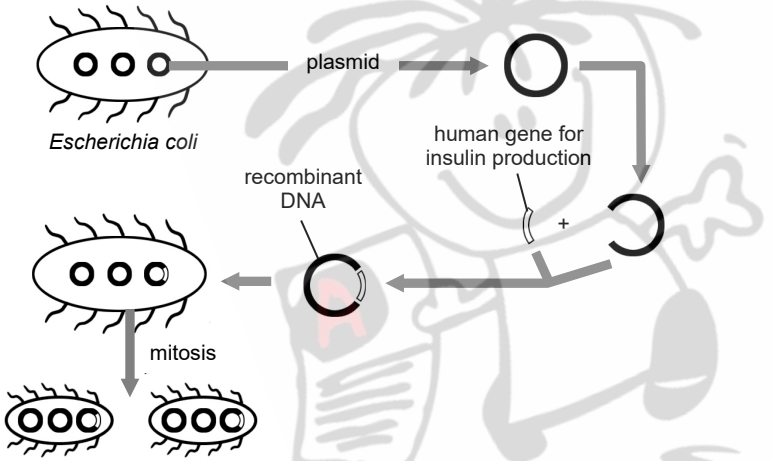
36.10 Define the term *biotechnology*.

36.11 Name THREE research areas where advances in biotechnology have had an impact.

36.12 Give THREE reasons to support genetic engineering in plants.

QUESTION 37

Study the diagrammatic representation below and answer the questions that follow.



37.1 What is the purpose/aim of the process represented above?

37.2 Why does the person not produce his/her own insulin?

37.3 What is the function of insulin in the human body?

37.4 Why is insulin production such a vital function?

37.5 What are plasmids?

37.6 What is meant by *recombinant DNA*?

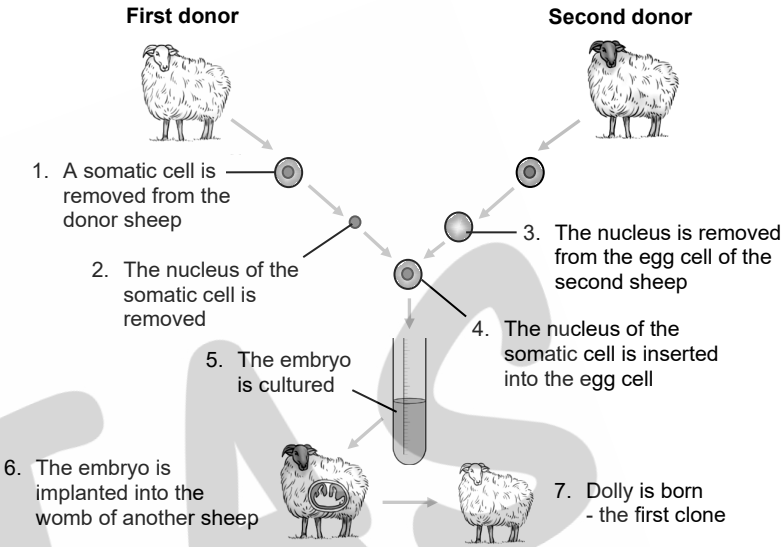
37.7 Explain how the recombinant DNA in the above diagram is formed.

37.8 What type of organism is *Escherichia coli*?

37.9 How does insulin eventually enter the human blood stream?

QUESTION 38

Study the diagram below that shows the cloning of a sheep named Dolly.



38.1 Define the term *cloning*.

38.2 Distinguish between the THREE types of cloning.

38.3 Name the type of reproductive cloning that was used to produce Dolly.

38.4 Why was it necessary to remove the nucleus of the egg cell of the second donor before the sheep could be cloned?

38.5 Will Dolly have the characteristics of the first or second donor sheep? Explain your answer.

38.6 Label number 5 in the diagram states that 'The embryo is cultured'. Through which type of cell division does the embryo develop?

38.7 Give THREE reasons against cloning in humans.

QUESTION 39

39.1 Define *stem cells*.

39.2 Identify the FOUR main sources of stem cells.

39.3 Define the term *pluripotent*.

39.4 Explain the process by which stem cells are used to treat spinal injuries.

QUESTION 26

26.1.1 Genes that are carried on the gonosomes.

26.1.2 A mutation on the gonosome that causes a particular disease/condition.

26.2 The X chromosome is bigger than the Y chromosome.

26.3 Women have two X chromosomes and because the mutation is recessive the abnormal allele must appear on both chromosomes to be expressed. However, men only have one X chromosome, so if the mutated allele is present, it will always be expressed.

26.4.1 The son always receives his Y chromosome from his father. His X chromosome comes from his mother.

26.4.2 The daughter receives one X chromosome from her father (with his sex-linked characteristics). She may pass on this X chromosome to her son, who will inherit the X-linked traits from the grandfather.

QUESTION 27

27.1 They are heterozygous because they receive their one normal X chromosome from their mother. Haemophilia is a recessive characteristic so daughters must be homozygous for it to be expressed.

27.2 No. The sons inherit their Y chromosome from their father and the haemophilia gene is on the X chromosome.

27.3.1 100%

27.3.2 50%

27.3.3 25%

27.3.4 0%

27.3.5 0%

27.3.6 25%

Explanation

$X^HX^h \times X^HY$

	X^H	Y
X^H	X^HX^H	X^HY
X^h	X^HX^h	X^hY

normal daughter; normal son; carrier daughter; haemophiliac son

QUESTION 28

28.1 50% chance that sons will be red-green colour blind.
0% chance that daughters will be red-green colour blind.

28.2 100%

28.3 50%

Explanation

$X^NX^n \times X^NY$

	X^N	Y
X^N	X^NX^N	X^NY
X^n	X^NX^n	X^nY

28.4 50%

Explanation

$X^NX^n \times X^nY$

	X^n	Y
X^N	X^NX^n	X^NY
X^n	X^nX^n	X^nY

QUESTION 29

29.1 Man A - X^hY
Woman B - X^HX^h
Girl C - X^hX^h
Boy D - X^hY
Girl E - X^HX^h

29.2 50%

29.3 0%

	X^H	Y
X^H	X^HX^H	X^HY
X^h	X^HX^h	X^hY

29.4 Yes

QUESTION 30

30.1 P_1 phenotype: affected female × unaffected male

P_1 genotype: $X^RX^r \times X^rY$

meiosis

gametes: X^R and X^r × X^r and Y

fertilisation

F_1 genotype: X^RX^r, X^RY, X^rX^r, X^rY

F_1 phenotype: 1 affected daughter, 1 affected son, 1 unaffected daughter, 1 unaffected son

OR

P_1 phenotype: affected female × unaffected male

P_1 genotype: $X^RX^r \times X^rY$

meiosis

fertilisation

F_1 genotype:

gametes	X^R	X^r
X^r	X^RX^r	X^rX^r
Y	X^RY	X^rY

F_1 phenotype: 1 affected daughter, 1 affected son, 1 unaffected daughter, 1 unaffected son

30.2 25%

30.3 It is caused by a dominant allele carried on the X chromosome - occurs in both males and females.

30.4.1 point mutation

30.4.2 It will code for a different amino acid which will result in a different protein being formed.

30.5
- It will help them evaluate whether they would cope with such a child.
- It will help them make an informed decision on whether to have children or not.

QUESTION 31

31.1 A **chromosome mutation** occurs when meiosis occurs abnormally. A change in the number or structure of the chromosomes may occur.

A **gene mutation** occurs as a result of a change in the nucleotide sequence in the DNA molecule. Thus the code for protein synthesis changes and an abnormal protein is formed or even no protein at all.

31.2 radiation; harmful chemicals

31.3
- substitution
- deletion
- insertion
- inversion

31.4.1 B

31.4.2 D

31.4.3 A

31.4.4 C

31.5 In frameshift mutations, deletions or insertions of bases that aren't in multiples of three, cause changes in many amino acids. In point mutations, there is a change in one base only.

31.6 See p. 38 in the notes under the heading *'Harmless gene mutations'*.

QUESTION 32

32.1.1 See p. 41 in the notes under the heading *'Genetic testing'*.

32.1.2 No. Neither the parents nor their children (F_1) suffered from albinism.

32.1.3 This person has the gene, but it is recessive so it is not shown in the phenotype.

32.1.4 They might marry someone who is also a carrier and then have children with albinism.

32.1.5 Yes. The disorder will only show phenotypically once two carriers/heterozygotes have a child with both recessive genes.

DIFFERENT THEORIES OF DEVELOPMENT

- **Three major observations** may be made when studying the natural environment:
  - the rich **biodiversity** of living organisms
  - how living **organisms** are well **adapted** to a particular environment
  - continuous **changes** take place in the environment
- The observation that there are continuous changes in the environment, was already made by intellectuals and scientists many centuries ago.
- They formed many ideas about the origin and diversity of species.
- **Jean-Baptiste de Lamarck** and **Charles Darwin** were two scientists whose views greatly contributed to the formulation of the theory of evolution.
- A more recent theory that explains evolution in terms of the fossil record, was proposed by **Stephen Jay Gould** and **Niles Eldredge** in 1972 (see p. 98).

LAMARCKISM

Jean-Baptiste de Lamarck (1744 - 1829), a French naturalist, proposed his theory of evolution in 1809 in his book ***Philosophie Zoologique***.

Lamarck's theory of evolution

Lamarck's theory was based on two related ideas:

- The **use** or **disuse of organs** may cause the organs to increase or decrease in size or even completely disappear.
- During their lifetime organisms acquire certain **changes in characteristics that are inherited by their offspring**. This results in changes in populations and eventually the formation of new species.

***Lamarckism** is a term that describes Lamarck's ideas that an organism's **acquired characteristics** are transferred to its offspring.*

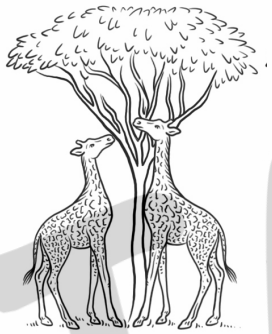
Lamarck's 'Laws':

1. 'Law' of Use and Disuse
2. 'Law' of Inheritance of Acquired Characteristics

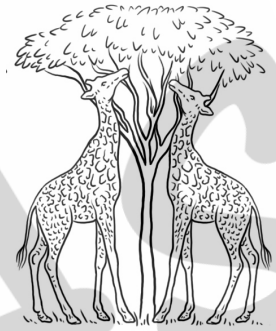
Applications of Lamarckism

The best known example of the application of Lamarck's theory is the elongated necks of giraffes. According to Lamarck, giraffe ancestors had short necks.

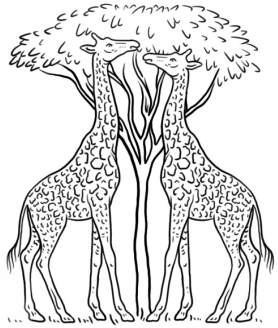
Over generations these short-necked giraffes stretched their necks to reach the leaves on the top branches for food. The stretching caused their necks to grow stronger and longer. This **acquired trait** (long neck) was passed on to the next generations. As a result all modern giraffes have long necks.



Original short-necked ancestors



Keep stretching their necks to reach leaves on the top branches



The long-neck trait is acquired and passed on to descendants

Lamarck believed that organisms possess an internal driving force - to strive for complexity and perfection.

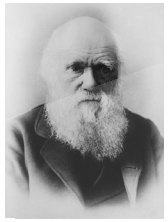
Reasons for rejection of Lamarckism

- After the discovery of modern genetics, Lamarck's theory of 'the inheritance of acquired traits' was completely rejected as it was not supported by evidence.
- Although he was wrong, Lamarck was the first scientist to propose that 'something' passed on the characteristics of the parents to the offspring.
- The knowledge of genetics did not yet exist in Lamarck's time, so he had no understanding of genes and mutations.
- The ancestors of the giraffe possessed the gene for long, strong necks and did not acquire the gene by stretching their necks.

Although Lamarck's theory was rejected, his pioneering work led to the formulation of Charles Darwin's theory of evolution.

DARWINISM

Darwinism is a broad term used to describe concepts and ideas associated with Darwin's theory of evolution by natural selection, as well as similar ideas by other evolutionary scientists.



Charles Darwin (1805 - 1882) was an English naturalist on the survey ship HMS Beagle that undertook a five-year expedition to the southern hemisphere from 1831 - 1836. His task as naturalist was to study the geography, plants and animals of the countries they visited. His most important observations were made on the Galapagos Islands off the northwest coast of South America.

HMS Beagle

In 1859, Darwin published his theory of evolution in his book, ***On the Origin of Species by means of Natural Selection***. Through this publication he convinced many scientists that evolution did indeed exist, and that it occurred through natural selection.

Darwin's observations

Darwin based his theory of evolution on the following **four observations**:

- Individuals of a **population produce more offspring than required** to ensure survival of the population.
- **A great deal of variation occurs within a population**.
- **Some individuals are better adapted** to a specific environment and are **more likely to reproduce** while the weaker adapted individuals will not reproduce or may even become extinct.
- **Characteristics are transferred from the surviving parents** to their offspring.

*Darwin used these observations to explain the **mechanism** of evolution - **natural selection**.*

Darwin's theory of evolution by natural selection

1. Organisms produce a large number of offspring - more than the number required for the survival of the population.
2. There is variation in the offspring.
3. Some individuals have favourable characteristics that give them an advantage in the environment.
4. When there is a change in the environment or increased competition, organisms with favourable characteristics that are better adapted to their environment, survive.
5. Organisms with unfavourable characteristics are less suited to the environment and will die. Therefore the number of 'less fit' organisms in the population will decrease.
6. The organisms that survive, reproduce and thus pass on the allele for the favourable characteristic to their offspring.
7. The next generation will therefore have a higher proportion of individuals with the favourable characteristic.
8. The changes occurring in the individuals of a species over time may lead to the formation of a new species (speciation).

*This phenomenon where the 'less fit' die out and the better-adapted ones survive ('survival of the fittest') is known as **natural selection**.*

Summary

a large number of offspring are produced
⇩
variation in a population
⇩
struggle for survival
⇩
natural selection ('survival of the fittest')
⇩
inheritance of favourable characteristics
⇩
change occurs over time
⇩
new species form = speciation

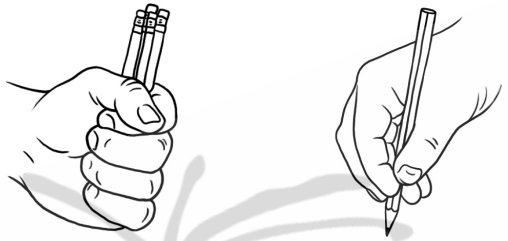
*Darwin's theory explains the slow accumulation of small, successive, gradual changes in species over time. This model of evolution is known as **gradualism**.*

Anatomical similarities between African apes and humans

Humans share the following characteristics with other primates:

- opposable thumbs that allow monkeys to have a **power grip**, while humans are capable of a **power grip** as well as a **precision grip (fine motor ability)**

Apes: power grip



Humans: power grip and precision grip (fine motor grip)

- two hands, each with five fingers; and two feet each with five toes
- long arms that rotate freely as shoulder joints allow movement in all directions
- naked fingertips and toes ending in flat nails
- a reduced snout with weakened sense of smell (reduced olfactory brain centres)
- stereoscopic vision as the eyes face forward providing depth of field - 3D vision
- eyes have cones (as well as rods) making colour vision possible
- brain centres that process information from hands and eyes are enlarged
- no tail
- sexual dimorphism where males and females are clearly distinguished
- have molars and premolars with rounded cusps

Anatomical differences between African apes and humans

African apes	Humans
Quadrupedal - knuckle-walkers	Bipedal - walk upright on two legs
Foramen magnum (opening for spinal cord) closer to back of skull	Foramen magnum closer to front of skull
C-shaped vertebral column	S-shaped vertebral column
Arms longer and stronger than legs	Arms shorter and weaker than legs
Knee joints smaller and weaker	Knee joints larger and stronger
Opposable (grasping) big toe with power grip	Non-opposable (forward-thrusting) big toe in line with other toes
Flat feet	Curved foot arch
Long and narrow pelvis	Short and wide pelvis
Smaller, less developed brain	Large, developed brain
Large, prominent canines	Smaller canines; the same size as other teeth
Thin tooth enamel	Thick tooth enamel
Large, prominent jawbone with no chin (prognathism)	Rounded jaw with developed chin (non-prognathism)
Wider, sloping face	Narrow, flat face
Narrow, rectangular palate	Wider, more curved palate
Prominent cranial and brow ridges	Reduced cranial and brow ridges

EVIDENCE OF COMMON ANCESTORS FOR LIVING HOMINIDS (including humans)

- The evolutionary theory does not state that humans evolved from the chimpanzee or the gorilla, but it proposes that they share a **common ancestor**.
- Scientists are searching for a common ancestor of all living hominids.
- The big question scientists have to answer is whether the common ancestor was ape-like or human-like.
- Remains of earlier hominids are very rare.

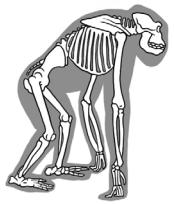
- There are three **main types of evidence** that indicate hominids may have shared a common ancestor:
  - **Fossil evidence**
  - **Genetic evidence** (see p. 115)
  - **Cultural evidence** (see p. 115)

Fossil evidence

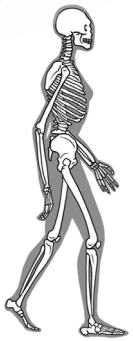
- Paleontologists study fossils to provide more information on the structure, movement, lifestyle and environment of a particular species.
- Certain features of hominid fossils indicate how changes occurred over time.
- Hominid fossils are rarely complete and consist mainly of fragments.
- Most hominid fossils are teeth, jaw bones or skull fragments.
- The remains of feet, hands, pelvic bones or vertebral columns are scarce.
- Long bones, e.g. femurs are more commonly found.
- In the search for a common ancestor for hominids, palaeontologists look particularly at the following features of hominid fossils:
  - bipedalism
  - dentition (teeth)
  - palate shape
  - brain size
  - prognathism
  - cranial and brow ridges

Bipedalism

- The greatest observable difference between ape and human fossils lies in the difference in posture and method of locomotion.
- Apes are four-footed (quadrupedal) with gorillas and chimpanzees demonstrating a particular manner of walking, i.e. knuckle-walking.
- Humans, however, are bipedal and walk upright.
- The main features that provide **evidence for bipedalism** are:
  1. position of the **foramen magnum**
  2. shape of the **spine**
  3. shape of the **pelvic girdle**



Chimpanzee (quadrupedal)



Human (bipedal)

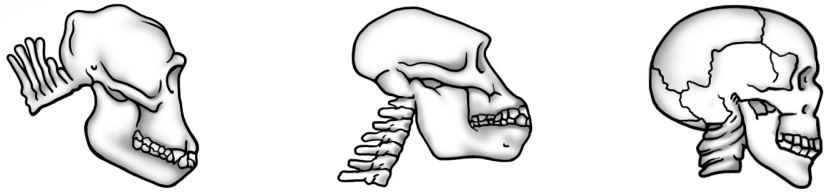
- Hominid fossils show evidence of a transition from quadrupedalism to bipedalism.

Anthropologists have provided various explanations of the advantages for the transition to bipedalism.

Advantages of bipedalism include:

- Upright bodies expose a smaller surface area to the sun which reduces risk of overheating while hunting, foraging or escaping predators.
- Upright bodies expose a larger surface area to air currents which causes cooling and reduces dependency on water.
- Hands are free to use tools, prepare food, carry young, hunt or fight.
- Vision extends further over the tall grass to find food or avoid predators.
- Adaptability to occupy a wider range of habitats.

- For early hominids to become bipedal and walk upright, their skeletons had to change quite considerably.
- The following **changes in structure** are observed in humans:
  1. In bipedal humans the **foramen magnum** shifted forward so that the skull rests on top of the vertebral column and the eyes face forward. The foramen magnum is positioned more forward at the base of the skull. In quadrupedal apes the head is positioned in front of the vertebral column with the foramen magnum closer to the back of the skull.



A **B** **C**

A. Chimpanzees: foramen magnum is positioned at the back of the skull

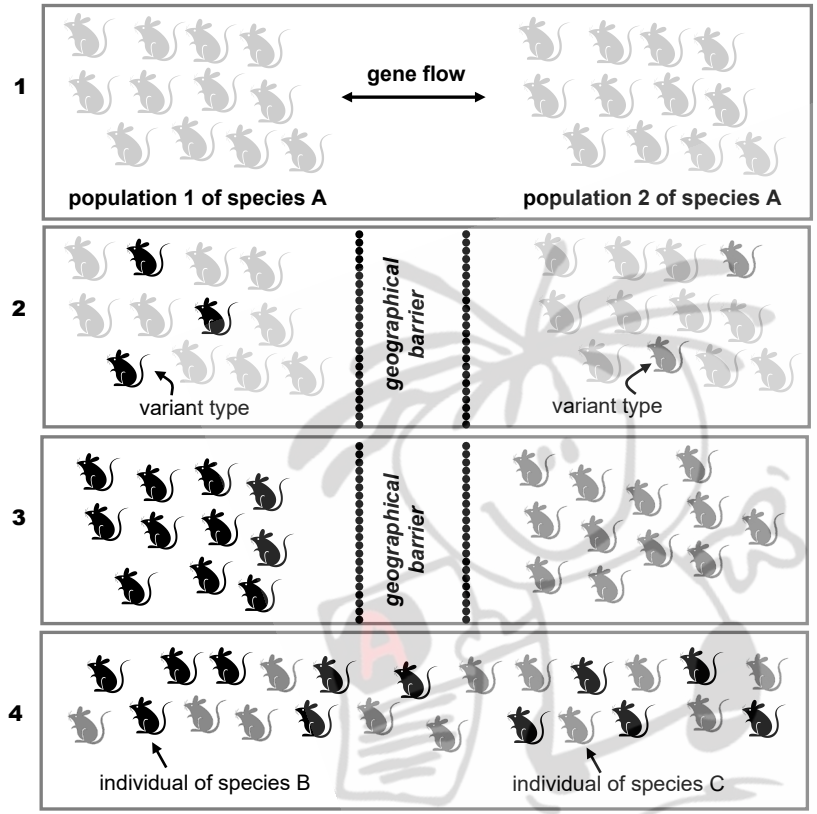
B. Early *Homo* species: foramen magnum is positioned closer to the front for stable upright walking

C. *Homo sapiens*: foramen magnum is positioned more forward, directly above the spine to balance the head above the vertebrae

QUESTION 24

Brants' flute rat *(Parotomys brantsii)* forms subspecies as a result of geographical barriers such as the 'Knersvlakte' and the Orange River.

Study the schematic representation (frames 1 - 4) below and answer the questions that follow.



24.1 Provide the schematic representation with a heading.

24.2 What is meant by *geographical barrier*?

24.3 Name TWO examples of geographical barriers.

24.4.1 Which process took place between frames 2 and 3 that resulted in the 'variant type' being the majority?

24.4.2 Why do you think the variant types on both sides of the geographical barriers differ?

24.5 Describe speciation as it is represented in the diagram by explaining each frame.

QUESTION 25

25.1 What is meant by the term *reproductive isolation*?

25.2 Name **and** define the two main groups of reproductive isolating mechanisms.

25.3 The frog species *Rana aurora* is sexually active from January to March, and *Rana boylii* from March to May, which prevents crossbreeding. What type of prezygotic reproductive isolation is involved here?

25.4.1 What is meant by courtship?

25.4.2 What is meant by species-specific courtship?

25.4.3 What type of prezygotic reproductive isolation is involved in species-specific courtship?

25.4.4 Name any FOUR examples of species-specific courtship that prevents cross-breeding.

25.5 Different plant species are adapted for pollination by different pollinators. What is this type of prezygotic reproductive isolation called?

25.6 Name THREE adaptations of different plant species that make them suitable for pollination by specific pollinators.

25.7 Name TWO examples where organisms are adapted to prevent fertilisation by physical incompatibility.

25.8.1 Name **and** explain the specific reproductive isolating mechanism that occurs when a donkey and a horse crossbreed.

25.8.2 What is the advantage of the hybrid vigour exhibited by a mule?

QUESTION 26

In mosquitoes there is a gene locus which has alleles involved in resistance to DDT, a well-known insecticide.

The graph below shows the number of mosquitoes and their genotypes collected from 1965 when DDT was first used, until 1970, two years after the spraying of DDT stopped.