Life Sciences IEB
Part 1

CLASS TEXT & STUDY GUIDE

Liesl Sterrenberg, Helena Fouché & Grace Elliott

GRADE
12
IEB

3-in-1

THE ANSWER SERIES *Your Key to Exam Success*

Grade 12 Life Sciences 3-in-1 Part 1 IEB

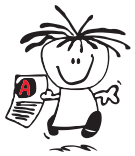
CLASS TEXT & STUDY GUIDE

This book is PART 1 of a SET of 2 Life Sciences study guides covering the Grade 12 IEB curriculum. This PART 1 study guide walks you through the knowledge strands Life at the Molecular, Cellular and Tissue level and Diversity, Change and Continuity. For Environmental Studies and Life Processes in Plants and Animals, please see PART 2.

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

IEB

3-in-1

Life Sciences

Part 1

Liesl Sterrenberg, Helena Fouché & Grace Elliott

Also available

GRADE 12
LIFE SCIENCES
PART 2

- Environmental Studies
- Life Processes in Plants and Animals

THIS HANDBOOK & STUDY GUIDE INCLUDES

ALL the content you need for **PAPER I**

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*

E-book available

2014 publication | ISBN: 978-1-920686-56-7

110821 | TAS

CONTENTS

NOTES with QUESTIONS:

INTRODUCTION TO 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.

How science works

- Fundamental knowledge built on scientific evidence
- Observation
- Designing an investigation
- Making measurements and the importance of scaling
- Presenting data in the form of drawings, written descriptions, tables and graphs
- Identifying patterns and relationships in data
- Societal aspects of scientific evidence
- Limitations of scientific evidence

PROTEIN SYNTHESIS

- Protein synthesis is the process whereby proteins are manufactured in living cells.
- The nucleic acids DNA and RNA control the synthesis of proteins.

In **Grade 10** you were introduced to proteins.

You already know:

- A protein is a large molecule called a **polymer** with **amino acids** as **monomers**.
- It consists of a long chain of **more than 50 amino acids** linked together.
- Proteins are composed of **twenty** different amino acids.
- The **sequence** and **type** of amino acids determine the type of protein.

- To synthesise a particular protein, specific **types** of amino acids have to be joined in a specific **sequence**.
- DNA in the nucleus provides the **genetic code** that determines the type and sequence of the amino acids.
- Each DNA strand carries the information for the synthesis of several proteins.
- Each segment/section of the DNA strand that carries the information to synthesise a particular protein, is known as a **gene**.

It is only a small section (the gene) of the DNA strand that is involved in the synthesis of one protein.

- Three consecutive nitrogenous bases on the DNA strand are known as a **base triplet** and provide the code for a particular amino acid.
- This base triplet sequence on the DNA strand determines the sequence in which the amino acids will link and thus determines the type of protein constructed.

*A **gene** consists of a group of triplet bases that code for the synthesis of a protein.*

- The process of protein synthesis occurs in two main steps:
  - **Transcription of DNA**
  - **Translation of RNA to proteins**

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 are used to build a complementary mRNA strand on one of the DNA strands (template).
- A single mRNA strand is formed.
- Each group of three nitrogenous bases on the mRNA, known as a **codon**, codes for a particular amino acid.
- The sequence of the nitrogenous bases 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.
- The code obtained by the mRNA is taken 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 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 now provides the code for the linking 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 it picks up amino acids in the cytoplasm and brings 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 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 **a triplet base** (DNA), a **codon** (mRNA) and an **anticodon** (tRNA).*

- Amino acids join in sequence as they fit in next to each other and 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 and the protein is formed.

*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.*

NB:
- 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.

*The table below shows which **mRNA codon** codes for which **amino acid** in the **genetic code**.*

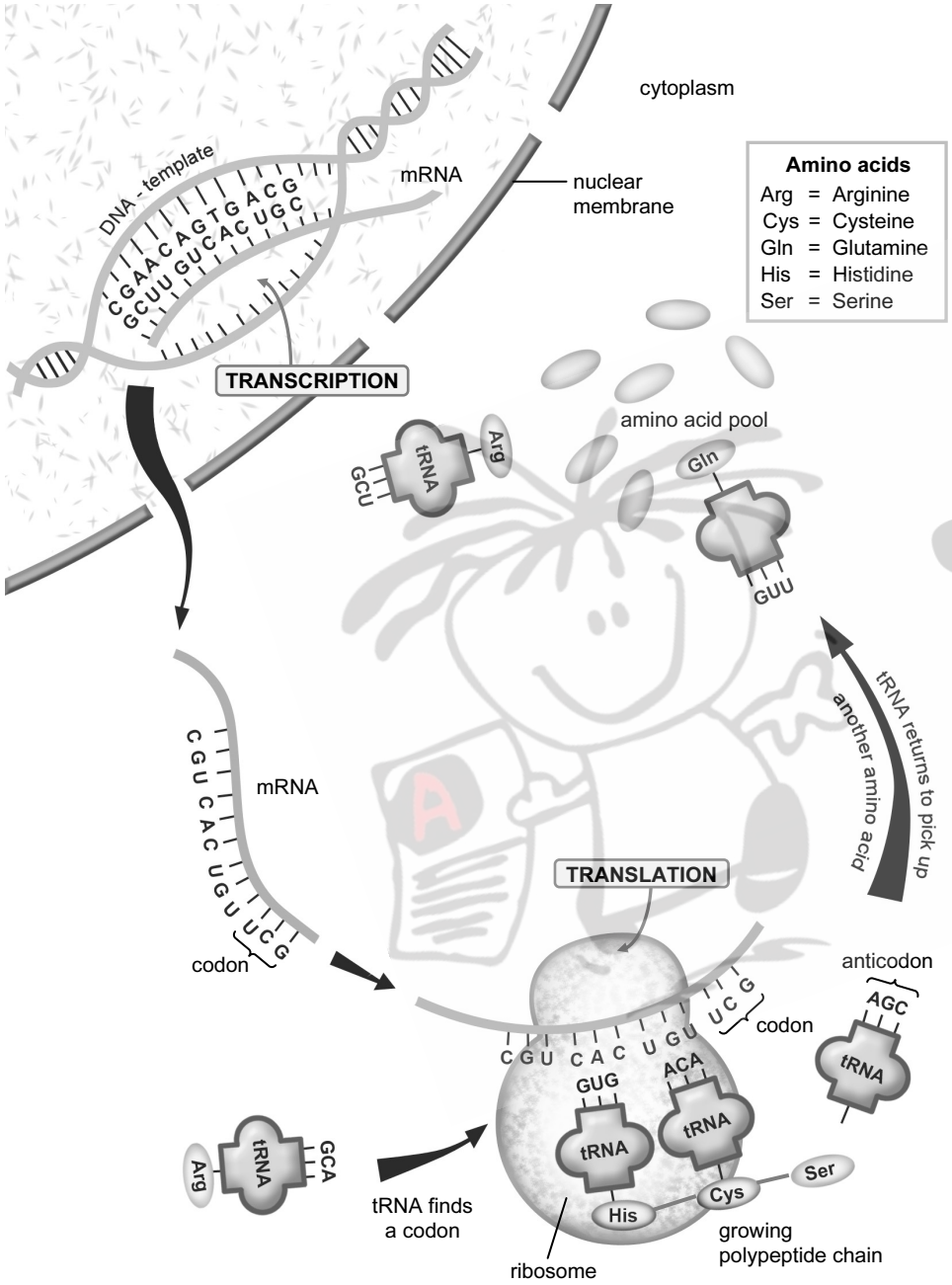
SECOND LETTER

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

DNA is incredibly efficient at storing information. Scientists have made significant breakthroughs in using DNA as a data storage 'device'. It has astounding capabilities in terms of coding information in the 4 nitrogenous bases (GCAT). It is vastly superior to any other man-made storage devices as it:

- *is a tiny, very dense molecule which is able to code huge quantities of data*
- *is a stable molecule which is able to survive for thousands of years*
- *does not require special storage conditions*
- *stores information three-dimensionally as opposed to two-dimensional storage devices.*

Genetic code - summary

- The genetic code for the synthesis of proteins is carried on one strand of DNA.
- The sequence of the nitrogenous bases A, G, C and T forms the basis of this code.
- A group of three consecutive nitrogenous bases, known as a **triplet base,** codes for a particular amino acid.
- The sequence of the triplet bases on the DNA strand determines the sequence in which the amino acids join, which, in turn, determines the type of protein.
- Proteins determine the characteristics of an organism (structure and functioning).
- A group of triplet bases that code for synthesis of one protein, is known as a **gene**.
- The genetic code is a universal code for all living organisms (including viruses and bacteria).
- This means that the protein of all living organisms is synthesised according to the same code. (The table with the genetic code on p. 1.10 is thus applicable to all living organisms.)

Protein synthesis may be blocked by antibiotics. Antibiotics combat bacterial infection by imitating tRNA and binding to the ribosomes. Thus they block protein synthesis and effectively prevent reproduction or growth of bacteria.

- 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.

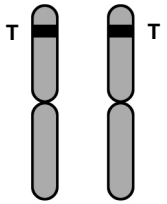
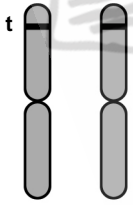
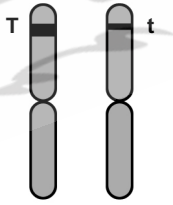
This notation for writing the genotypes of pea plants also applies to other organisms. In the questions section of this module, you will come across various crosses of different organisms and traits.

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 (in this case plant length).
- When two alleles on the homologous chromosomes **differ** from each other, e.g. **Tt**, the individual is **heterozygous** for that particular trait (in this case plant length).

'homo' = same
'hetero' = different

Homozygous		Heterozygous
		
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).

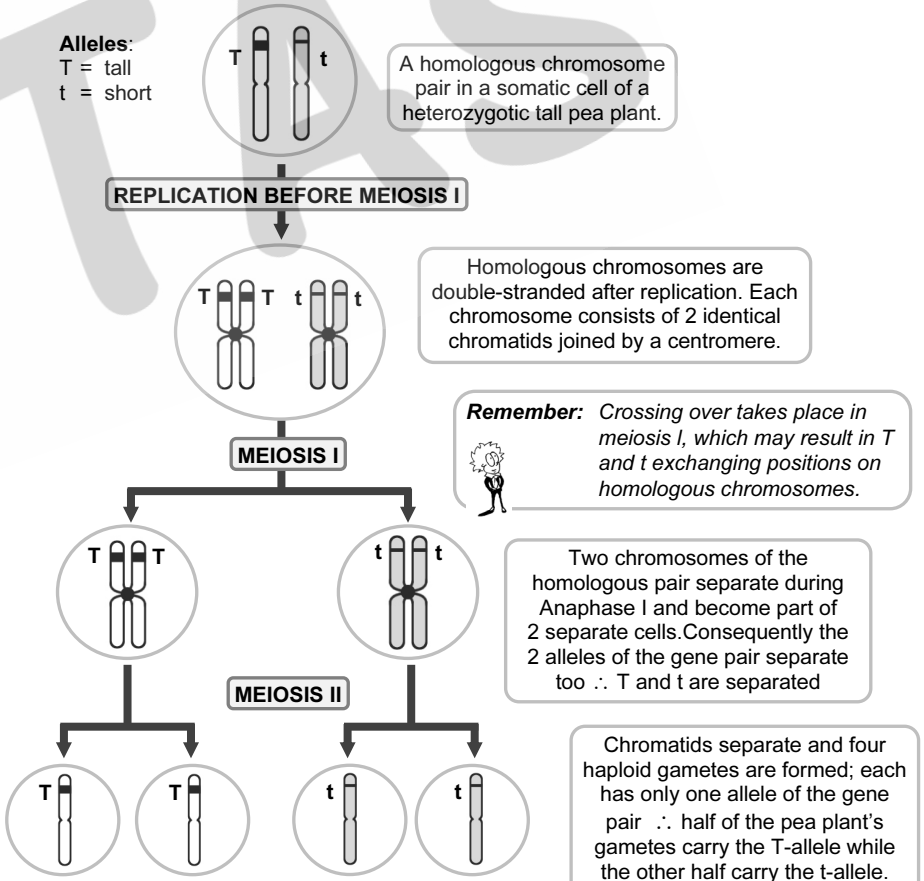
G = yellow
g = green

Meiosis and the separation of alleles

- During meiosis, homologous chromosome pairs (that carry pairs of alleles to control hereditary characteristics) separate from each other.
- Thus each gamete that is produced receives only one allele of a gene pair.
- This phenomenon is known as **Mendel's Law of Segregation**.

segregation = separation

- **Example**:



10.2 Name FOUR similarities between mitosis en meiosis.

10.3 Tabulate the differences between mitosis and meiosis, referring to:

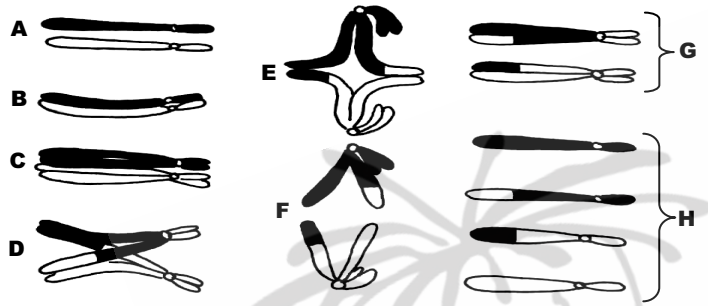
10.3.1 the site where the process takes place

10.3.2 the purpose of the process

10.3.3 the division process

QUESTION 11

The sketches below represent the behaviour of chromosomes during a certain cell division. Study the representations and answer the questions that follow:



11.1 Identify the phase represented by the chromosomes at . . .

11.1.1 C 11.1.2 F

11.2 Write down the LETTER of the stage where . . .

11.2.1 crossing over takes place.

11.2.2 chromosomes are represented at the end of meiosis II.

11.2.3 homologous chromosomes are present.

11.2.4 chromosomes are represented at the end of meiosis I.

11.2.5 chromatids are formed.

QUESTION 12

Study the statements relating to cell division below. In each case write down if the statement is applicable to MITOSIS or MEIOSIS.

12.1 Each mother cell is the origin of four daughter cells.

12.2 Chiasmata are present and crossing over occurs.

12.3 Chromosomes position themselves on the equator with centromeres on the equator.

12.4 Chromosome number of both mother and daughter cells are identical.

12.5 The diploid chromosome number is halved.

12.6 During Anaphase I, one chromosome of each bivalent moves to the opposite pole.

12.7 Two daughter cells originate from each mother cell.

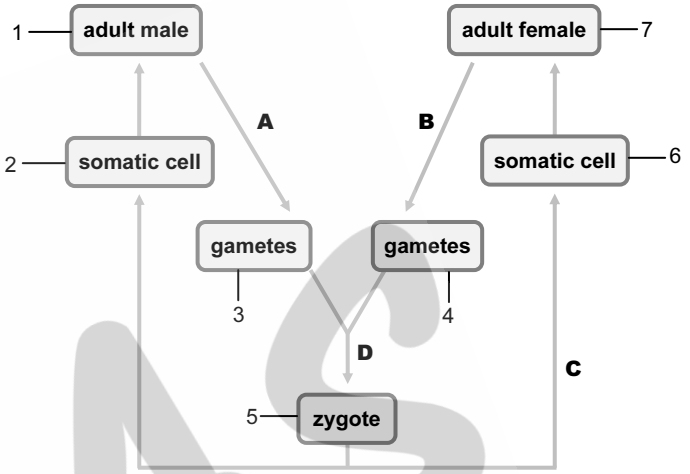
12.8 Gametogenesis.

12.9 The pairing of homologous chromosomes results in the formation of a bivalent.

12.10 Daughter cells are haploid with exchanged genetic material.

QUESTION 13

Study the schematic representation of the human life cycle below and answer the questions that follow.



13.1 Which type of cell division is represented by A, B and C, respectively?

13.2 Which process is represented by D?

13.3 Which chromosome composition (haploid/diploid) will be found at numbers 1 to 7, respectively?

13.4 Why is the process of meiosis necessary in the life cycle of humans?

13.5 How many chromosomes are ...

13.5.1 present in each human sperm cell?

13.5.2 present in the human zygote?

13.5.3 present in each human somatic cell?

QUESTION 14

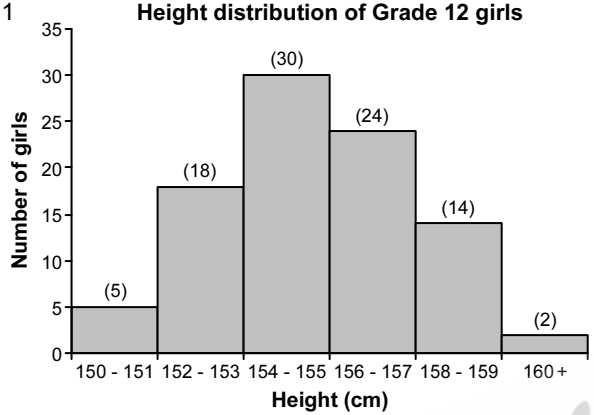
Read the case study below, study the karyotypes marked A and B, and answer the questions that follow.

A 43 year old woman is pregnant. Due to the maternal age effect, women over 40 years of age are classified in a high risk group for having a baby with Down syndrome. Due to this risk, the woman decides to have an amniocentesis. During this procedure a thin needle is used to extract some of the amniotic fluid that surrounds the foetus. The karyotype of the foetus is analysed to determine if 'trisomy' is present. The result of this test can lead to:

- the decision to terminate the pregnancy
- the decision to continue with the pregnancy with the necessary counselling and preparation

QUESTION 13

13.1 **Height distribution of Grade 12 girls**



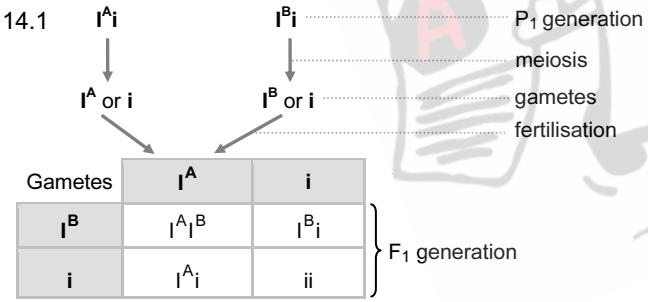
13.2 polygenic inheritance

13.3 Polygenic: genes at different/multiple loci
One gene: gene at one locus **OR**
Polygenic: a range of intermediate phenotypes for the trait/continuous variation
One gene: has distinct phenotypic traits/discontinuous variation

13.4
- environmental factors/nutrition
- sex/gender
- age
- medical conditions

QUESTION 14

14.1



14.2.1 25% 14.2.2 25% 14.2.3 25%

14.3.1 AB

14.3.2 In the other blood groups the phenotype shows only one of the genes in the genotype, because the one dominates the other, e.g. I^Ai and I^Bi, or if it is homozygous, e.g. I^AI^A ; I^BI^B or **ii**.

14.3.3 Co-dominance. Genes I^A and I^B are equally dominant and both appear in the individual phenotypically.

QUESTION 15

15.1 **Mr and Mrs Q - probabilities**:

Gametes	I^A	I^A
I^B	I^AI^B	I^AI^B
I^B	I^AI^B	I^AI^B

Gametes	I^A	i
I^B	I^AI^B	I^Bi
I^B	I^AI^B	I^Bi

Gametes	I^A	I^A
I^B	I^AI^B	I^AI^B
i	I^Ai	I^Ai

Gametes	I^A	i
I^B	I^AI^B	I^Bi
i	I^Ai	ii

It is possible that Baby X or Baby Y **could be** the baby of Mr and Mrs Q.

Mr and Mrs P - probabilities:

Gametes	I^A	I^A
I^A	I^AI^A	I^AI^A
I^B	I^AI^B	I^AI^B

Gametes	I^A	i
I^A	I^AI^A	I^Ai
I^B	I^AI^B	I^Bi

Mr and Mrs P **cannot** have a baby with blood group O, but it is possible for them to have a baby with blood group A.

Baby Y must be the baby of Mr and Mrs Q and Baby X must be the baby of Mr and Mrs P. Thus the babies were indeed switched.

15.2.1 Both couples can possibly have babies with blood group A or B.

15.2.2 They could use DNA fingerprints.

15.3.1 Dominance - allele I^A is dominant over allele **i**

15.3.2 Co-dominance - allele I^A and allele I^B are both equally dominant

15.3.3 Recessive allele - allele **i** is dominated by I^A or I^B.

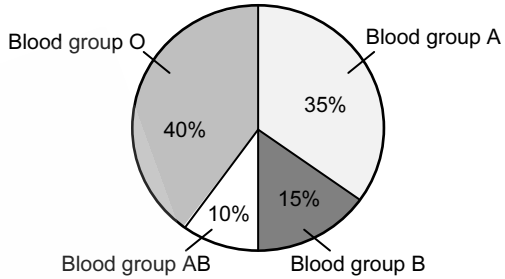
15.4 Allele I^A and allele I^B dominate the recessive allele **i**, but allele I^A and allele I^B are co-dominant and do not dominate each other.

QUESTION 16

16.1 one

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

16.3 **Percentage distribution of blood groups in a province**



Blood group A: $\frac{35}{100} \times \frac{360}{1} = 126°$

Blood group B: $\frac{15}{100} \times \frac{360}{1} = 54°$

Blood group AB: $\frac{10}{100} \times \frac{360}{1} = 36°$

Blood group O: $\frac{40}{100} \times \frac{360}{1} = 144°$

QUESTION 17

Mother : I^AI^A or I^Ai ; **Father :** I^AI^B ; **Child :** **ii**

Option 1:

Gametes	I^A	I^A
I^A	I^AI^A	I^AI^A
I^B	I^AI^B	I^AI^B

Option 2:

Gametes	I^A	i
I^A	I^AI^A	I^Ai
I^B	I^AI^B	I^Bi

This man cannot be the father of this child, because he does not carry the **i** gene in his genotype. The child's genotype must receive an **i** gene from both parents in order to be **ii**, because the I^Ai and I^Bi genotypes do not show an O-phenotype, as **i** is recessive - I^A and I^B are dominant over **i**.

QUESTION 18

18.1 3 : 1

18.2 X: $\frac{5\,474}{1\,850} = 2{,}96 : 1$ Y: $\frac{6\,022}{2\,001} = 3{,}01 : 1$

seed colour

ERASMUS DARWIN (1731 - 1802)

Erasmus Darwin was a respected medical doctor, well-known poet, philosopher, botanist and naturalist in England.

As a naturalist, he formulated one of the first theories about evolution in his book ***Zoonomia*** (1794-1796). His views on evolution greatly influenced the ideas of his grandson, Charles Darwin.

Erasmus Darwin was the grandfather of Charles Darwin.

Erasmus Darwin proposed the following **ideas about evolution**:

- Life on earth originated from a **single common ancestor** (a simple life form).
- There are similarities between different organisms which indicate that **one species developed from another** over time.
- Phenomena such as **artificial selection** in animals as well as **metamorphosis** in tadpoles were used to illustrate how changes possibly occurred over time.

JEAN BAPTISTE DE LAMARCK (1744 - 1829)

Jean-Baptiste de Lamarck 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 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.*

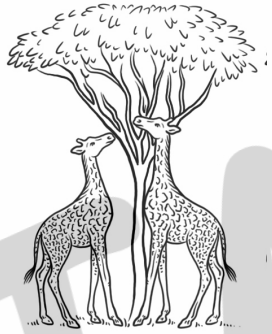
Lamarck's' Laws':

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

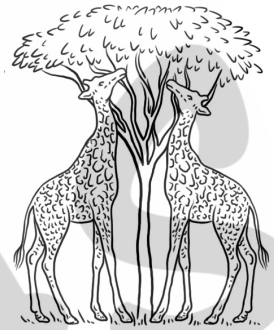
Applications of Lamarckism

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.

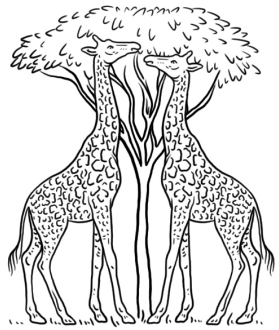
Over generations these short-necked giraffes stretched their necks to reach the leaves on the top branches for food. The stretching caused their necks to grow stronger and longer. This acquired trait (long neck) was passed on to the next generations. As a result all modern giraffes have long necks.



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.
- 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.

ALFRED WALLACE (1823 - 1913)

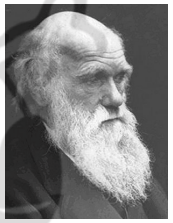
Alfred Wallace was a British naturalist who accepted the concept of evolution. However, like many others, he was searching for an explanation of exactly how evolution took place.

Thomas Malthus published a book, ***An Essay on the Principle of Population***, dealing with the competition and struggle for survival among individuals in a population. After Wallace read the book he formulated a hypothesis about the mechanism of evolution and introduced his idea of natural selection.

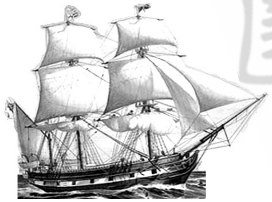
Independently of Wallace, Charles Darwin also read Malthus's book and introduced similar ideas. Darwin and Wallace then jointly published an article on natural selection. However, Darwin refined the theory and was the one mainly responsible for the acceptance of the theory.

CHARLES DARWIN (1805 - 1882)

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 used these observations to explain the **mechanism** of evolution - 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'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 without these favourable 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 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**.*

- There are three **main lines of evidence** that indicate hominids may have shared a common ancestor:
  - **Fossil evidence**
  - **Genetic evidence**
  - **Archaeological evidence**

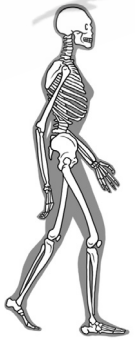
Fossil evidence

- 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 apes and humans 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.

Chimpanzee (quadrupedal)



Human (bipedal)

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

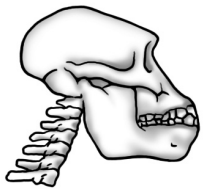
Various explanations are given for the transition from quadrupedalism to bipedalism. Many anthropologists question whether these advantages were sufficient to cause the significant changes involved in the evolution of bipedalism.

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 of the savannah 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:
  - 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 centrally at the bottom of the skull. In quadrupedal apes the head is positioned in front of the vertebral column with the foramen magnum at the back of the skull.

A



B

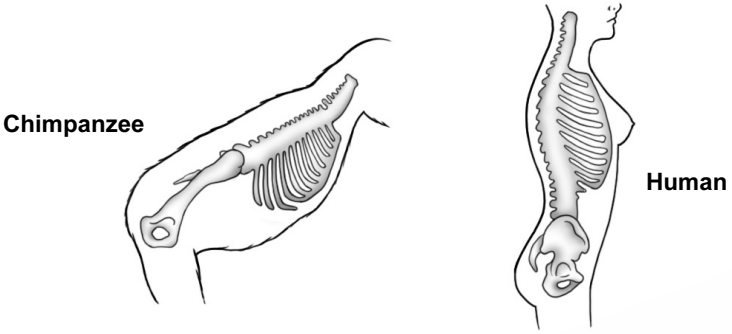
C

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

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

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

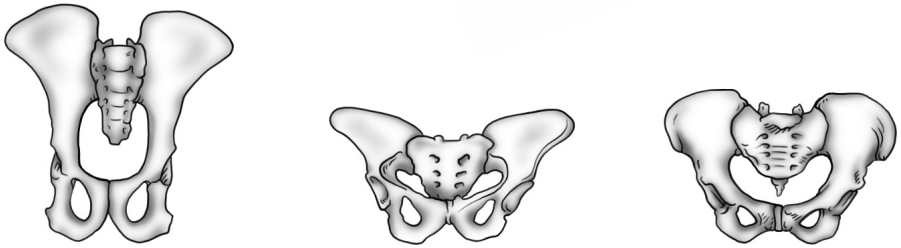
- The human vertebral column is S-shaped for flexibility and shock absorption. The vertebral column of apes is C-shaped.



- Humans have shorter arms and longer legs, while apes have shorter legs and longer arms.
- In humans the knee-joints have become larger and stronger to support greater body weight.
- The human big toe is parallel with the other toes and helps to maintain balance. Apes have opposable big toes with a grasping action for climbing and moving in trees.
- A foot arch developed in humans, whereas an ape's foot is flat.

The foot arch acts as a shock absorber and enables the rolling action over the ball of the foot which is more energy efficient.

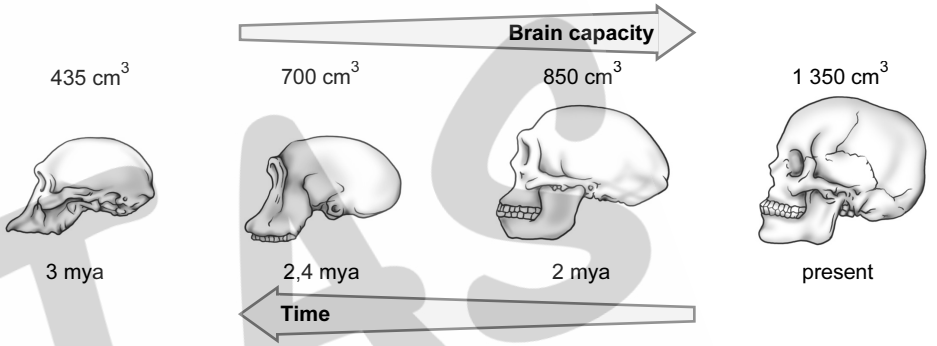
- The human pelvic girdle has become larger, shorter and wider to support the greater weight due to the upright posture. The pelvic girdles of apes are long and narrow.



Brain size

- Hominid fossils indicate that the size of the **cranium** increased in most fossils over time.
- We may conclude that, in general, the size of the brain (**brain capacity**) increased over time.

See the comparative table of brain capacities of the main hominid species on p. 2.36.



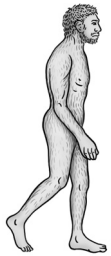
- The cranium of apes is small and elongated and contains a small, less developed brain.
- Chimpanzee brains have an average size of approximately 395 cm^3.
- Humans have a more rounded skull with an enlarged cranium which contains a large, highly developed brain.
- The average size of the human brain is approximately 1 400 cm^3.
- The more complex human brain gave rise to:
  - well developed hand-eye coordination (to make and use tools)
  - the capacity for language
  - the use of fire

The larger brain contributed to the survival of humans in that they could successfully adapt to changing environments.

Homo neanderthalensis

- The Neanderthals were a group of people that lived between approximately 230 000 and 30 000 years ago in Europe and Western Asia.
- The first fossil was discovered in 1856 in the Neander Valley in Germany.
- Their skulls were long and flat, with a low forehead, broad nose and a prominent brow ridge above the eyes.
- Although their brains were larger than *Homo sapiens,* language was not well developed and their technological development was limited.
- They were hunters, wore clothes made from animal skins, built shelters in caves and used fire.
- They buried their dead, which is an indication of some form of 'spiritual life' or advanced culture.

Homo sapiens



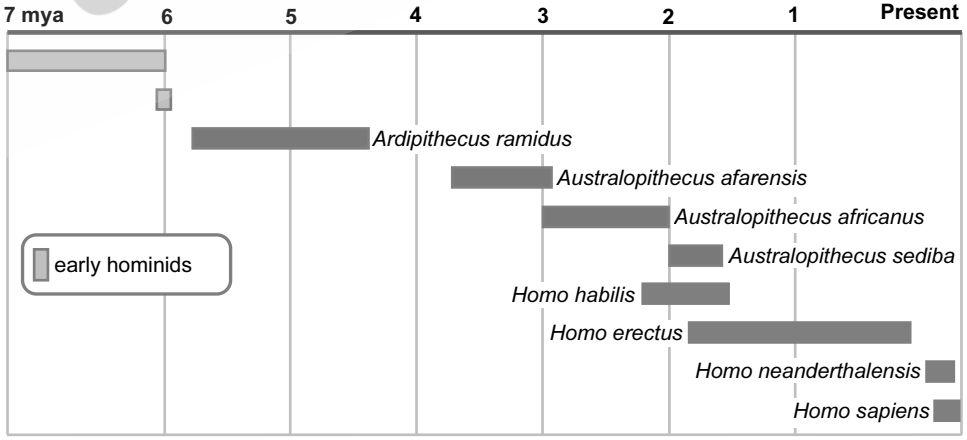
- This group is considered to be the direct ancestors of modern humans.
- Presumably, *Homo sapiens* appeared about 200 000 years ago.
- It is claimed that the appearance of *Homo sapiens* resulted in the disappearance of the Neanderthals.
- *Homo sapiens* developed better skills and had more advanced technology.
- Therefore modern humans are not directly related to *Homo neanderthalensis*.
- *Homo sapiens* used tools made from bone as well as stone, which included spears, arrows, bows and hooks for fishing.
- Their clothes were made mainly from leather and plant material.
- They lived in tents and formed communities.
- As hunters they followed the annual animal migrations in the summer.
- They developed agriculture and cultivated the land.
- They wore jewellery and decorated their bodies with paint.
- They developed rituals that were linked to hunting, births and deaths.
- Like the Neanderthals, they buried their dead which indicates a development of advanced culture and spiritual rituals.

Sometimes modern humans are referred to as ***Homo sapiens sapiens****, a subspecies of* ***Homo sapiens****.*

- Due to a large brain capacity of about 1 400 cm^3, modern humans have the ability to change their environment to suit their needs, unlike early *Homo* species who could not change their environments and therefore became extinct.
- Today, modern humans are on the brink of the sixth extinction as a result of their own destructive impact on the environment.

Comparative table of the average brain capacity of the most important hominid species

Hominid species	Average brain capacity (in cm^3)
Australopithecus afarensis	440
Australopithecus africanus	450
Australopithecus sediba	500
Homo habilis	640
Homo erectus	1 000
Homo neanderthalensis	1 500
Modern *Homo sapiens*	1 400



Timeline to illustrate evolution of hominids

It is not necessary to memorise this timeline. You may, however, be expected to interpret it in an exam question.

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 incompatability.

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

Darwin did extensive research on the finches of the Galapagos Islands.

26.1 Why was the birdlife on the Galapagos Islands mainly restricted to finches and not other bird species?

26.2

The medium ground finch was studied on Daphne Major Island, one of the Galapagos Islands, during a research project.

This island has plant species with small seeds as well as large, hard seeds. Ground finches are seed eaters that prefer small seeds although some have small beaks and others have large beaks.

A drought occurred during this research period (from July 1975 to January 1979) and hundreds of ground finches died. Post-mortem examinations showed that most finches that died had small beaks, while those with large beaks survived.

Use the information above and the table below to answer the following questions.

Year	Month	Population size of medium-sized finches
1975	July	1 400
1976	January	1 100
1976	March	1 500
1977	May	400
1977	November	150
1978	July	350
1979	January	250

26.2.1 a) When did the drought probably start? Give a reason for your answer.

b) How long did the drought probably last?

c) What was the size of the finch population before the drought?

d) How many finches survived the drought?

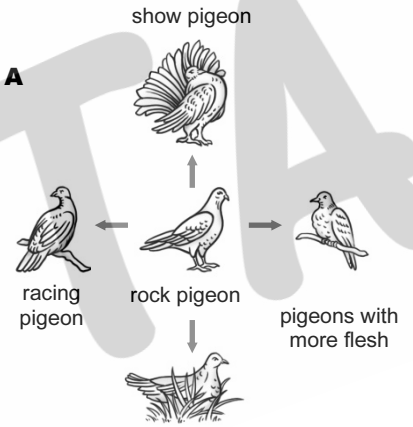
e) What % of finches died during the drought? (Show your calculations)

26.2.2 Predict the beak size of the offspring after the drought has ended. Give a reason for your answer.

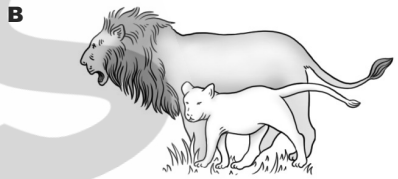
26.2.3 Fully explain how Darwin would have explained the change in beak size of the medium ground finch on Daphne Island in 1977.

QUESTION 27

Study the illustrations below marked A to C and answer the questions that follow.



Selective breeding of pigeons



Yellow-brown adult lion with white cub

Black and white moths on a tree trunk

27.1 In which illustration will natural selection result in increased chances of survival? Explain your answer.

27.2 Which illustration shows natural selection and results in greater variation, but does not necessarily increase the chances of survival? Explain your answer.

27.3 Which illustration shows a phenotypic variation that is the result of genotypic variation? Explain your answer.

27.4 Would you say that illustration B is an example of natural selection? Give a reason for your answer.

27.5 Give ONE reason why:

27.5.1 the black moth (illustration C) will have a better chance of survival

27.5.2 the white colour of the lion (illustration B) will be a disadvantage in its environment