Western Cape Government
Education

Directorate: Curriculum FET

TELEMATICS 2020

LIFE SCIENCES

Grade 12

1. TIPS FOR WRITING LIFE SCIENCES

- The external examination for Life Sciences consists of two (2) question papers of 150 marks each. Each question paper covers a variety of content topics. Ask your teacher for an outline of the content topics and weighting of each topic in each question paper.
- The duration of each question paper is 2½ hours and all questions are COMPULSORY.
- Each Life Sciences question paper consists of THREE sections i.e. SECTION A (50 marks), SECTION B (two questions of 40 marks) and SECTION C (20 marks).
- When answering a multiple choice question in Section A read the question and four options carefully, evaluate each option and eliminate each incorrect option.
- In questions that require only a LETTER you only need to write down a LETTER e.g. 'Give only the LETTER of the molecule that carries the amino acid'. Other questions might require you to write down both the LETTER and a NAME, for example of a part from a diagram.
- Use the correct spelling when you use biological terminology in your answers. Use scientific names in terminology and avoid using common names.
- You need to do all your drawings and graphs in pencil and labels should be in blue or black ink. You may not use graph paper when drawing graphs.
- Make sure that you have all the necessary stationery for your examination e.g. blue or black pens, a pencil, an eraser, a ruler, a non-programmable calculator, protractor and a compass.

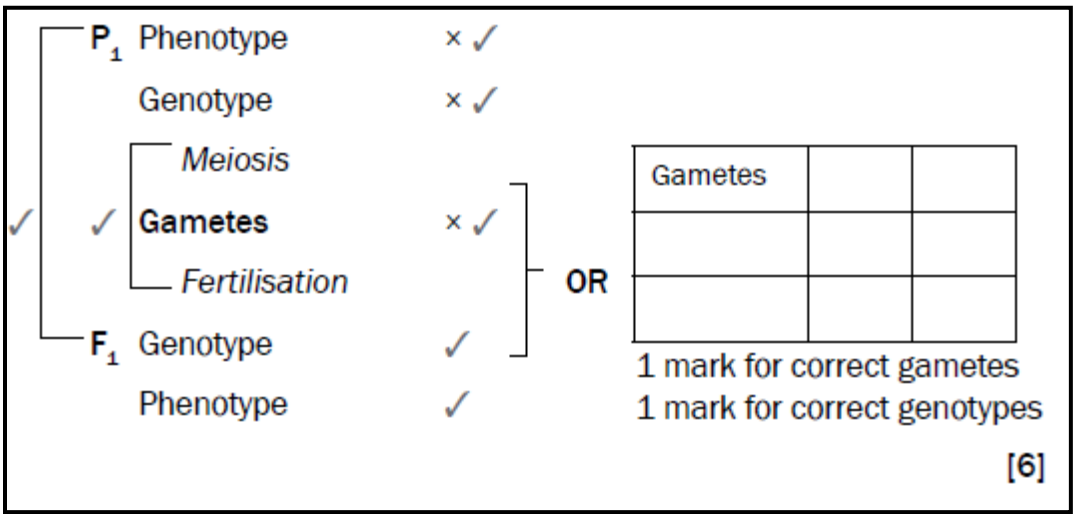
GENETICS

Genetic crosses (Monohybrid crosses)

A monohybrid cross involves the inheritance of **one characteristic.**

You need to be able to solve genetic cross problems involving **complete dominance, incomplete dominance, co-dominance, inheritance of sex, inheritance of blood groups and sex-linked characteristics.**

Use the following genetic problem format to solve genetic problems:



Example of questions on genetic crosses:

1.1 A grey (**G**) male rabbit was mated with an albino (**g**) female rabbit. The entire F_1 generation was grey. Use a genetic cross to show the phenotypic ratio of their offspring if one of the males of the F_1 generation was mated with an albino female. (7)

P_2 Phenotype: Grey male x Albino female✓
Genotype: Gg x gg✓

Meiosis

Fertilisation

Gametes	G	g
g	Gg	gg
g	Gg	gg

1 mark for correct gametes
1 mark for correct genotypes

F_2 Phenotype: 2 grey rabbits : 2 albino rabbits ✓

Phenotypic ratio of offspring is *1 : 1✓
P_2 and
F_2✓
Meiosis and fertilisation✓

(7)

***1 compulsory** + any 6

1.2 Haemophilia is a **sex-linked disease** caused by the presence of a recessive allele (X^h). A normal father and heterozygous mother have children. Represent a genetic cross to determine the possible genotypes and phenotypes of the children of the parents.

		Father		Mother
P_1/parent	phenotype	Normal	*x*	Normal✓
	genotype	X^HY	*x*	X^HX^h ✓

Meiosis

G/gametes X^H , Y *x* X^H , X^h✓

Fertilisation **OR**

F_1/offspring X^HX^H , X^HX^h , X^HY , X^hY ✓

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

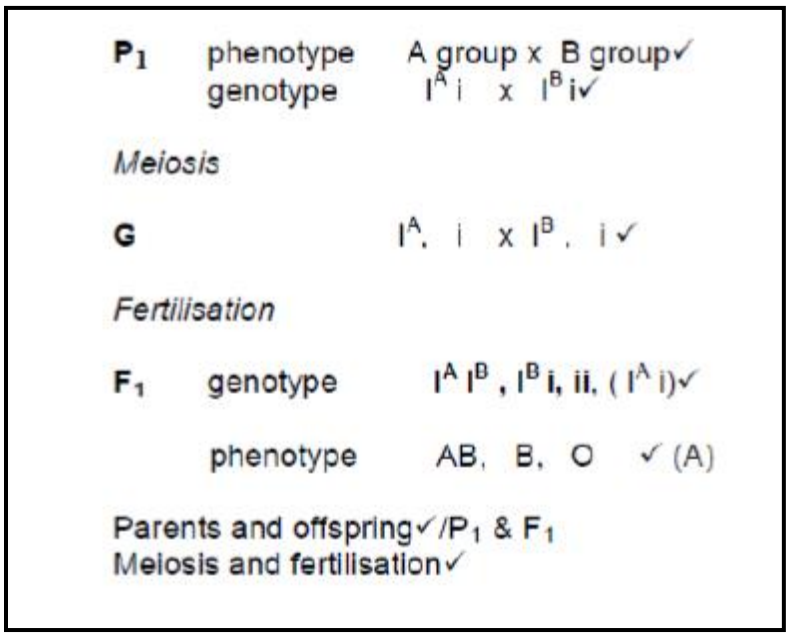
1 mark for correct gametes
1 mark for correct genotypes

2 normal daughters, 1 normal son, 1 son with haemophilia✓

P_1 and F_1/Parents and offspring✓

Meiosis and fertilisation✓

1.3 A man with **blood type** A married a woman with blood type B. They had three children with blood types O, B and AB. Show with a representation of a genetic cross the genotypes and phenotypes of the parents and children.



Dyhibrid crosses

- 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.

Example of a dihybrid crossing question

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.

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**

Question on a dyhibrid cross:

1.1 In tomato plants the allele for red fruit **(R)** is dominant over the allele for yellow fruit **(r)**. The allele for tallness **(T)** is dominant over the allele for shortness **(t)**.

Plant **A**, which is heterozygous for red fruit and homozygous tall, was crossed with Plant **B**, which has yellow fruit and is short.

1.1.1 Write down the genotype of:

(a) Plant **A**

(b) Plant **B**

1.1.2 Write down ALL the possible genotypes of the gametes of plant **A**.

1.1.3 Name the phenotype of an offspring having the genotype:

(a) Rrtt

(b) RrTt

1.1.4 Plant **B** was then crossed with another plant (Plant **C**) and all the offspring had red fruit and were tall. Use this information to write down the genotype of Plant **C**.

Possible answer:

1.1.1
(a) RrTT✓

(b) rrtt✓

1.1.2 RT✓ rT✓

1.1.3
(a) Red fruit, short✓
(b) Red fruit, tall✓

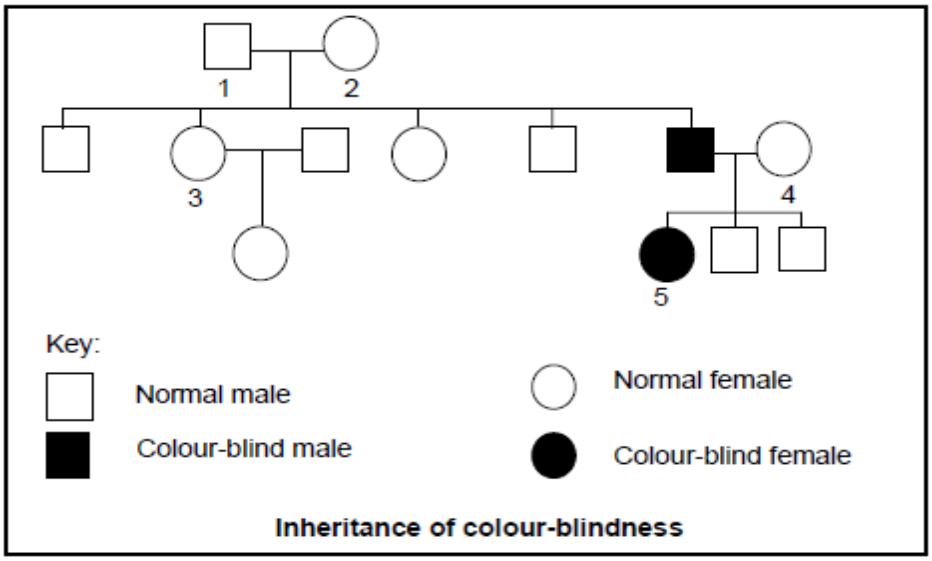
1.1.1 RRTT✓✓

Pedigree diagrams:

Remember the following steps when interpreting pedigree diagrams:

- Study any key and opening statement/s and look for dominant and recessive characteristics and phenotypes
- Write in the phenotypes of all the individuals as given in the problem
- Fill in the genotype of all the individuals with the recessive condition – it must have two recessive alleles e.g. ff
- For every individual 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
- If the parent showed the dominant characteristic, fill in the second letter which represents the dominant allele e.g. F
- Any other individual showing the dominant characteristic will most likely be homozygous dominant (FF) or heterozygous dominant (Ff)

1.2 The pedigree diagram below shows the inheritance of colour-blindness in a family. Colour-blindness is sex-linked and is caused by a recessive allele (d). The ability to see colour normally is caused by a dominant allele (D).



Inheritance of colour-blindness

1.2.1 How many of the male offspring of parents 1 and 2 were normal?

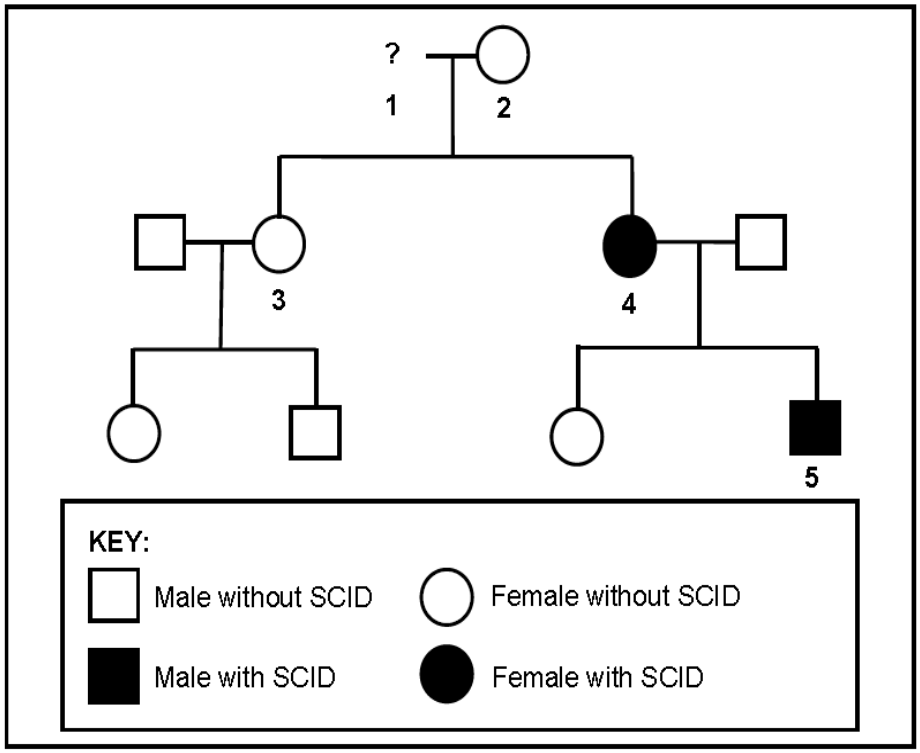
1.2.2 State the genotype of:
(a) Individual 2
(b) Individual 5

1.2.3 If individual 5 marries a normal male, what percentage of their daughters will have an allele for colour –blindness, but will not be colour-blind?

Possible answers:

1.2.1 2✓
1.2.2 (a) X^DX^d✓✓ (b) X^dX^d✓✓
1.2.3 100%✓

1.3 Severe combined immune deficiency syndrome (SCID) is a disorder affecting the immune system. It is caused by a sex-linked recessive allele ($\mathbf{X^d}$).
The diagram below shows the inheritance of the disorder in a family. It is not known if individual **1** has the disorder or not.



1.3.1 Give the:

(a) Phenotype of individual 2 (1)

(b) Phenotype of individual **1** (1)

(c) Genotype of individual **3** (2)

1.3.2 Explain how individual **5** inherited the disorder. (2)

Answers:

1.3.1 (a) Female without SCID
(b) Male with SCID
(c) X^DX^d

1.3.2 He inherited the recessive allele/X^d from the mother/individual 4

CELL DIVISION

MITOSIS AND MEIOSIS

Revision of MITOSIS which was covered in Grade 10.

There are four phases during mitosis

Prophase

(Chromatin network shortens and become visible as chromosomes. A chromosome consists of two chromatids joined by a centromere)

Metaphase

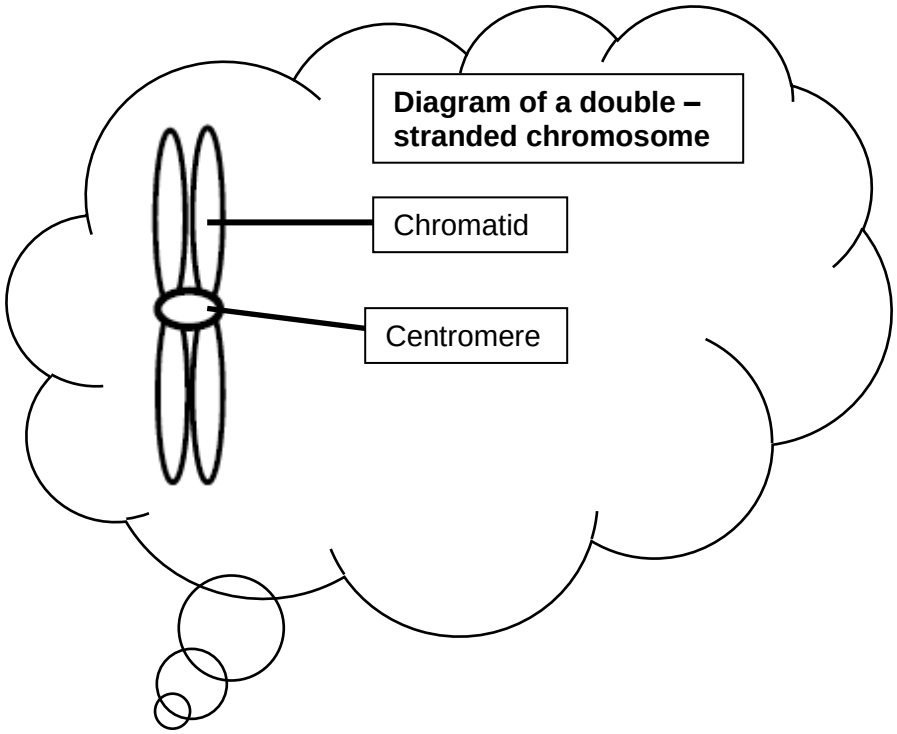
(Chromosomes arrange in a single row on the equator of the cell)

Anaphase

(Centromere divides into two and chromatids seperate and move to opposite poles)

Telophase

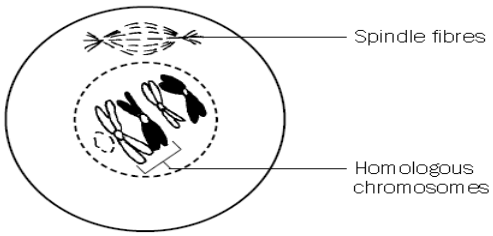
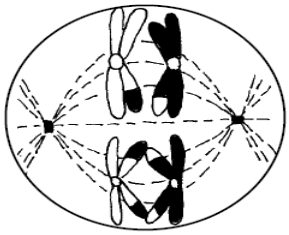
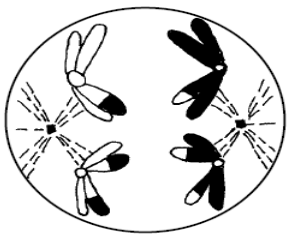
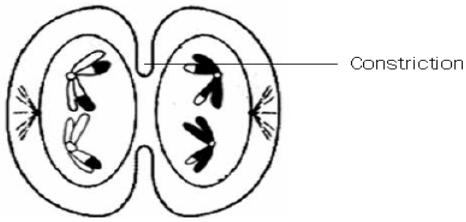
(Chromosomes arrange at poles of cell, cytokinesis occurs and two identical daughter cells have been formed)



MEIOSIS:

Meiosis is a type of cell division whereby a diploid cell (somatic cell) undergoes divisions to form haploid cells (gametes or sex cells). It is a continuous process which is divided into the first meiotic division (Meiosis I) and the second meiotic division (meiosis II)

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.

Second meiotic division:

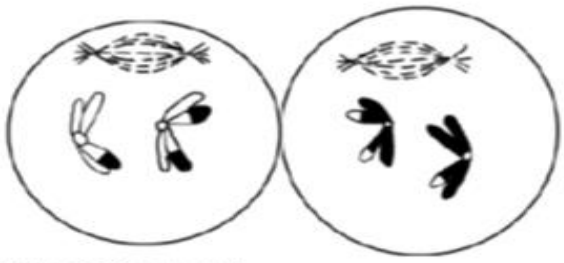


Figure 2.6 Prophase 2

Prophase 2

- Each cell formed during meiosis I now divides again.
- A spindle forms in each of the new cells.

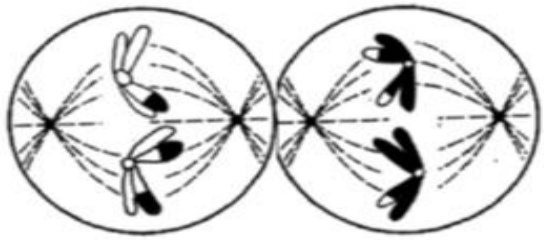


Figure 2.7 Metaphase 2

Metaphase 2

- Individual chromosomes line up at the equator of each cell, with the centromeres attached to the spindle fibres.

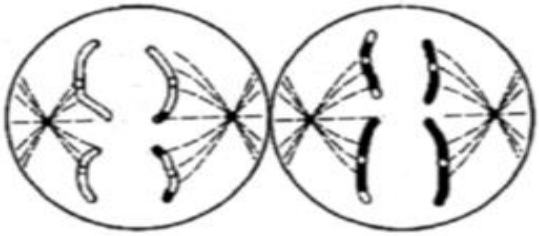


Figure 2.8 Anaphase 2

Anaphase 2

- The spindle fibres start to contract.
- The centromeres split and chromatids are pulled to the opposite poles of each cell.

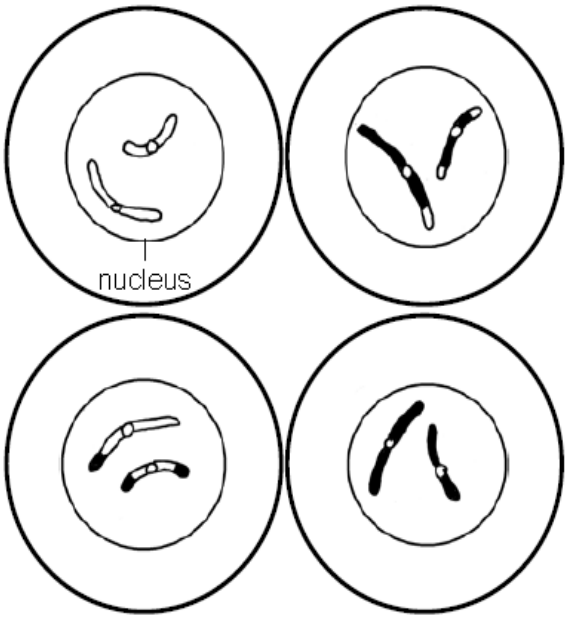


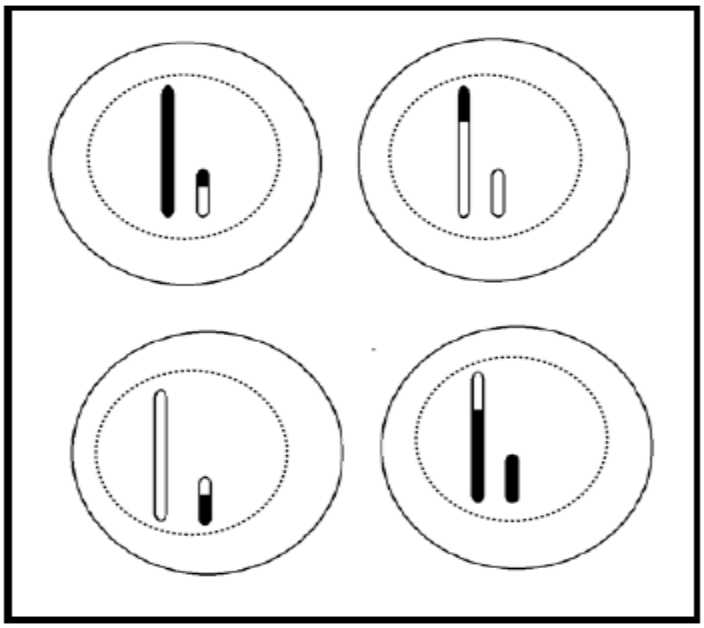
Figure 2.9 Telophase 2

Telophase 2

· The chromosomes reach the poles and a new nucleus forms.
· The cell membrane of each cell constricts and the cytoplasm divides into two cells.
· Four haploid cells are formed.
· Each cell has half the number of chromosomes of the original cell.
· The cells are genetically different from each other.

Questions:

1.1 Study the diagram of a phase during meiosis below.



1.1.1 **Identify** the phase in the diagram above. (1)

1.1.2 **Give** TWO visible reasons for your answer to QUESTION 1.1. (2)

1.1.3 How many chromosomes:
(a) are present in EACH cell in the diagram (1)
(b) were present in the original cell at the start of meiosis (1)

1.1.4 The cells in the diagram are NOT identical.
(a) **Name** TWO processes during meiosis that lead to the cells being different from one another. (2)
(b) **Explain** the significance to a species of the cells being different from one another. (3)

Answers:

1.1.1 Telophase II✓

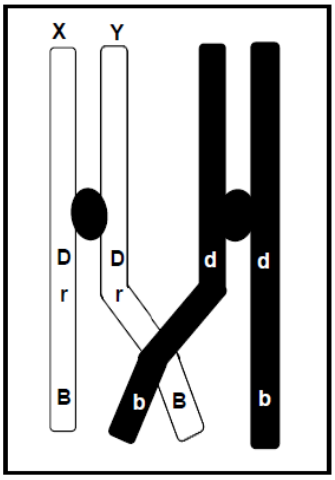
1.1.2 There are 4 cells✓
Each cell contains only a single set of un-replicated✓/single stranded chromosomes

1.1.3 (a) Two/2✓
(b) Four✓/4/2 pairs

1.1.4 (a) Crossing over✓
Random arrangement✓of chromosomes on the equator

(b) The gametes that form will be genetically different✓
leading to variation in the offspring✓/increasing the gene pool
This increases a species chances of survival✓

1.2 The diagram below shows crossing over during meiosis.



Explain:
Express your answer in a cause-effect or statement and reason sequence.

1.2.1 **Name** the phase of meiosis during which the process represented above takes place. (1)
1.2.2 **Describe** the process of *crossing over*. (3)
1.2.3 **Explain** the importance of crossing over. (2)

Answers:

1.2.1 Prophase I ✓

1.2.2 Homologous chromosomes lie next to each other✓
Chromatids overlap✓/touch at points called chiasmata✓
and genetic information is exchanged✓/swapped

1.2.3 Crossing over introduces genetic variation✓ in gametes
It may lead to new characteristics which are favourable✓
or new characteristics which are unfavourable✓
therefore, affecting the chances of survival of the organism✓/ natural selection.

ABNORMAL MEIOSIS:

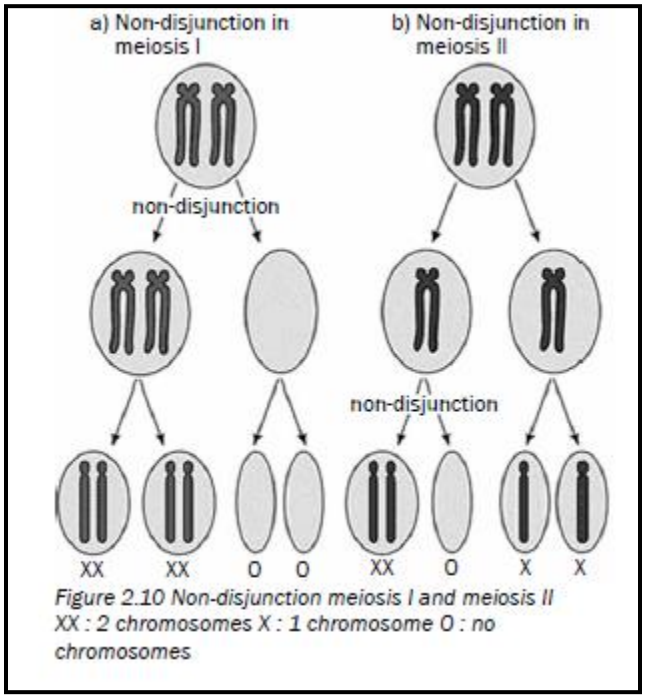
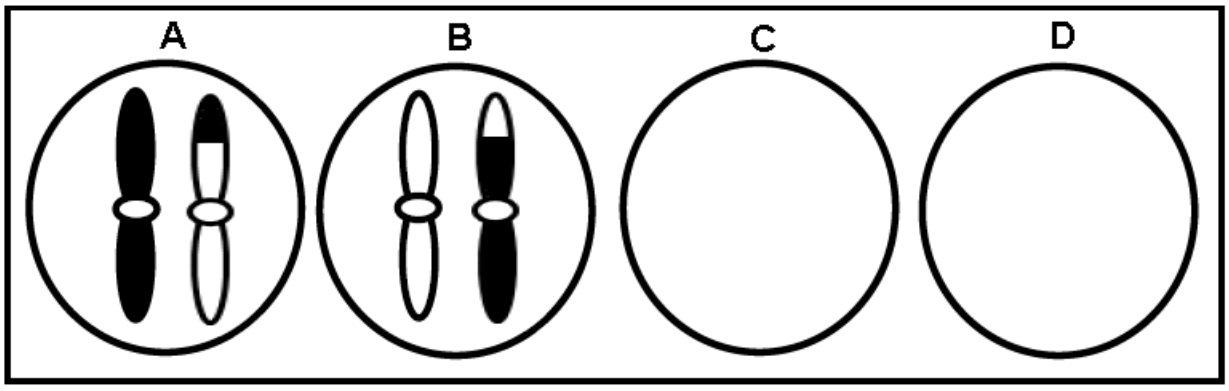


Figure 2.10 Non-disjunction meiosis I and meiosis II
XX : 2 chromosomes X : 1 chromosome O : no chromosomes

- Mistakes can occur during meiosis
- During Anaphase I one or more homologous pairs of chromosomes may not separate. Also called **non-disjunction**
- During Anaphase II chromatids of one or more chromosomes may not separate
- 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 a normal gamete fuses with a gamete with an extra copy of chromosome 21 the resulting zygote will have 3 copies of chromosome 21 (47 chromosomes instead of 46)
- This leads to Down syndrome

1.3 The diagrams below represent the distribution of chromosome pair 21 as it appears in gametes at the end of meiosis II in a human male.



1.3.1 Explain why the gametes represented by diagrams C and D do not have any chromosomes. (3)

1.3.2 If gamete A is involved in fertilisation, describe how this may result in Down syndrome. (3)

1.3.3 Due to the process of crossing over, the chromosomes in diagrams A and B appear different to each other.

(a) Identify the phase of meiosis during which crossing over occurs. (1)

(b) Describe the events during crossing over. (3)

(c) Explain the significance of crossing over in natural selection. (3)

Answers:

1.3.1 - Due to non-disjunction/ Non-separation of a chromosome pair during Anaphase I.
- Two chromosomes moved to the one pole and none moved to the other pole

1.3.2 - Gamete A will have 24 chromosomes/an extra chromosome
- and when it fertilises a normal ovum/gamete with 23 chromosomes
- the zygote will have 3 chromosomes at position 21/ 47 chromosomes

1.3.3 (a) Prophase 1

(b) - Adjacent chromatids of homologous chromosomes cross
- at a point called the chiasma
- There is an exchange of DNA segments/genetic material

(c) - Crossing over introduces genetic variation in gametes
- Genetic variation may result in favourable characteristics
- that ensure a better chance of survival when environmental conditions change.

PLANT HORMONES (ROLE OF AUXINS IN TROPISMS)

Tropisms are growth movements of a plant in response to a stimulus.

Phototropism

Phototropism is the growth movement of part of a plant in response to a unilateral light stimulus. Stems and leaves usually grow towards the light to absorb maximum light for photosynthesis.

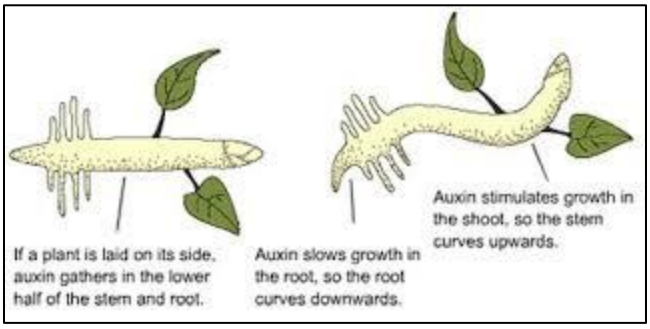
What happens when the growing tip of a stem receives unilateral light?

- Auxins move away from the light and accumulate towards the shaded side
- Auxins stimulate cell elongation on shaded side
- Shaded side grows faster
- Stem curves in the direction of the light.

Geotropism

Geotropism is the growth movement of a plant or part of the plant in the response to a gravitational stimulus.
When a pot plant is placed horizontally the roots will curve downwards and the stem will curve upwards.

Explain why the root and the stem grow of a pot plant grow in different directions when the plant is placed horizontally on the ground and receive light equally from all directions.



Source: https://biology-igcse.weebly.com/auxins.html

- Auxins will accumulate on the lower side of the stem and root because auxins are attracted by gravity.
- This leads to uneven distribution of auxins in the stem and root

In the stem:

- There will be a higher concentration of auxins on the lower side of the stem.
- Growth on the lower side of the stem is stimulated.
- The lower side of the stem grows faster.
- This causes the stem to grow/bend upwards away from gravity.

In the root:

- There will be a higher concentration of auxins on the lower side of the root.
- Growth on the lower side of the root is inhibited.
- This causes the upper side of the root to grow faster
- This will cause it to bend downwards towards gravity

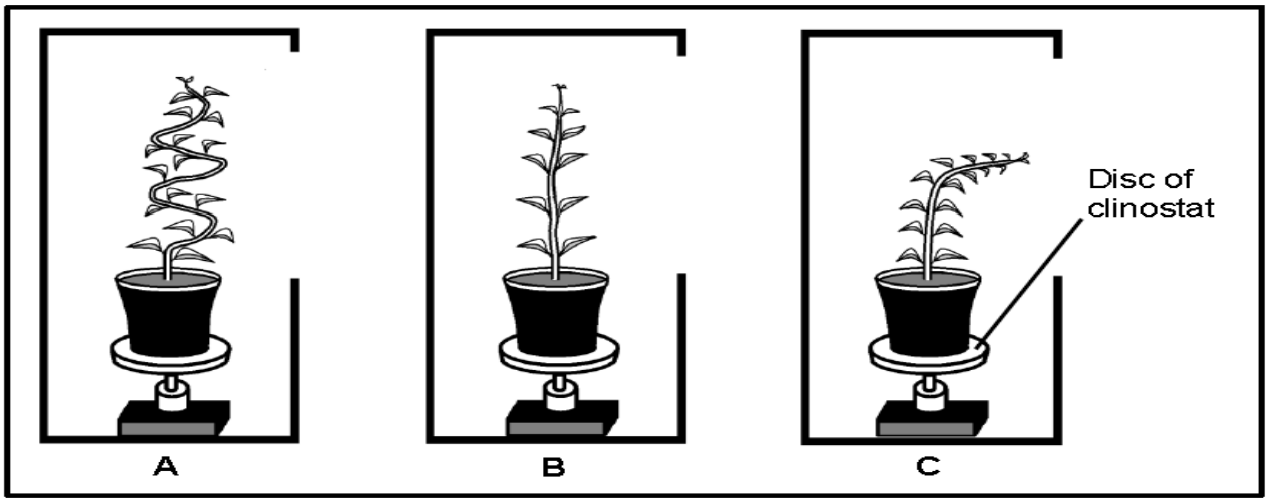
QUESTIONS:

1.1 A clinostat is a device used to investigate plant growth responses. It has a disc that rotates very slowly when the clinostat is switched on.

During an investigation on plant responses to light, the procedure below was followed:

- Three pot plants of the same species were used.
- Each pot plant was placed on one of three identical clinostats.
- Each set of apparatus, A, B and C, was placed in a box with a single opening.
- Each clinostat was treated in a different way over a period of five weeks.

The results of the investigation are represented in the diagrams below.



1.1.1 Name the plant growth response to light. (1)

1.1.2 State TWO factors that were kept constant during the investigation. (2)

1.1.3 Give ONE reason why the results of this investigation may be considered to be unreliable. (1)

1.1.4 In which apparatus (A, B or C) was the clinostat:

(a) Switched on and rotating slowly (1)

(b) Switched off, but manually rotated through 180° once a week (1)

1.1.5 Explain the effect of the unilateral light on the distribution of auxins in the plant in apparatus C. (3)

Answers:

1.1.1 Phototropism

1.1.2 - The same species of plant was used in each set-up
- Identical clinostats were used in each set-up
- The same period of time/5 weeks was used for each set-up
- Each apparatus was placed in a box with a single opening
- The opening on each box was in the same position/was the same size

1.1.3 - The investigation was only done once/not repeated
- Only one plant was used in each set-up/the sample size was too small

1.1.4 (a) B
(b) A

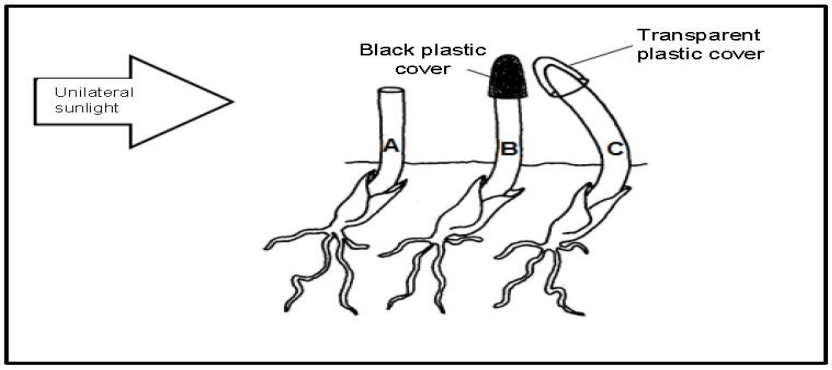
1.1.5 - The auxins moved away from the light/were destroyed by the light
- so that the darker side had a higher concentration of auxin
- and the lighted side had a lower concentration of auxins

1.2 The diagram below shows the results of an investigation carried out to determine the effect of auxins on the growth of coleoptiles (young shoots).

The procedure was as follows:

Three coleoptiles were used.
Coleoptile A had its apical bud removed.
Coleoptile B had its apical bud covered with a black plastic cover.
Coleoptile C had its apical bud covered with a transparent plastic cover.
All three coleoptiles (A, B and C) were then exposed to unilateral sunlight.

The diagram below shows the results of the investigation.



1.2.1 Explain the results obtained, as shown by coleoptile:
(a) B
(b) C

Answers:

1.2.1 (a)

- The shoot grows straight up
- The tip of the shoot does not receive any light
- The auxins remain evenly distributed in the tip
- All parts of the shoot are equally stimulated to grow

1.2.1 (b)
- The shoot bends towards the light/stimulus/shows positive phototropism
- because it is exposed to unilateral light
- The auxins in the tip move away from the lighted/to the darker side of the shoot/are destroyed on the lighted side
- The cells on the darker side are stimulated to grow/elongate
- Growth is inhibited in cells on the lighted side