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Life sciences in

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By Silaule SJ

GRADE 12

STUDY NOTES

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AMENDMENTS

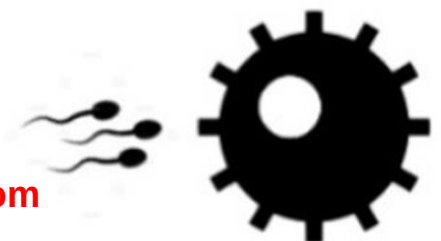


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LIFE SCIENCES IN BLACK AND WHITE

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LIFE SCIENCE IN BLACK & WHITE

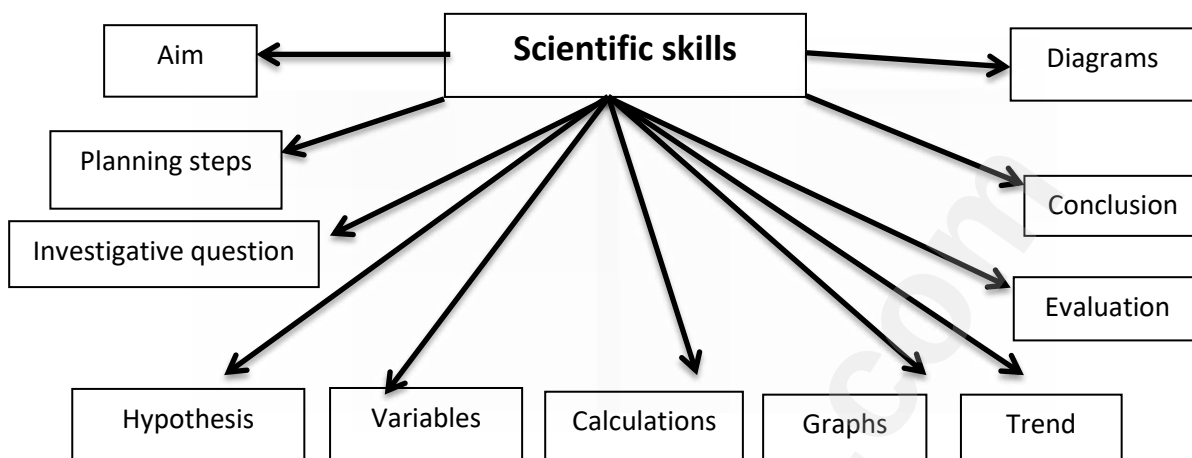
YOUTUBE:

LIFE SCIENCES IN BLACK & WHITE

FULL BOOKS WILL BE AVAILBLE IN MARCH 2021



1. SCIENTIFIC SKILLS



LESSON OBJECTIVES

- ✓ Determine the aim of an investigation
- ✓ Describe planning steps of a typical investigation
- ✓ Determine the investigative question
- ✓ Determine the hypothesis of an investigation
- ✓ Determine the variables of an investigations
- ✓ Calculate the difference, average, percentage, percentage increase and decrease from data provided
- ✓ Plot and analyse graphs such as line graph, bar graph, histogram and pie chat
- ✓ Describe the trend of data represented as a table and graph
- ✓ Describe how the reliability and validity of investigation can be ensured/was ensured
- ✓ Provide conclusion for an investigation
- ✓ Calculate the actual length of a biological diagram

The aim

- The aim of an investigation is a statement that describes what will be done in the investigation or identifies the purpose of the investigation.
- The aim usually includes the following keywords:
 - To investigate
 - To determine
 - To show that



Example: Antibiotics are substances that are used to kill bacterial cells. An investigation was conducted to determine the effect of antibiotic A on the growth of bacterial strain V. Bacterial strain V was placed in a petri dish with agar gel that contains all nutrients needed for bacterial growth. At the centre of the agar gel a cork borer was used to create a hole where the antibiotic was poured. The bacteria were grown at 37.5°C and the bacterial colony was counted by the same individual every 30 minutes.

- **To determine the effect of antibiotic A on the growth of bacterial strain V.**

Planning steps for an investigation

- A series of steps that outline how the investigation will be carried out.
- General steps include:
 - Determine the sample size
 - Find volunteers
 - Find a comparable group to act as control
 - Decide on the equipment for measuring
 - Decide on the duration
 - Obtain consent/permission
 - Design a way of recording the data
- Note the above steps are a guideline and during the exam should be adapted for the question that is posed.

Investigative question

- Scientists observe a phenomenon (observable event) and from that come up with a question. This question based on their observation is referred to as an investigative question

Example: Antibiotics are substances that are used to kill bacterial cells. An investigation was conducted to determine the effect of antibiotic A on the growth of bacterial strain V. Bacterial strain V was placed in a petri dish with agar gel that contains all nutrients needed for bacterial growth. At the centre of the agar gel a cork borer was used to create a hole where the antibiotic was poured. The bacteria were grown at 37.5°C and the bacterial colony was counted by the same individual every 30 minutes.

- **Does antibiotic A have an effect on the growth of bacterial strain V?**



Hypothesis

- Can be described in a number of ways which include; an attempt to explain a phenomenon or a prediction/educated guess of what will happen in the investigation.
- In other words you predict the effect X will have on y.

Criteria for a hypothesis

- Must express variables (the cause and effect)
- State the relationship between the two variables
- It must be testable
- Never expressed as a question but rather a prediction

We can use the aim to write the hypothesis

- **The aim** - To determine the effect of antibiotic A on the growth of bacterial strain V.
- **The hypothesis:**
 - **Antibiotic A has an effect on the growth of bacterial strain V**
 - **Antibiotic A has no effect on the growth of bacterial strain V**

Variables

- In an investigation various factors are tested to determine which one has an effect on the results.
- These factors are known as variables.
- An investigation usually has an experiment and a control.

There are three types of variables:

- **Independent variable** – this is the variable that is manipulated during an investigation. This variable has an effect on the dependent variable. It is plotted on the X-axis.
- **Dependent variable** – this is the variable that is measured during the investigation. Is the effect of the independent variable and is plotted on the Y- axis.
- **Control** – the variable that is kept constant throughout the investigation. Also described as the experiment without the variable that is being tested.



Example: Antibiotics are substances that are used to kill bacterial cells. An investigation was conducted to determine the effect of antibiotic A on the growth of bacterial strain V. Bacterial strain V was placed in a petri dish with agar gel that contains all nutrients needed for bacterial growth. At the centre of the agar gel a cork borer was used to create a hole where the antibiotic was poured. The bacteria were grown at 37.5°C and the bacterial colony was counted by the same individual every 30 minutes.

We can use the aim to determine the dependent and independent variable.

- **The aim** - To determine the effect of antibiotic A on the growth of bacterial strain V.
- If **X has an effect on Y**, this means Y is dependent on X which makes Y the dependent variable and X the independent variable
- This means Antibiotic A is the **independent variable** (if there was more than one antibiotic, the independent variable would be type of antibiotic)
- and the growth of bacterial strain is the **dependent variable**

How to set up a control

- In order to set up a control the key step is to set up the same experiment without the variable that is being tested (independent variable)
- In this example: **the control will be set up by placing the bacterial strain V in agar gel with a hole made using a cork borer but water is poured in the hole instead of antibiotic A and allowed to grow at 37.5°C with the colony being counted every 30 minutes by the same individual.**

Reason to have a control

- To ensure that the results obtained are only due to the effect of the independent variable and not any other factor
- Used to compare the results
- Increase the validity of the investigation



Calculations

- The number of TB cases reported at a hospital between the years 1998 to 2002.

Year	TB cases reported
1998	75
1999	82
2000	95
2001	101
2002	121

Difference:

Calculate the difference in TB cases from the year 2000 to 2001

$$\begin{aligned}\text{Diff} &= 101 - 95 \\ &= 6 \text{ TB cases reported}\end{aligned}$$

Average:

Calculate the average TB cases reported between 1998 to 2002.

$$\begin{aligned}&= \frac{75 + 82 + 95 + 101 + 121}{5} \\ &= 94.8\end{aligned}$$

Percentage:

Calculate the percentage of TB cases in 2001.

- Find total = $75 + 82 + 95 + 101 + 121 = 474$
- Cases in 2001 = 101

$$\begin{aligned}P &= \frac{101}{474} \times 100 \\ &= 21.3\%\end{aligned}$$

Percentage increase:

Calculate the percentage increase in the number of TB cases between 1999 and 2000

- Increased from 82 to 95
- Started increasing from 82

$$\begin{aligned}P.I &= \frac{\text{difference}}{\text{starting value}} \times 100 \\ &= \frac{95 - 82}{82} \times 100 \\ &= 15.9\%\end{aligned}$$

Percentage decrease:

Calculate the percentage decrease in the number of TB cases between 2001 and 2002

- Decreased from 121 to 101
- Started decreasing from 121

$$\begin{aligned}P.D &= \frac{\text{difference}}{\text{starting value}} \times 100 \\ &= \frac{121 - 101}{121} \times 100 \\ &= 16.5\%\end{aligned}$$



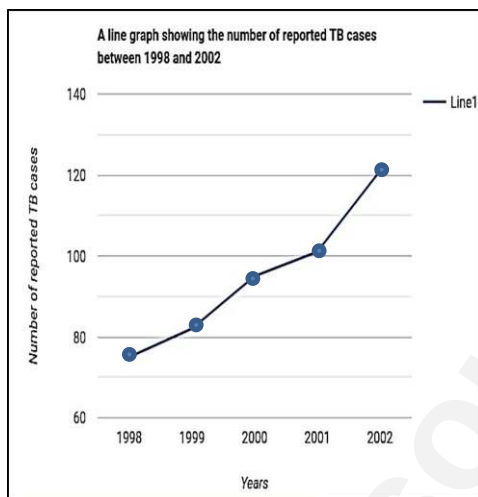
Graphs

- In life sciences data can be represented as a table, line graph, bar graph, histogram and pie chart.
- In the exam **it will be stated which type of data representation to be used** and thus will be penalised if the wrong type is used.
- Each type of data representation has a set of criteria as a marking guideline.

Example: The number of TB cases reported at a hospital between the years 1998 to 2002.

TB reported cases	75	82	95	101	121
Year	1998	1999	2000	2001	2002

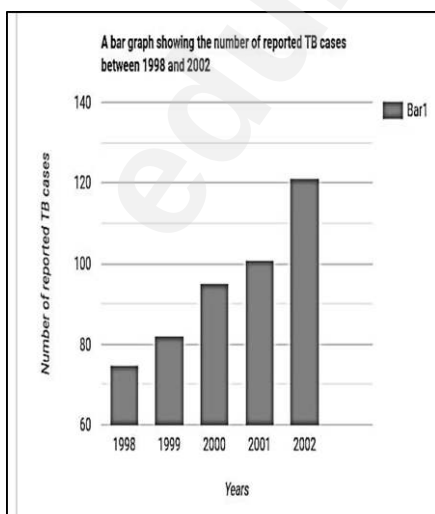
Line graph



Marking guideline

Caption (c) Both variables included	1 mark
Type of graph (T)	1 mark
X-axis label, unit and scale (X)	1 mark
Y-axis label and scale (Y)	1 mark
Plotting of points (P)	0 mark – No points plotted correctly
	1 mark – 1 to 5 points plotted correctly
	2 marks – all points plotted correctly

Bar graph



Marking guideline

Caption (c) Both variables included	1 mark
Type of graph (T)	1 mark
X-axis label, unit and scale (X)	1 mark
Y-axis label and scale (Y)	1 mark
Plotting of points (P)	0 mark – No points plotted correctly
	1 mark – 1 to 5 points plotted correctly
	2 marks – all points plotted correctly

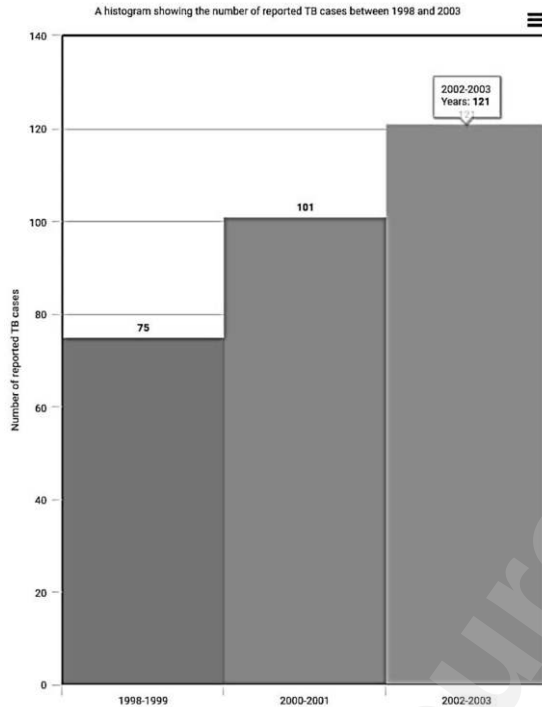
-If a line graph is drawn – marks will be lost for the 'type of graph' and for 'plotting' only.

-If a histogram is drawn – marks will be lost for the 'type of graph' and 'correct scale' only



Histogram

TB reported cases	75	101	121
Years	1998-1999	2000-2001	2002-2003



Marking guideline

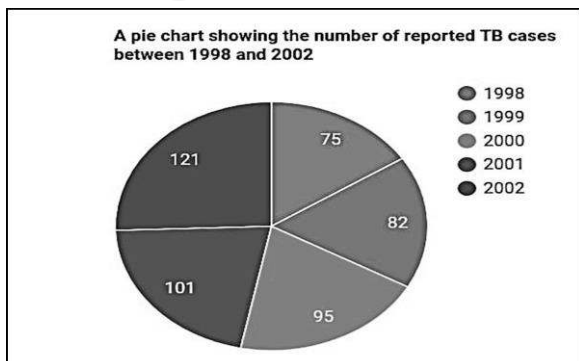
Caption (c) Both variables included	1 mark
Type of graph (T)	1 mark
X-axis label, unit and scale (X)	1 mark
Y-axis label and scale (Y)	1 mark
Plotting of points (P)	0 mark – No points plotted correctly 1 mark – 1 to 5 points plotted correctly 2 marks – all points plotted correctly

Note: If the wrong graph is drawn, marks will be lost for “correct type of graph”. If axes are transposed, marks will be lost for labelling of X-axis and Y-axis.

Pie chart

TB reported cases	75	82	95	101	121
Years	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003

- $75/474 \times 360^\circ = 57.0^\circ$
- $82/474 \times 360^\circ = 62.3^\circ$
- $95/474 \times 360^\circ = 72.2^\circ$
- $101/474 \times 360^\circ = 76.7^\circ$
- $121/474 \times 360^\circ = 91.8^\circ$



Marking guideline

Criteria	Mark allocation
Correct type of graph	1 mark
Title of graph	1 mark
Calculations to determine the correct proportions	1: 1 to 3 calculations correct 2: All four calculations correct
Proportions accurate for each sector/key	1: 1 to 2 sectors plotted correctly 2: All 4 sectors plotted correctly

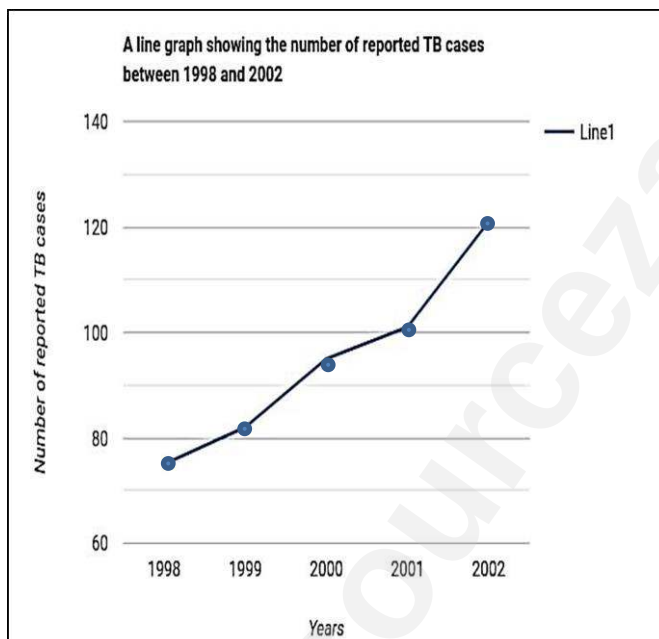
Note:

If the wrong type of graph is drawn, marks will be lost for ‘correct type of graph’ as well as for ‘plotting of sectors in correct proportions’.



Trends

- A statement (not an explanation) where the progression of the results is stated usually in relation to time.
- Can also be described as the major changes that occur on the dependent variable in relation to the independent variable.
- They key changes are stated and sometimes the values that represent a major change can be included in the description of the trend of the data.
- **Example:**



- The number of reported cases started from low number in 1998 then increased to 2001 and then increased at constant rate between 2001 and 2002 to reach a maximum in 2002

Evaluation of results

- Evaluating the results of investigation involves determining the reliability and validity of the results obtained
- This can help in providing improvements on the way in which the investigation can be carried out.

Validity

- Validity is about how fair the test was and fairness can be reached by keeping all variables constant except the one that is being tested
- **Example:**
 - Same species
 - Same age
 - Equal number for samples between parts of the experiment



- Measurements must be done at the same time, by the same person and using the same apparatus
- Choose sample randomly
- Maintain same environmental conditions

Reliability

- Reliability is about if the results can be trusted such that if repeated similar results can be obtained.
- **Example:**
 - **Repeat the experiment**
 - **Increase the sample size**
 - Add a control
 - Obtain an average

Conclusion

- A conclusion aims to link the results to the aim and hypothesis by explaining what the results tell us about what was being investigated. The conclusion should indicate whether the results agree with the hypothesis or not and explain why the results agree or disagree with the hypothesis.

Example: Antibiotics are substances that are used to kill bacterial cells. An investigation was conducted to determine the effect of antibiotic A on the growth of bacterial strain V. Bacterial strain V was placed in a petri dish with agar gel that contains all nutrients needed for bacterial growth. At the centre of the agar gel a cork borer was used to create a hole where the antibiotic was poured. The bacteria were grown at 37.5°C and the bacterial colony was counted by the same individual every 30 minutes.

- **Hypothesis:** Antibiotic A has an effect on the growth of bacterial strain V
- **Aim:** To determine the effect of antibiotic A on the growth of bacterial strain V.
- **Results:**

Minutes	30	60	90	120
Number of bacteria	185	168	137	63

-
- **Conclusion:** The hypothesis is accepted, as the results prove that antibiotic A has an effect on the growth of bacterial strain V because the number of bacteria in the colony decreased from 185 at 30 minutes to 63 at 120 minutes. This means antibiotic has properties that make it effective in killing the bacterial strain V.



Evaluation of results

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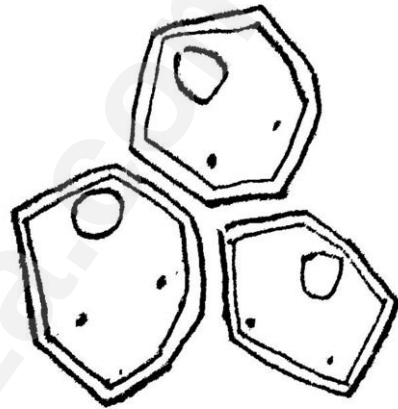
Diagrams

Wrong type of drawing

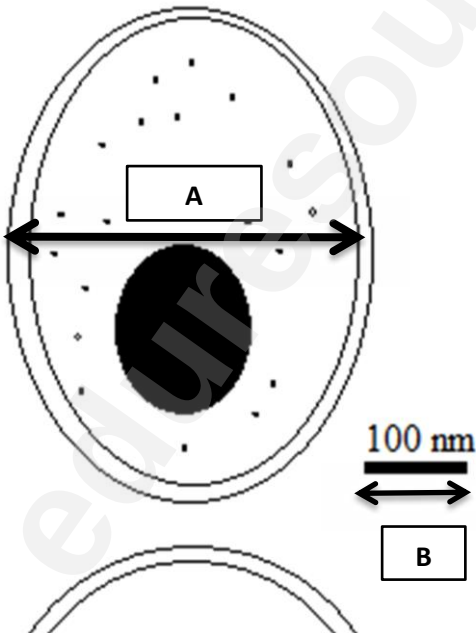


- No shading
- Must have caption
- Indicate scale of drawing
- Labels lines should be parallel

Correct type of drawing



(no sketching)



Calculating actual size:

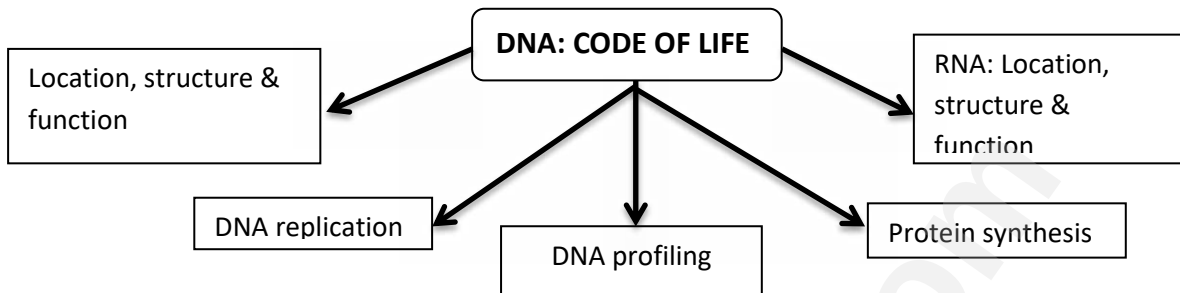
$$= \frac{\text{measured size} \times \text{true length of scale line}}{\text{measured length of the scale}}$$

$$\frac{A \text{ mm} \times 100 \text{ nm}}{B \text{ mm}}$$

Note: the measured size (A) and the measured length of the scale (B) must be measured using a ruler on the diagram in millimetres



2. DNA: THE CODE OF LIFE

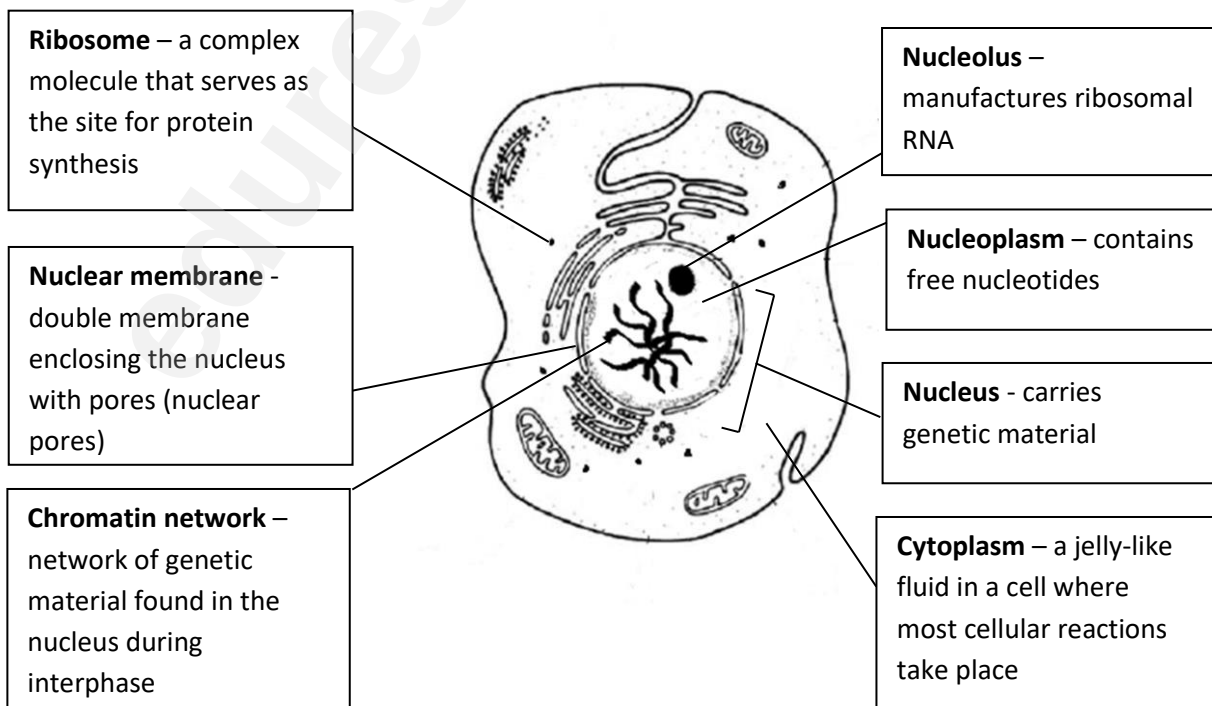


Introduction

LESSON OBJECTIVES

- ✓ Label parts of a basic cell
- ✓ Describe the functions of parts of a cell
- ✓ Describe the function of a nucleus
- ✓ Name the two types of nucleic acids
- ✓ Identify & describe parts of a nucleotide

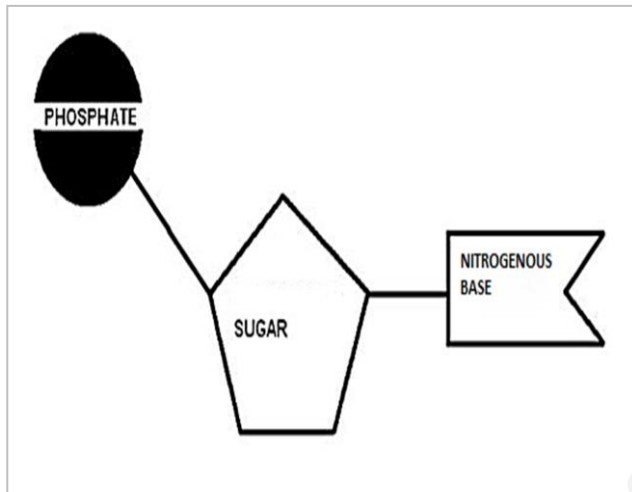
The structure of the cell





Nucleic acids

- Nucleic acids are organic molecules that are made up of nucleotides and control the synthesis of proteins
- There two types of nucleic acids;
 - DNA (Deoxyribonucleic acid)
 - RNA (Ribonucleic acid)



- **Nucleotides** – are building blocks/monomers of nucleic acids
- A nucleotide is made up of a phosphate ion, sugar molecule and nitrogenous base
- **Sugar molecule** – can be deoxyribose (for DNA) and ribose (for RNA)
- **Nitrogenous bases:**
 - Adenine (A), Guanine (G), cytosine (C), thymine and uracil (U)

Deoxyribonucleic acid (DNA)

LESSON OBJECTIVES

- ✓ Naming the scientists that discovered the double helix model of DNA and the x-ray photograph
- ✓ Name the different locations where DNA can be found in a cell
- ✓ Identify and describe the structure of DNA
- ✓ Name, describe and label the components of a DNA nucleotide
- ✓ Describe the function of DNA

Brief history

- Theoretical model (double helix) was put forward by **Watson and Crick**
- Watson and crick discovered DNA nitrogenous bases and that it is double helix
- **Franklin and Wilkins** provided the X-ray photograph of DNA



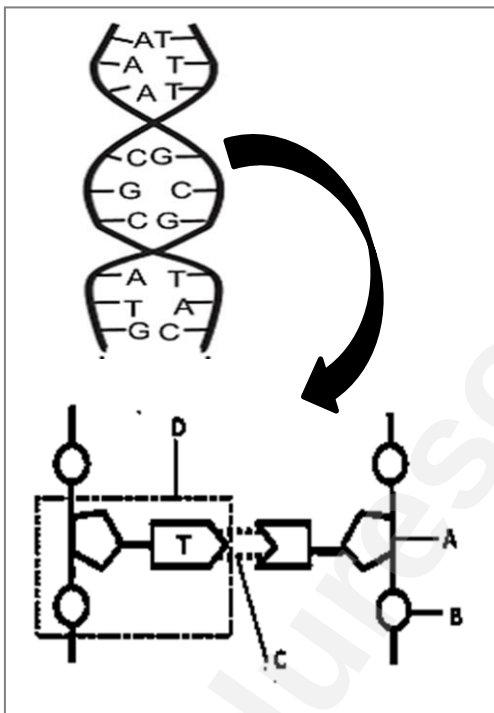
Location of DNA

- DNA that is found in the nucleus is called Nuclear DNA
- DNA that is found outside the nucleus is called Extra-nuclear DNA
- Extra nuclear DNA :
 - Chloroplastic DNA (found in chloroplast)
 - Mitochondrial DNA/mtDNA (found in mitochondria)

Functions of DNA

- Carrying hereditary characteristics from parents to their offspring
- Controls the synthesis (manufacturing) of proteins
- Acts as template for formation of mRNA

The structure of DNA



- The natural shape of DNA is a double helix
- The sugar molecule in DNA is deoxyribose (**A**)
- The backbone of DNA structure is made up of a Sugar and Phosphate (**B**)
- In DNA the nitrogenous bases are paired
- The pair of nitrogenous bases in a DNA molecule are held together by Weak hydrogen bond (**C**)
- Therefore a DNA nucleotide (**D**) is made up of a deoxyribose sugar, phosphate and a nitrogenous base

DNA replication

LESSON OBJECTIVES

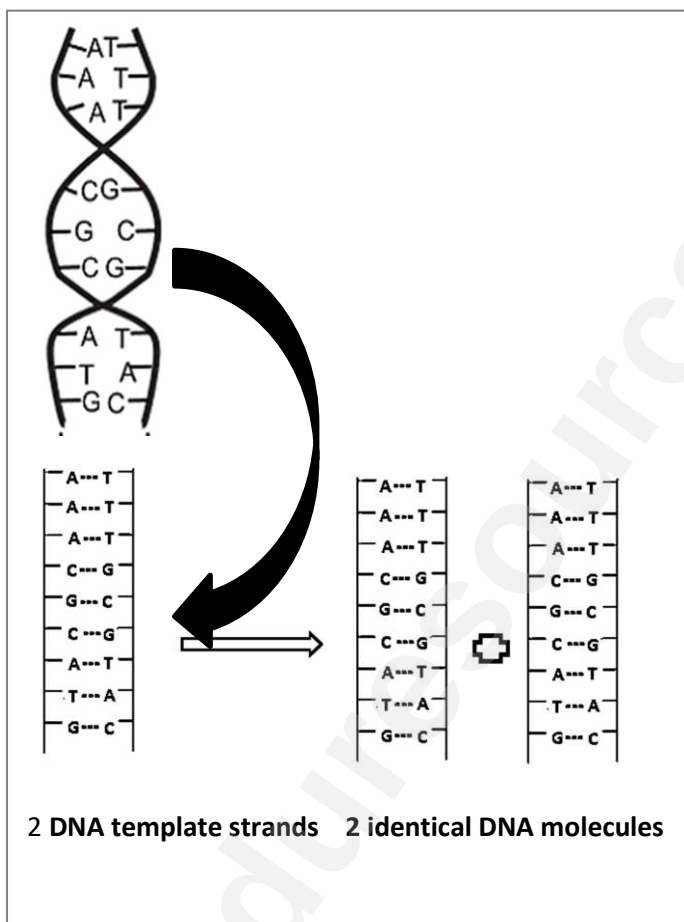
- ✓ Name the phase in which DNA replication takes place in the cell cycle
- ✓ Where in the cell does DNA replication take place
- ✓ Describe how DNA replication takes place
- ✓ Explain the significance of DNA replication



The process of making an identical copy of DNA (chromosome)

- This increases the number of chromosomes so that they can be shared between the cells resulting from cell division
- Occurs within the nucleus
- Occurs before mitosis and meiosis, during **interphase**
- **Interphase** is the period between consecutive cell divisions
- The process is controlled by enzymes

DNA replication – the process



- DNA molecule **unwinds**
- Weak hydrogen bonds **break**/the DNA strands **unzip**
- **Each** strand serves as a **template**
- **Free DNA nucleotides** from the **nucleoplasm** attach to the template strands
- they arrange according to the base sequence of the DNA templates, in a **complementary way**, A – T and C – G,
- Sugar-phosphate bonds form between nucleotides to form **two identical DNA molecules**
- This process is controlled by **enzymes**

Significance/importance of DNA replication

- Doubles genetic information so it can be shared between the resulting daughter cells during cell division
- Ensures that each daughter cell has identical DNA composition to the mother cell
- Ensures that each daughter cell contains the same number chromosomes as the mother cell



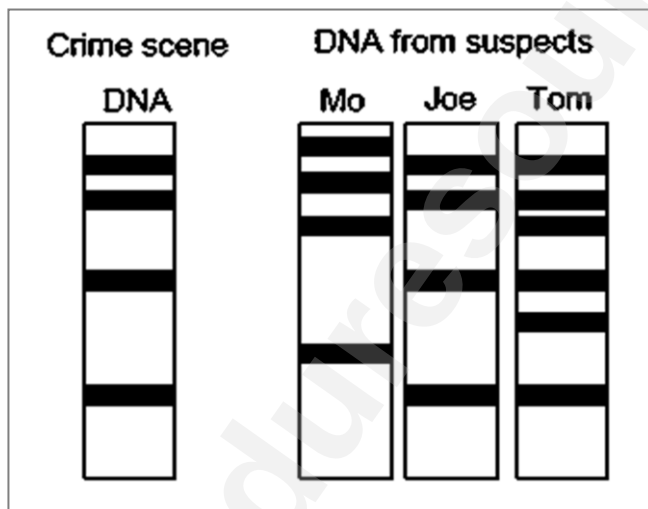
DNA profiling

LESSON OBJECTIVES

- ✓ Define the term DNA profile
- ✓ Analyse DNA profiles for criminal investigations and paternity
- ✓ Describe uses of DNA profiles and name the sources DNA
- ✓ Describe the limitations of DNA profiling

- **DNA profile** is the unique pattern formed by the DNA fragments of an individual.
- DNA profile is sometimes referred to as DNA fingerprint but is not the same as fingerprints which appear on a person's hands.
- The DNA profile of people are not the same except for identical twins
- DNA profile can be made using DNA from:
 - Body tissue
 - Hair
 - Body fluids such as blood, semen or saliva

Example: DNA profiling used to solve a crime



- On the left are DNA profiles for a criminal case
- The crime scene DNA profile is compared to all the DNA profiles of the three suspects
- By comparing each DNA band to the DNA bands from crime scene profile it can be concluded that Joe committed the crime
- This is because all of Joe's DNA bands are similar/match those in the crime scene DNA profile

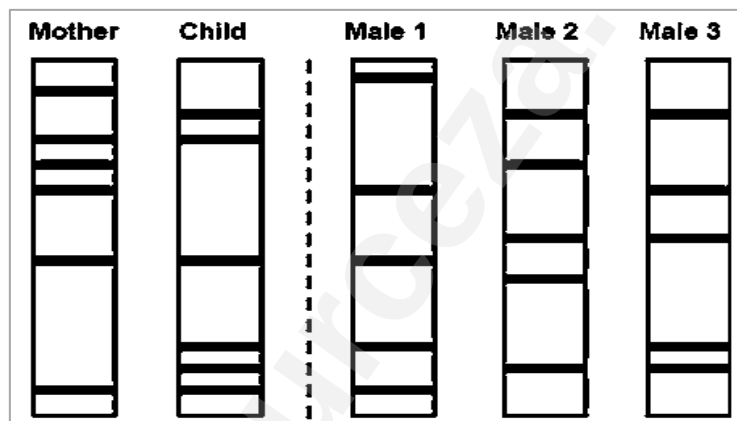
Use of DNA profiling to solve paternity cases

- Since DNA is unique for an individual with the exception of identical twins for whom their DNA is identical.
- DNA samples are collected from the child, mother and possible father(s).
- Given that also a child inherits half of his/her genetic material from each of his/her parents
- The DNA profile of the child will be compared to both parents



- If we are trying to prove paternity then the child's DNA profile will be compared with that of the possible father(s).
 - If most of the DNA bands of the possible father match that of the child then that male is definitely the father because the child inherited that genetic material from him.
- In proving paternity for a male child the Y chromosome can be used since the Y chromosome is passed down to male offspring from the father with very little variation. The use of the Y chromosome for paternity is used in cases where mutations are a factor that can influence the results and cause disputes.

Example: DNA profiling used for paternity



- Above are DNA profiles from a paternity case
- To determine paternity both parent's DNA profiles are compared to that of the child.
- First eliminate the DNA bands that belong to the mother from the child's DNA profile as it is already known she is the mother
- Then the remaining bands must be compared to the suspected/possible fathers
- In this case **male 3** is the father since **3 DNA bands** from his DNA profile match with those found on the child's DNA profile

<u>Uses of DNA profiling</u>	<u>Why DNA profiling may NOT be reliable</u>
• To investigate crimes • Paternity tests • Determine identity of dead persons • Determine genetic disorders • Determine the probability or cause of genetic disorders • To establish matching tissues for organ transplant	• Small segment of DNA is analysed • Human error during DNA profiling process • Suspect was framed by leaving DNA evidence at the scene/swopping specimens at the lab • The DNA evidence of the accused was at the scene before the crime was committed • Suspect had an identical twin who has the same DNA profile



Ribonucleic acid (RNA)

LESSON OBJECTIVES

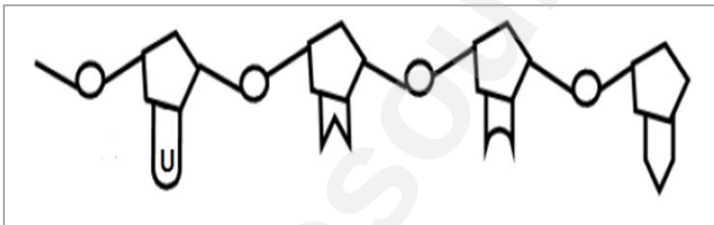
- ✓ Name the different types of RNA and give their locations as well as their functions
- ✓ Describe the structure of RNA

Types of RNA

- **Ribosomal RNA (rRNA)** – forms part of the structure of the ribosome
- **Messenger RNA (mRNA)**– acts a messenger by carrying the genetic code from DNA in the nucleus to the ribosome in the cytoplasm to be used to synthesize proteins
- **Transfer RNA (tRNA)** – picks up amino acids in the cytoplasm and carries them to the ribosome during protein synthesis

Location of RNA

- Can be found the nucleus as mRNA
- mRNA is manufactured in the nucleus
- rRNA & tRNA are located in the cytoplasm



The structure

- It is single stranded
- Shorter strand
- Made up of nucleotides
- The sugar is Ribose
- Thymine is replaced by Uracil

Structure of mRNA and tRNA

mRNA *this strand of mRNA is made of 4 codons	tRNA *this tRNA has a single anticodon and is carrying a single amino acid
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Protein synthesis

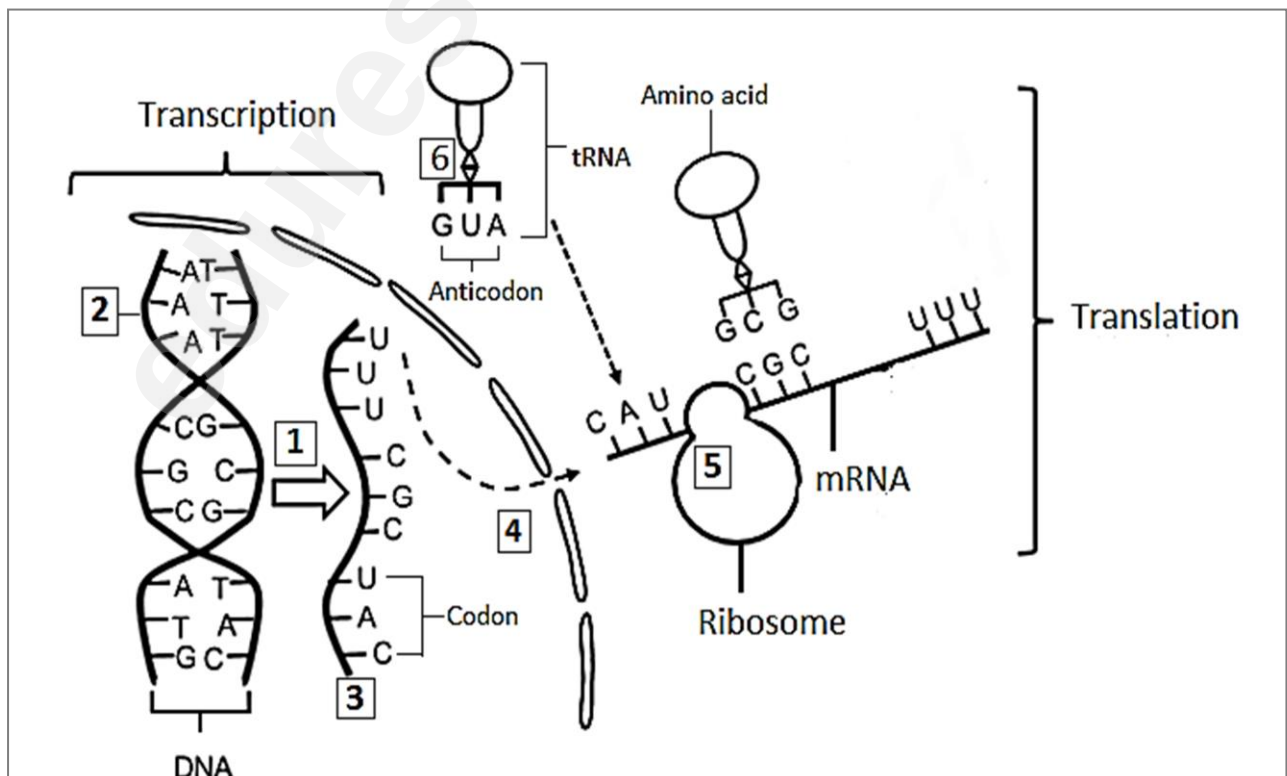
LESSON OBJECTIVES

- ✓ Describe the role of DNA and RNA during protein synthesis
- ✓ Transcribe DNA code/base triplets to mRNA codons and reverse transcribe mRNA codons to DNA base triplets
- ✓ Translate mRNA codons to tRNA anticodons
- ✓ Use DNA base triplets/codons/anticodons to arrange given amino acids
- ✓ Describe the effect of mutation on the structure of a protein
- ✓ Describe the similarities of DNA and RNA
- ✓ Describe the differences between DNA and RNA

Stages of protein synthesis

- Protein synthesis involves:
 - **Transcription** of DNA
 - **Translation** of RNA to proteins

Protein synthesis – the process





TRANSCRIPTION (in the nucleus)

(1) DNA double helix **unwinds**, weak hydrogen bonds **break** (unzip) forming **two separate** strands, (2) One strand acts as a **template** to build the **complementary strand** (mRNA), Using free **RNA nucleotides** from the **nucleoplasm**, they arrange according to the base sequence of the **DNA template**, in a complementary way, **A – U** and **C – G**, Sugar-phosphate bonds form between nucleotides to form required **mRNA (3)**, Process controlled by **enzymes**

MOVEMENT OF mRNA OUT OF THE NUCLEUS

(4)-The mRNA leaves the nucleus through the **nuclear pores** into the cytoplasm where it attaches to the **ribosome**

TRANSLATION (in the cytoplasm on the ribosome)

(5)- The mRNA strand from the nucleus becomes attached to a **ribosome** with its codons exposed, (6)-each **tRNA** molecule carrying a specific **amino acid** according to its **anticodon**, matches up with the **codon** of the mRNA, so that the amino acids are placed in the correct sequence, adjacent amino acids are linked by **peptide bonds** to form a **protein**.

Effect of mutation on the structure of a protein

- A **mutation** is sudden change in the sequence of nitrogenous bases/ nucleotides on a gene. Nitrogenous bases can be deleted/replaced/added.
- If the sequence of nitrogenous bases on DNA changes, the codons on the mRNA will be different and will code for a different amino acid.
- A different amino acid will be brought in by a tRNA. This will lead to a change in the sequence of amino acids in the polypeptide chain resulting in the formation of a different protein.
- **But there are exceptions** , some amino acids are **coded for by more than one codon** and therefore a mutation can occur changing the codon but still result in the same amino acid therefore it means this kind of mutation will not have an effect on the structure and function of a protein.



Similarities for DNA and RNA

- Both contain sugar alternating with phosphate
- Both contain nitrogenous bases: Adenine, Guanine and Cytosine
- Both play a role in protein synthesis

Differences between DNA and RNA

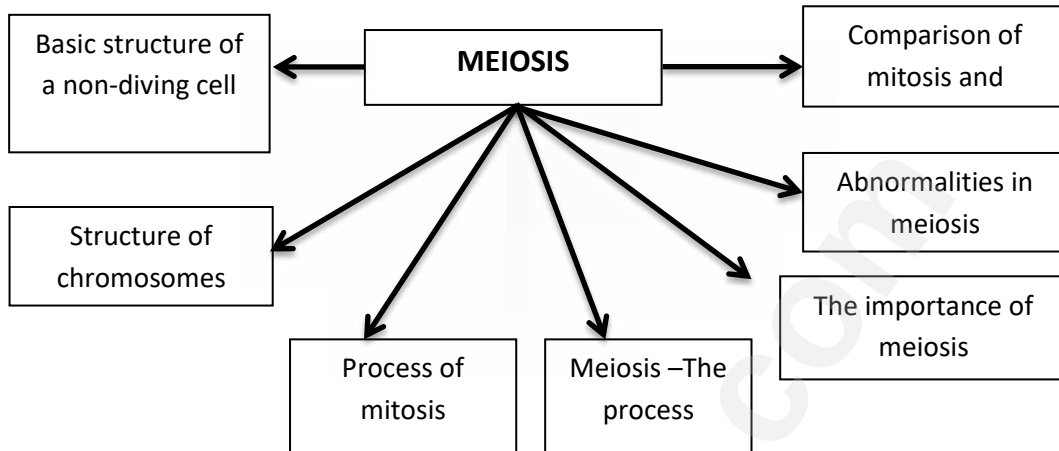
DNA	RNA	
Double stranded molecule/paired bases	Single stranded molecule/unpaired bases	↓ Structural differences
Longer	Shorter	
Contains deoxyribose sugar	Contains ribose sugar	↑
Helix shape	No Helix	↓
Contains the nitrogenous base thymine	Contains the nitrogenous base uracil	↑ Differences in the monomers/nucleotides

Key terms

- **Base triplet** – three consecutive nitrogenous bases on the DNA strand
- **Codon** – three consecutive nitrogenous bases on the mRNA strand
- **Anticodons** – three exposed nitrogenous bases on a single tRNA
- **Amino acids** – monomers or building blocks of proteins
- **Peptide bond** – a bond that holds amino acids together
- **Polypeptide chain** – three or more bonded amino acids
- **Gene** – consists of a group of triplet bases that code for the synthesis of a protein
- **Template strand** – strand of DNA upon which another strand of DNA is built /mRNA is transcribed



3. MEIOSIS



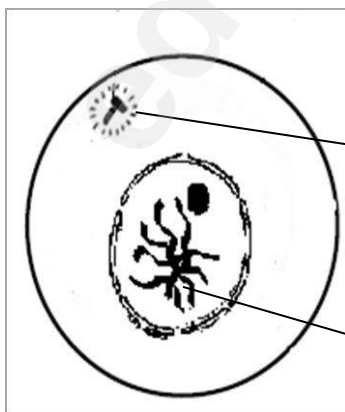
Meiosis – An introduction

LESSON OBJECTIVES

- ✓ Label and describe the components of a non-dividing cell
- ✓ Define terms chromosome, genes, chromatids, centromere, cytokinesis & karyokinesis
- ✓ Label chromatids, centromere and chromosome
- ✓ Differentiate between haploid and diploid
- ✓ Differentiate between somatic cells and gametes
- ✓ Differentiate between autosomes and gonosomes
- ✓ Describe the process of mitosis

Components of a non-dividing cell

- A non-dividing cell can be recognised by presence of chromatin network, a single centriole and nuclear membrane

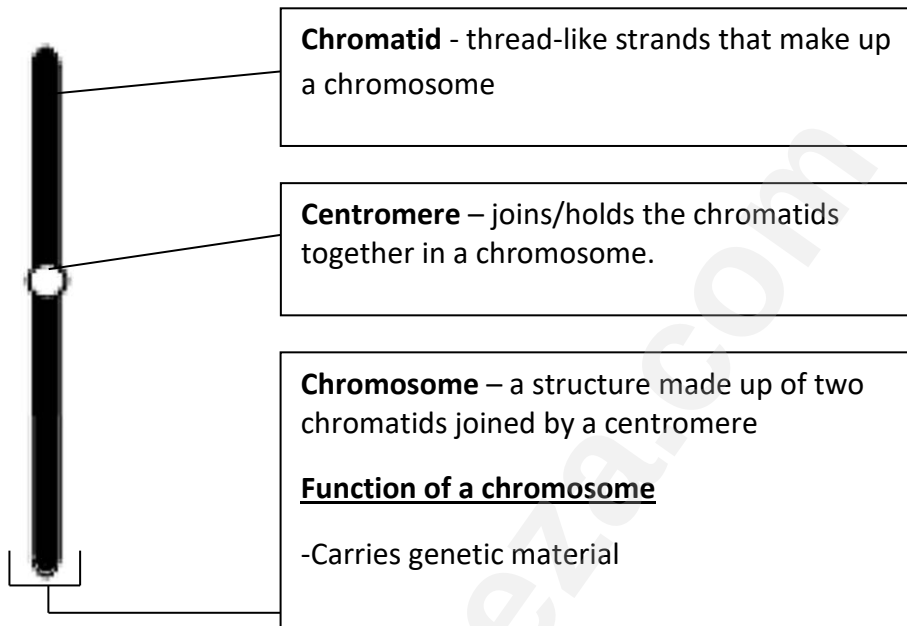


- **Centrosome/centriole** – produces the spindle fibre
- **Spindle fibre** – contracts to pull chromosomes to opposite sides of the equator

- **Chromatin network** - network of genetic material found in the nucleus during interphase



The chromosome



Chromosomes and cell division

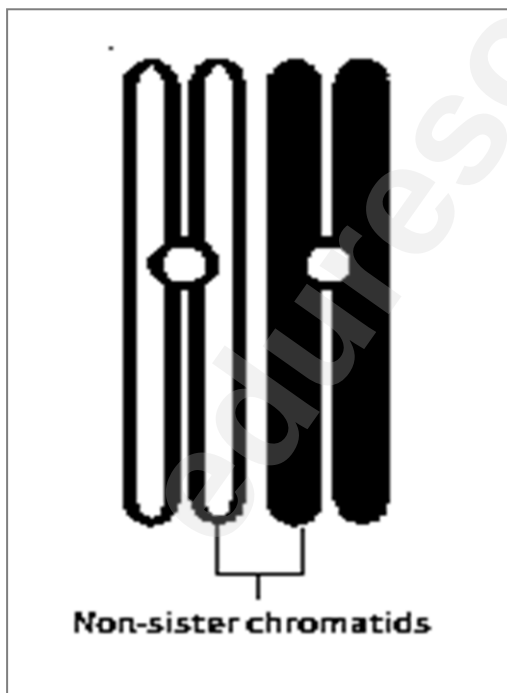
A chromosome before DNA replication (interphase) • One chromatid • One centromere = one chromosome One single stranded chromosome	A chromosome after DNA replication (interphase) • Two chromatids/sister chromatids • One centromere = one chromosome One single stranded double chromosome



Types of chromosomes

- Chromosomes exist as single/individual chromosomes or they exist as part of a pair.
- As a pair they are referred to as **homologous pairs/chromosomes**.
- Cells have two types of chromosomes called autosomes and Gonosomes
- **Autosomes** - the 22 pairs of chromosomes in the human karyotype that is not associated with gender
- **Gonosomes** – the two pairs of chromosomes in the human karyotype that determine gender
- There are also two types cells called somatic cells and gametes (sex cells)
- **Somatic cells** which are body cell have two sets of chromosomes which are paired (homologous pairs).
- **Gametes** (sperm cells or ova) have a single set of chromosomes.
- Humans have 46 chromosomes in their somatic cells and 23 chromosomes in their gametes.
- In human somatic cells 44 chromosomes are autosomes and the remaining two are gonosomes
- In human gametes 22 chromosomes are autosomes and the remaining single chromosome is a gonosome

Homologous chromosomes



- **Non-sister chromatid** – chromatids of different chromosomes of the same homologous pair.
- **Maternal** relates to chromosomes or genetic material inherited from the mother while **paternal** relates to that inherited from the father

Criteria for a homologous pair:

- A pair of chromosomes that are similar in length/shape/size
- Carry genes for the same characteristics
- Have the same centromere position
- One is obtained from each parent (one paternal and the other maternal)
- Have alleles at the same loci

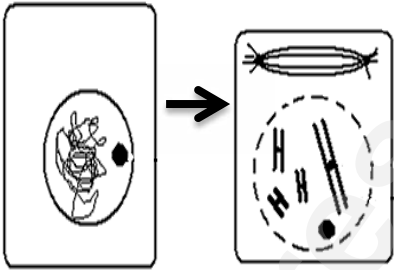
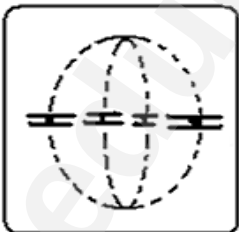


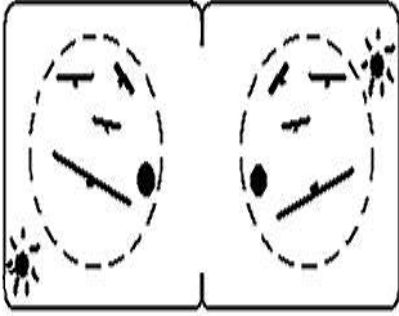
Haploid and Diploid number

- All somatic cells are **Diploid cells** and All **gametes** are **haploid cells**

Haploid cell	Diploid cell
 <i>*the cell above is haploid since it contains a single set of chromosomes. If you look careful at the two chromosomes you will notice that they are not the same length and are thus not homologous.</i>	 <i>*the cell above is diploid since it consist of two sets of chromosomes. In each set the chromosomes are similar length and thus homologous pairs.</i>

Mitosis – the process

	<u>Prophase</u> - Chromosomes contract to become dense and visible - The nuclear membrane disappears - Centriole produces the spindle fibre
	<u>Metaphase</u> Chromosomes align in the equator of the cell
	<u>Anaphase</u> Spindle fibre contracts to separate chromatids by dividing the centromere and chromatids (now called daughter chromosomes) move to their opposite poles



Telophase

- **Cytokinesis** which is the division of the cytoplasm occurs
- **Karyokinesis** also occurs which is the division of the nucleus
- Two identical daughter cells are formed with the same number of chromosomes and same genetic composition

Meiosis – the process

LESSON OBJECTIVES

- ✓ Define the term meiosis
- ✓ Name the site where meiosis occurs in plants and animals
- ✓ Describe the events of interphase
- ✓ Describe the process of meiosis
- ✓ Identify the phases and stages of meiosis

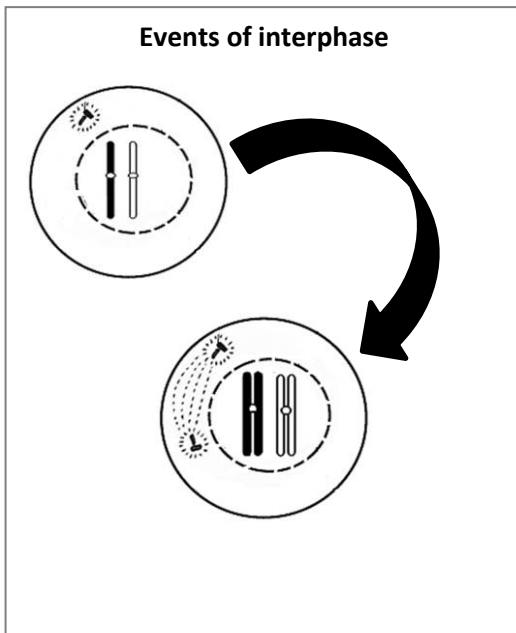
- **Meiosis** a type of cell division that halves the number of chromosomes to form **haploid gametes**.
- The resulting haploid cells will be **genetically different from each other**.
- Therefore the daughter cells have **half the number of chromosomes** as the parent cell
- Takes place during the formation of gametes in animals or spores in plants (in the **anther**).
- Meiosis occurs in the **testes** for a male and the **ovaries** for a female where somatic cells are converted into gametes by halving the number of chromosomes.
- A male will produce **haploid sperm cells** while a female will produce a **haploid ovum**.
- The sperm cell and ovum will undergo fertilisation to form a **diploid zygote** (doubling the chromosome number). The zygote will subsequently develop into a foetus and later on an adult which will also form its own gametes using meiosis.

Meiosis is divided into two stages:

- **Meiosis I** – chromosome number is halved and exchange of genetic material occurs
- **Meiosis II** – daughter chromosomes are separated



Interphase



Interphase - a phase between consecutive cell divisions where DNA replication occurs.

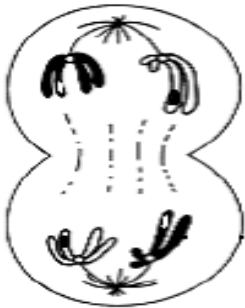
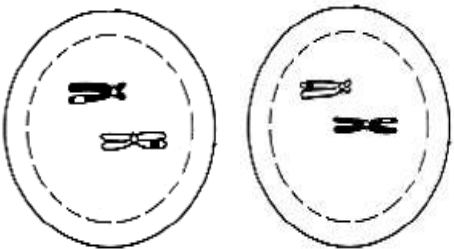
- DNA replication occurs
- The centriole is replicated during interphase
- Chromosomes change from single stranded to double stranded
- Each double stranded chromosome is now composed of a single centromere and two chromatids

Meiosis – the process

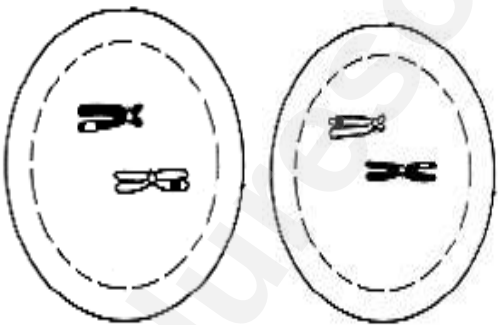
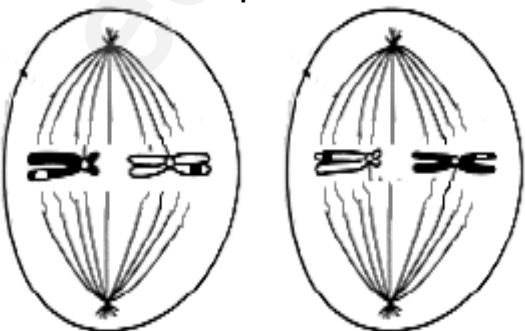
Meiosis I

Prophase I	• Chromatin network condenses and the threads shorten & thicken to become visible as Chromosomes • Chromosomes arrange in pairs as Homologous pairs • Chromatids from each homologous chromosome overlap and this is called Crossing over • The point where they overlap is the Chiasma (chiasmata-plural) • Genetic material is exchanged between the homologous chromosome thereby introducing variation • The nucleolus and nuclear membrane disappear
Metaphase I	• The chromosomes line up along the equator of the cell as homologous pairs • The homologous chromosomes attach to the spindle fibre using the centromere • Each pair of the homologous pair line up randomly on the equator independently of how other pairs line up. This is called Random arrangement of chromosomes • Random arrangement of chromosomes also brings about genetic variation

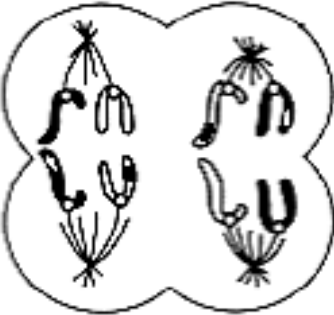
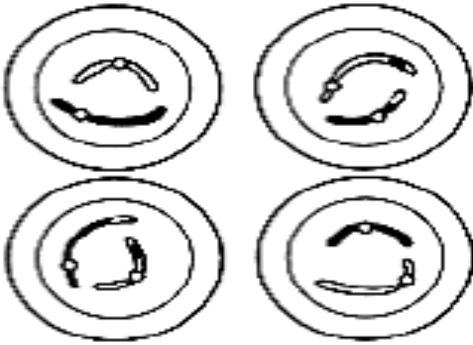


Anaphase I 	• The spindle fibre shortens/contracts thereby separating the homologous chromosomes as they move to the opposite poles of the spindle • Therefore Anaphase 1 is the separation of homologous chromosomes
Telophase I 	• Spindle fibres disappear • Nuclear membrane and nucleolus form • Cytokinesis and karyokinesis occur • Two daughter cells are formed with half the number of chromosomes of the mother cell

Meiosis II

Prophase II 	• The spindle fibre reforms • The nucleolus and nuclear membrane disappear • Each chromosome consists of two chromatids joined at the centromere
Metaphase II 	• The chromosomes attach to the spindle fibre using the centromere • Individual chromosome lines up randomly at the equator independently of how other chromosomes line up (Random arrangement of chromosomes)



Anaphase II 	• The spindle fibre shortens/contracts thereby splitting the centromere of each chromosome • the two daughter chromosomes are pulled to opposite poles of the cell • Therefore Anaphase 2 is the separation of chromosomes
Telophase II 	• Spindle fibres disappears • Nuclear membrane and nucleolus reform • Cytokinesis and karyokinesis occur • Four daughter cells are formed with half the number of chromosomes of the mother cell. • The four daughter cells are genetically different because of crossing over and random arrangement of chromosomes

Importance/significance meiosis

LESSON OBJECTIVES

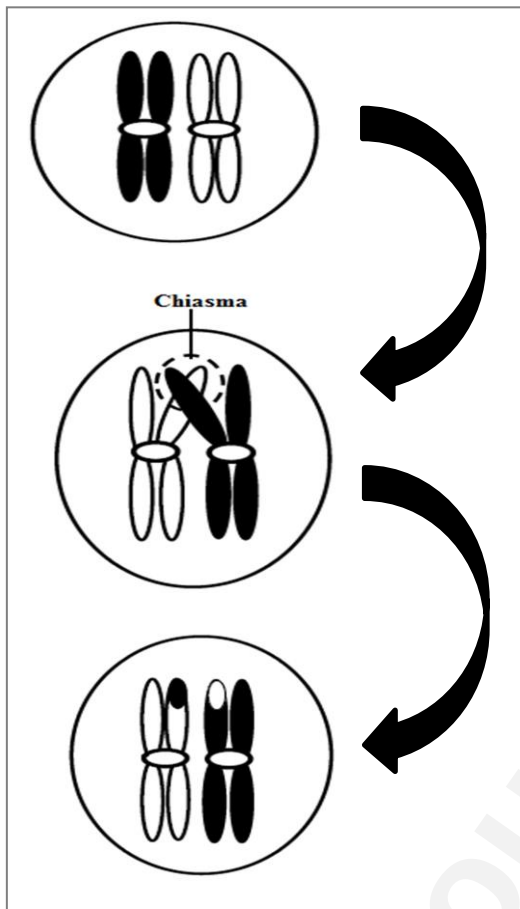
- ✓ Explain the importance of meiosis
- ✓ Describe the process of crossing over and its importance
- ✓ Describe the process of random arrangement of chromosomes and its importance

Importance/significance meiosis

- Production of gametes that are genetically different
- Prevents the chromosome number of an organism from doubling with every generation (Doubling effect)
- Forms gametes for sexual reproduction
- Introduction of genetic variation through:
 - Crossing over
 - Random arrangement of chromosome

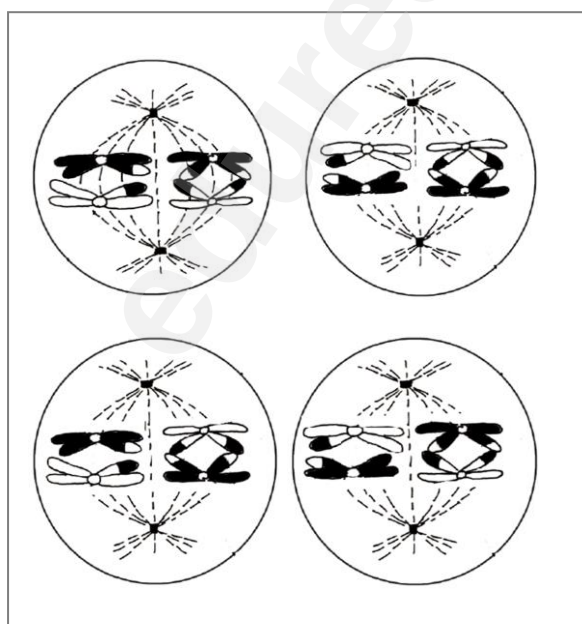


Variation in meiosis



Crossing over

- During **prophase 1**
- **Homologous chromosomes** pair up
- Non-sister chromatids **overlap**/cross over
- Points at which crossing-over takes place are referred to as **chiasmata**
- **Genetic material is exchanged** between the sister chromatids
- After the process of crossing-over chromosomes have genes/alleles from its homologous partner
- This means that each gamete formed will have a mix of genes/alleles from both parents
- Brings about **variation in the gametes** formed and also the offspring



Random arrangement of chromosomes

- During **Metaphase I**
- Each pair of **homologous chromosomes**
- may line up randomly on the equator
- Independently of what the other pairs are doing
- During **Metaphase II**
- Each **individual chromosome**
- may line up randomly at equator
- This means that gametes will have a differing mix of maternal and paternal chromosomes



Abnormal meiosis and consequences

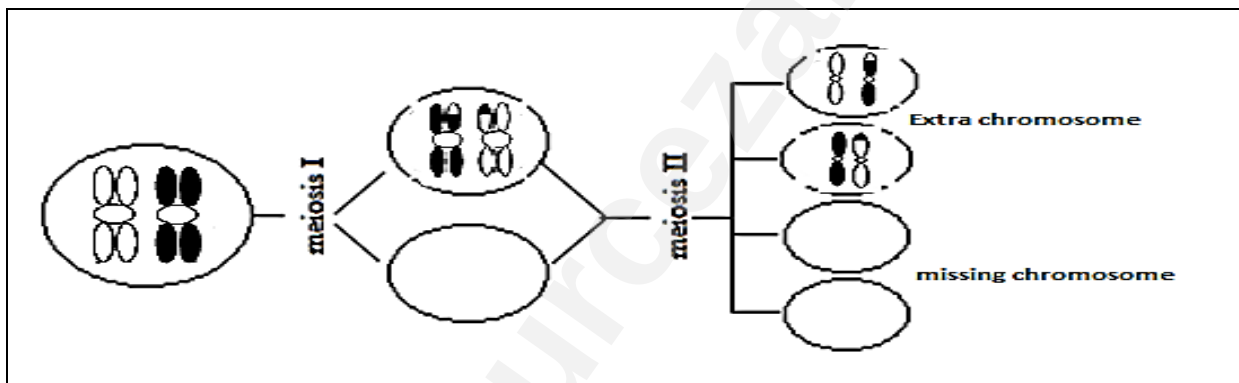
LESSON OBJECTIVES

- ✓ Define the non-disjunction
- ✓ Describe non-disjunction of chromosome pair 21 during anaphase1 in humans and the consequences

Non-disjunction

- **Non-disjunction** - Failure of one or more chromosomes to separate during meiosis

Non-disjunction – explanation



- In Meiosis I during **anaphase I** homologous chromosomes can **fail to separate** resulting in **non-disjunction**. At the end of meiosis II, four gametes will be formed where **two gametes will have an extra chromosome** and **two gametes will be missing a single chromosome**

Consequence of non-disjunction

- **Homologous chromosomes** can **fail to separate** in **meiosis I** during **anaphase 1**
- If this failure to separate occurs on **position 21** four gametes will be formed where two will have **an extra chromosome on position 21 each** and two will have a **missing chromosome each on position 21**.
- If the gamete that has an extra chromosome at position 21 fertilizes with a normal haploid gamete (which has a single chromosome at position 21) this will result in a **zygote with three extra chromosomes at position 21** and will lead to the offspring having a disorder called **Down syndrome**.

**In a normal situation, a haploid gamete will fertilize another haploid gamete to produce a diploid zygote with a normal number of chromosomes.*

** Non-disjunction can also occur in meiosis II during anaphase II*



Comparison of mitosis and meiosis

LESSON OBJECTIVES

- ✓ State the similarities between mitosis and meiosis
- ✓ Differentiate between mitosis and meiosis
- ✓ Differentiate between meiosis I and meiosis II

Similarities between mitosis and meiosis

- DNA replication occurs in both
- Nucleus divides in both
- Cytoplasm divides in both
- Both consist of all four phases (P.M.A.T)

Differences between mitosis and meiosis

Mitosis	Meiosis
Occurs to form somatic cells	Occurs to form gametes
One nuclear division	Two nuclear divisions
Two cells are formed with the same number of chromosomes as the mother cell	Four daughter cells are formed with half the number of chromosomes as the mother cell
Two cells are formed that are genetically identical to each other and to the mother cell	Four daughter cells are formed which are genetically different from each other and the mother cell
During prophase the chromosomes are not in pairs	During prophase I the chromosomes come together as homologous pair
No crossing over	Crossing over takes place during prophase I
During Anaphase the chromosome splits and daughter chromatids are pulled towards the opposite poles	During Anaphase I, whole chromosomes are pulled towards the opposite poles. The chromosome does not split

Differences between Meiosis I & II

Meiosis I	Meiosis II
Crossing over takes place	No crossing over takes place
In metaphase the chromosomes align on the equator in homologous pairs	In metaphase chromosomes align singly on the equator
Reduction division	No reduction division
During anaphase whole chromosomes move towards the poles	During anaphase daughter chromosomes move towards the pole
Homologous chromosomes in prophase I	Chromosomes occur singly in prophase II