SECONDARY SCHOOL IMPROVEMENT PROGRAMME (SSIP)

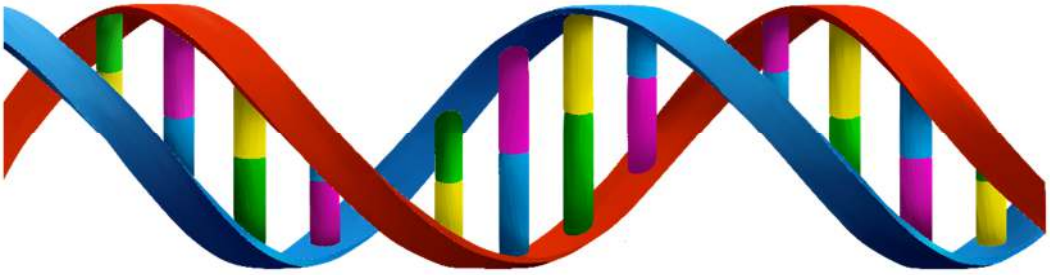
GAUTENG PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

GRADE 12

SUBJECT: LIFE SCIENCES

LEARNER'S BOOKLET 2021

SESSIONS 1-4



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SESSION 1: SKILLS NEEDED IN LIFE SCIENCES

EXAM GUIDELINE

Orientation to Life Sciences:

- **How science work.**

Science is based on: • fundamental knowledge built on scientific evidence and verified findings (articles that are published in journals or at conferences: peer review); • observing; • investigating; • making measurements and understanding the importance of scaling; • collecting and presenting data in the form of drawings, written descriptions, tables and graphs; • understanding the limitations of scientific evidence; • identifying patterns and relationships in data; • communicating findings; and • taking societal aspects of scientific evidence into account.

Scientific skills involve: • importance of biological principles such as relationship between surface area and volume/size, the relationship between structure and function • biological drawings: principles that apply • translating 3 dimensional objects or specimens into 2 dimensional drawings and photographs and interpreting 2 dimensional drawings and photographs: transverse and longitudinal sections • introduction to graphs: different kinds of graphs and when to use them; interpreting graphs. • calculating

(CAPS, GR.10)

NOTES & EXAM TIPS

1. GRAPHING SKILLS

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

LINE GRAPHS

Show the relationship between **two types of information** where the **independent variable is continuous**. Line graphs are useful in showing trends over time and are often used for biological data.

HOW TO DRAW A LINE GRAPH

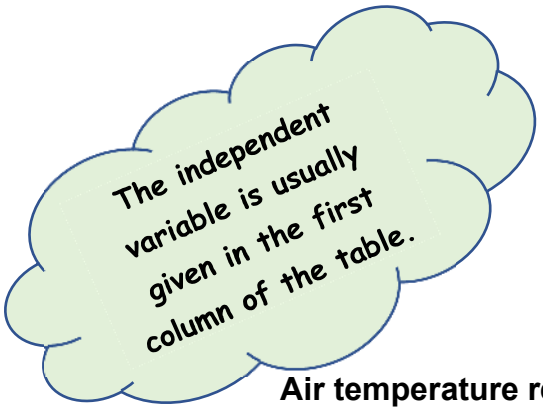
STEP 1

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

• **Dependent**: This is the variable or factor that is being ***measured***, i.e. the temperature in degrees Celsius in this example.

• **Independent**: This is the variable that the investigator can ***change.*** The dependent variable changes as the independent variable changes, i.e. the time in hours in this example.

FOR EXAMPLE:

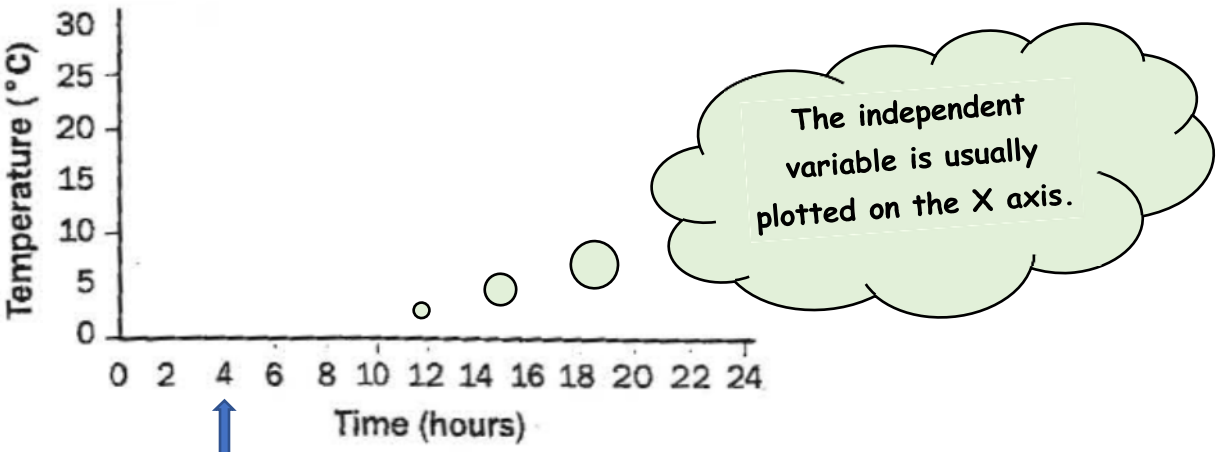


Air temperature recorded over a time period of 24 hours.

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

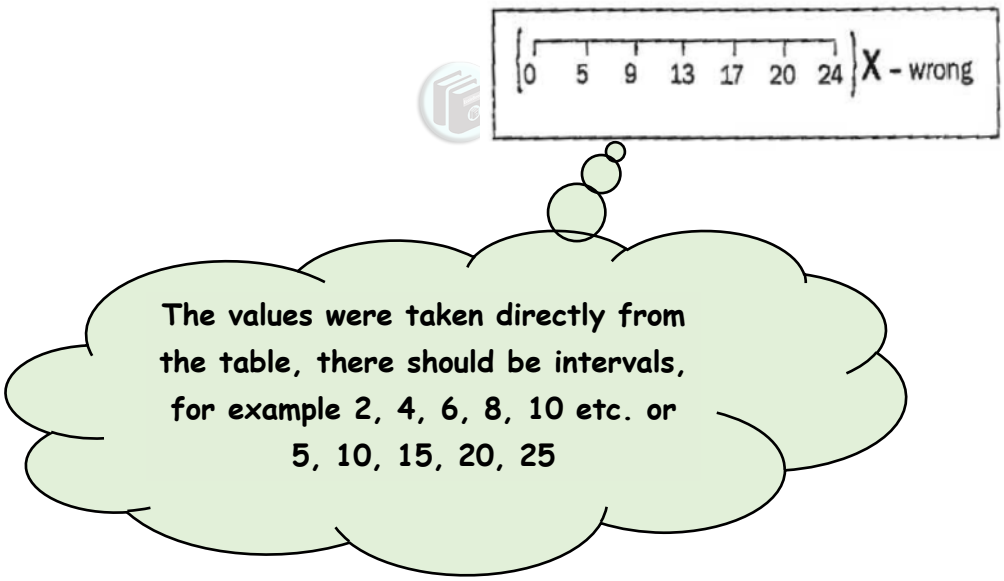
STEP 2

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



STEP 3

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



STEP 4

Place a dot at the point where the two values for each result intersect (meet).

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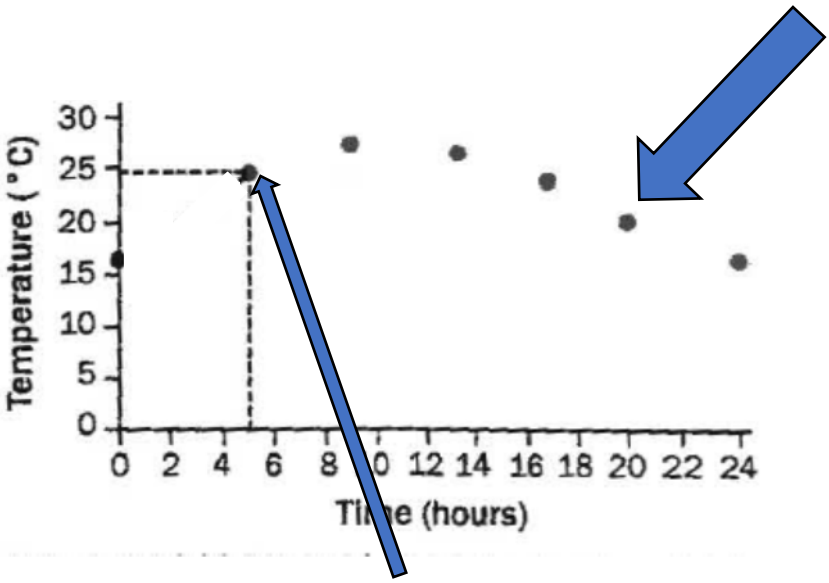
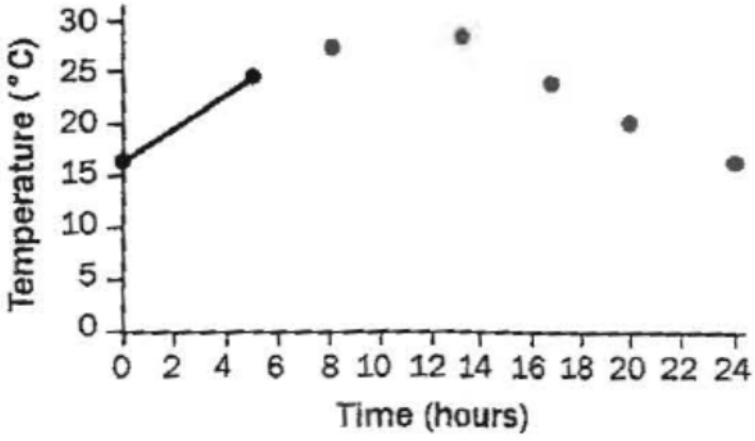


In the example, the point where ***5 hours and 24 º C intersect*** on the graph is indicated by the second dot on the graph. Plot all the points using the information in the table.

STEP 5

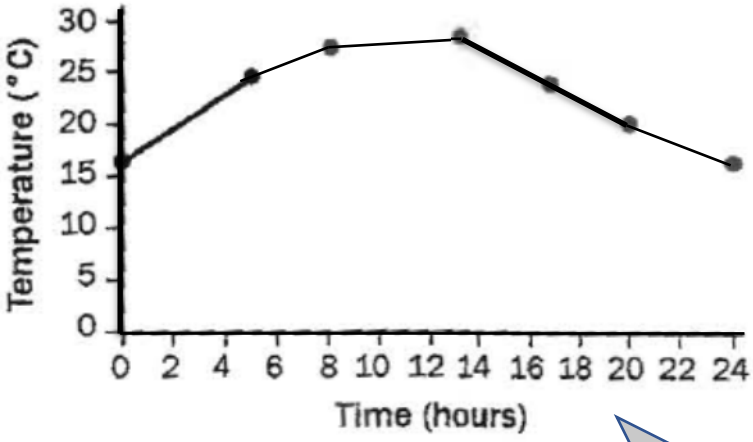
Join the dots using a ruler until all the dots have been joined in sequence.



STEP 6

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

A line graph showing the *air temperature* measured over a period of *24 hours.*



If the graph has two lines on it, then you should draw a key to show what the different lines represent. For example, if there was another line on this graph for rainfall, then your key might look like this:

Key: _____ rainfall

-------- temperature

PIE CHARTS

Pie charts are circular charts used to compare parts of the whole. They are divided into sectors that are equal in size to the quantity represented. They are used for discontinuous data.

How to draw a pie chart

STEP 1

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

Table of contraceptive use by a sampling group of women

Contraceptive	Number of women
Sterilisation	34
Pills	38

Condom	22
Rhythmic method	30
None	76

34 + 38 + 22 + 30 + 76 = 200

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

STEP 2

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

34/200 x 360 º = 61.2º (round down to 61º)
38/200 x 360 º = 68.4º (round down to 68º)
22/200 x 360 º = 39.6º (round up to 40º)
30/200 x 360 º = 54º
76/200 x 360 º =136.8º (round up to 137º)

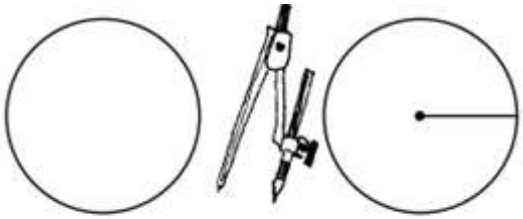
NB: *Check that your calculations are correct. All the degrees should add up to 360º. In our example:*

61 + 68 + 54 + 40 + 137 = 360º.

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

STEP 3

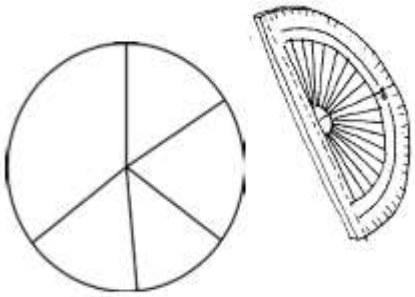
Use a mathematical compass to draw a circle. Draw in one radius on the circle. Start at the exact middle of the circle and draw a line to the edge of the circle



Draw a circle and then draw a radius

STEP 4

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



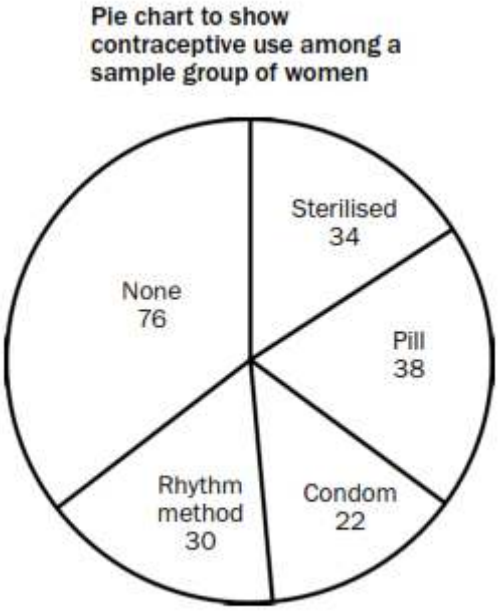
Measure out the sectors

STEP 5

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

STEP 6

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



Final pie chart with heading

BAR GRAPHS

Bar graphs show different categories of data and are used when the independent variable is not a set of continuous numbers or continuous groups (discontinuous data). They are best used to compare values across categories.

STEP 1

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

- **Dependen**t: This is the variable or factor that is being measured.
- **Independent**: This is the variable that the investigator can change. The dependent variable changes as the independent variable changes or manipulated.

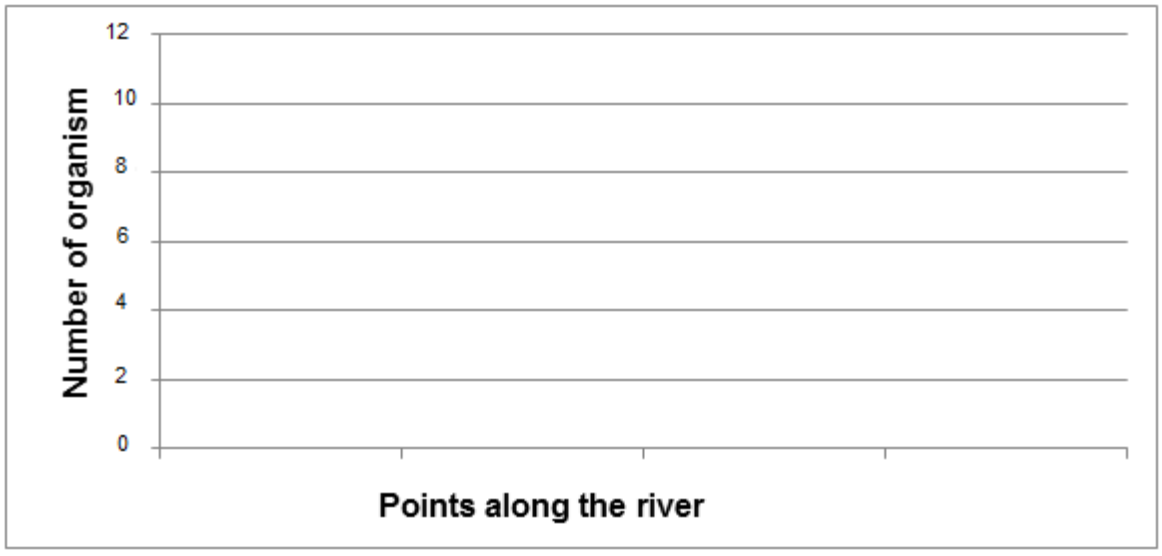
STEP 2

Use the table to identify the **dependent** and **independent variables**.

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

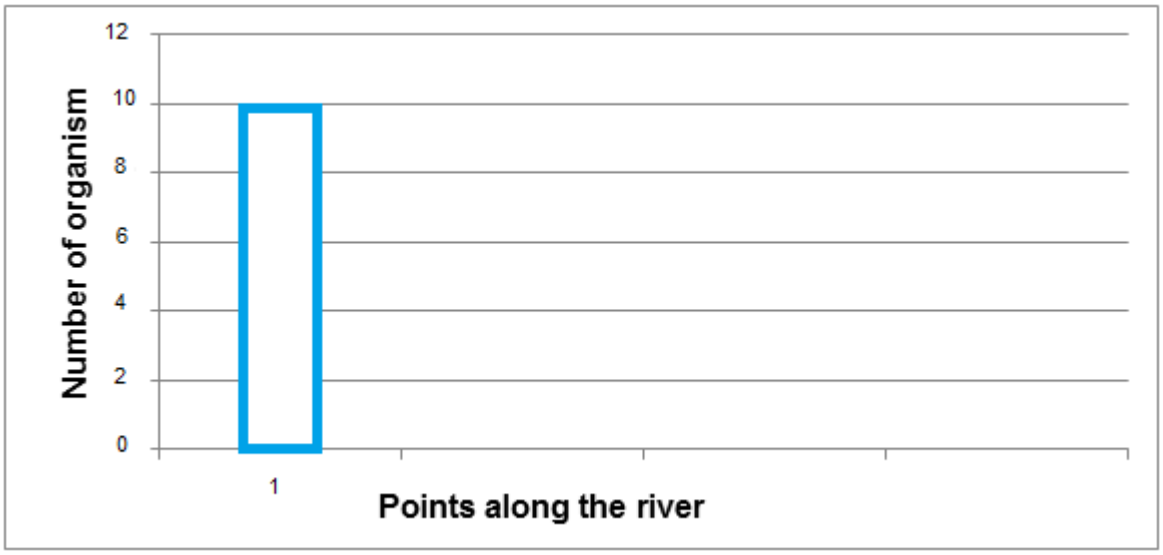
STEP 3

Draw the **axes** and choose a **scale**. Note that there will be no units when labelling the X- and the Y-axes in this particular graph.



STEP 4

Draw a bar to show that 10 organisms were found at point number 1 on the river.

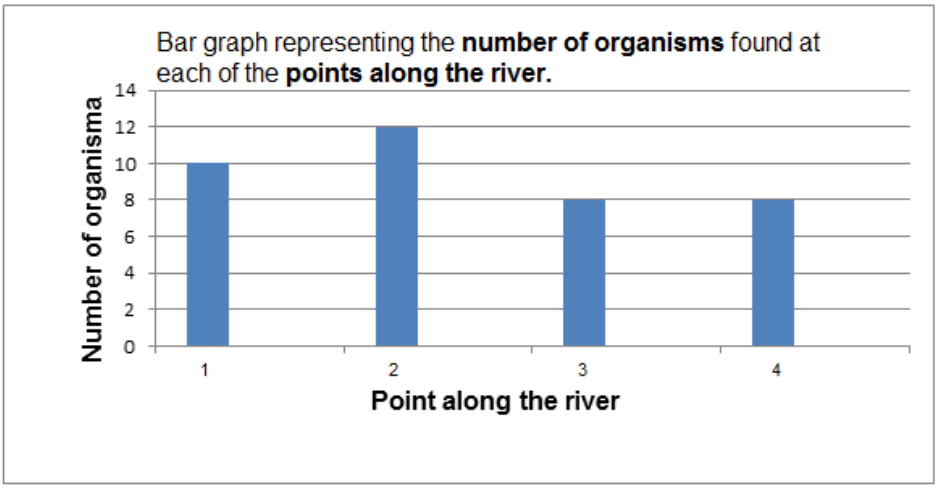


STEP 5

Give the graph a **heading or caption**. The heading or caption should include **both variables**. In this case both organisms found in each point along the river must be mentioned in the heading.

Then draw bars to represent the number of organisms found at each of the points along the river. Since this is a bar graph, the bars **should not touch** as the points along the river have **no direct relationship** with each other.

- The bars must be of the same width and must be of the same distance apart from each other.
- Bars can be presented vertically or horizontally.
  Example:



HISTOGRAMS

Histograms have connected bars displaying continuous data. They are used when the values of the independent variables are continuous but fit into categories or groups that follow on after each other.

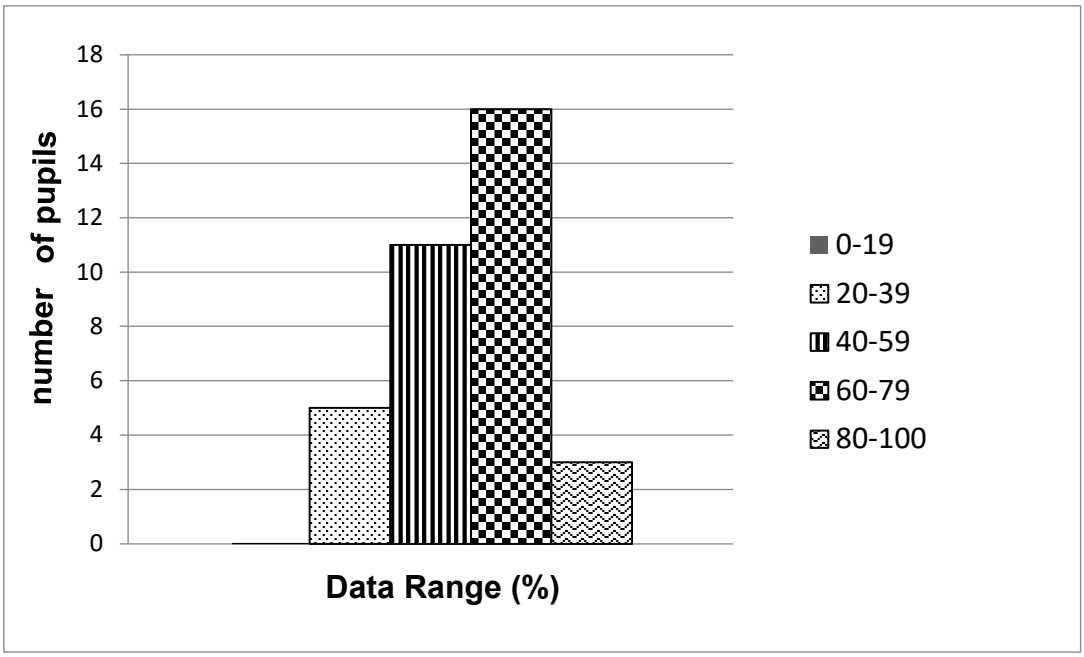
How to draw a histogram

A histogram is drawn in exactly the same way as a bar graph. The only difference is that a histogram is used when the **independent variable is groups of information along a continuous scale.** Note that in a histogram, the **bars are drawn without any spaces** between them.

e.g.:

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

Number of pupils in each percentage range



2. CALCULATIONS

2.1 How to calculate averages:

Find the sum of all the items and divide this total by the number of items.

For example:

The following data represents the weight of male jackals caught in a specific area:

Jackals number	Weight (kg)
1	42
2	41
3	38
4	35
5	46
6	39

Average weight of jackals: $\frac{\text{sum of the weight}}{\text{total number}}$

$$= \frac{42+41+38+35+46+39}{6}$$

$$= 40.17\text{kg}$$

2.2 Calculating Percentage:

Take the value of which you want the percentage of and divide it by the total sum of items.

For example;

The following data represents the weight and health of male jackals caught in a specific area:

Jackals number	Weight (kg)	Health
1	42	Healthy
2	41	Healthy
3	38	Sick
4	35	Sick
5	46	Healthy
6	39	Healthy

Calculate the percentage sick jackals in the investigation above:

2 out of 6 jackals are sick.

Percentage: $\frac{\text{value}}{\text{total}} \times 100$

$$= \frac{2}{6} \times 100$$

$$= 33.33\ \%$$

2.3 Calculating percentage difference

When you have to calculate the percentage increase or decrease in data, you divide the difference between the values by the starting value.

For example:

The following table is a summary of the Rhino poaching incidents for two provinces in South Africa from 2000 – 2010.

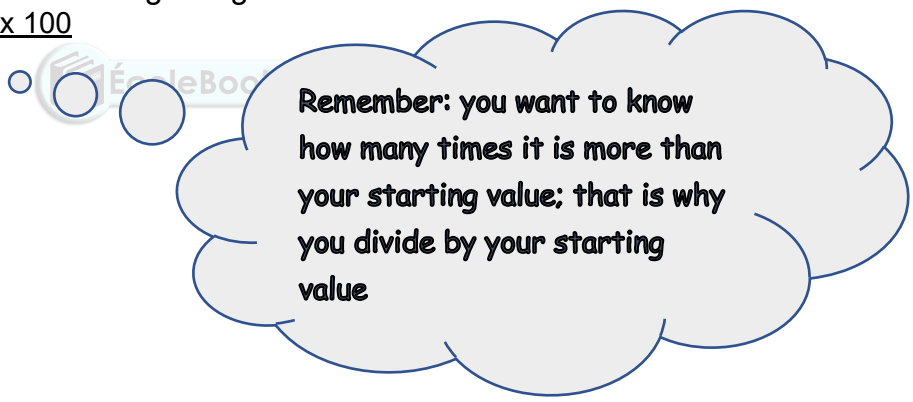
Province	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	TOTAL
North West	0	0	0	0	0	2	0	0	7	10	44	**63**
Eastern Cape	0	0	0	0	0	0	0	0	1	3	2	**6**

With what percentage did the poaching of rhino incidents increase in North West since 2008 to 2010? Show all working.

Percentage increase: $\frac{\text{end – beginning (difference)}}{\text{value at beginning}} \times 100$

$= \frac{44-7}{7} \times 100$

$= 529\%$



2.4 Using Formulas

Substitute values in formulas.

For example:

Mark re-capture experiments

$$P = \frac{F \times S}{M}$$

P = Estimated **total** number of individuals in the population.
F = Number caught and marked in **the first catch.**
S = Number **caught** in the **second catch**.
M = Number **marked** in the **second catch**.

For example:
A researcher wanted to know how many fish were in a dam. She *caught 20 fish* **and marked them by clipping out a small section of their tail fins. She then released them back into the dam. A few days later she caught** *25 fish* **and found that** *8 had been marked*.

F = 20
S = 25
M = 8

$$P = \frac{F \times S}{M}$$

$$= \frac{20 \times 25}{8}$$

$$= 62.5$$

Substitute values in formula

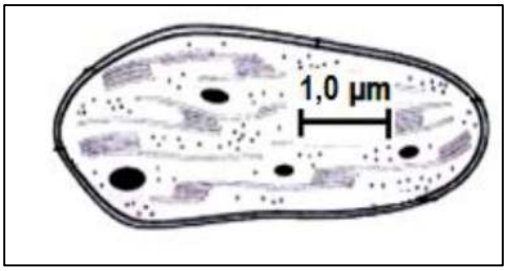
2.5 Calculations for magnification

Use the formula:

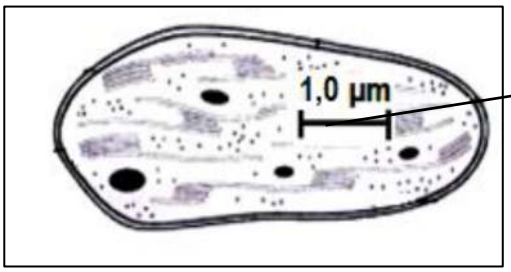
Actual length of specimen = measured length of specimen x length on scale
measured length on scale

For example:

When Nomsa investigated the cell structure she made some pencil drawings. The diagram below shows a chloroplast as seen on a micrograph that the teacher showed.



Use a ruler to measure the actual length of the scale and the length of the full chloroplast. Use your answers to calculate the actual length of the chloroplast.



Measure scale bar with ruler = 12mm

Measure whole organelle with ruler = 600mm

Use the formula:

$$\text{Actual length of chloroplast} = \frac{\text{measured length of chloroplast x number on scale}}{\text{measured length of scale}}$$

Show all working and give the answer in microns (µm)

1mm = 1000 µm

60mm x 1000 = 60 000 µm

12mm x 1000 = 12000 µm

$$\textbf{Actual length of chloroplast} = \frac{60\,000 \times 1}{12000}$$

$$= 5\ \mu m$$

3. DRAWING SKILLS

Diagrams must:

- have a title or caption
- be drawn in pencil to ensure clear smooth lines
- be labelled in ink(pen)
- be large enough to see all the structures that are in the diagram
- be positioned in the centre of the page
- be two dimensional (show length and width only)
- not be shaded

Note: ***label lines must:***

- be drawn with a ruler.
- not cross each other
- not have arrows at the end
- touch the part that is labelled
- be on one side of the diagram if they are few
- be aligned neatly, preferably one label below the other

4. HYPOTHESIS TESTING INVESTIGATIONS

4.1 Variables

There are 3 types of variables:

- Independent/manipulated variable – variable that is controlled or changed by the investigator to determine what effect it has. In graphs it is the variable that is drawn on the horizontal axis/X-axis
- Dependent /responding variable – variable that is the effect of the independent variable – this is the response that is measured or monitored during the investigation. In a graph, it is the variable that is drawn on the vertical axis/Y-axis.
- Fixed/Constant variable – all the factors that must be controlled/fixed when conducting an investigation.

4.2 Hypothesis Definition:

A hypothesis is an attempt to explain some event or observation using whatever information is currently available.

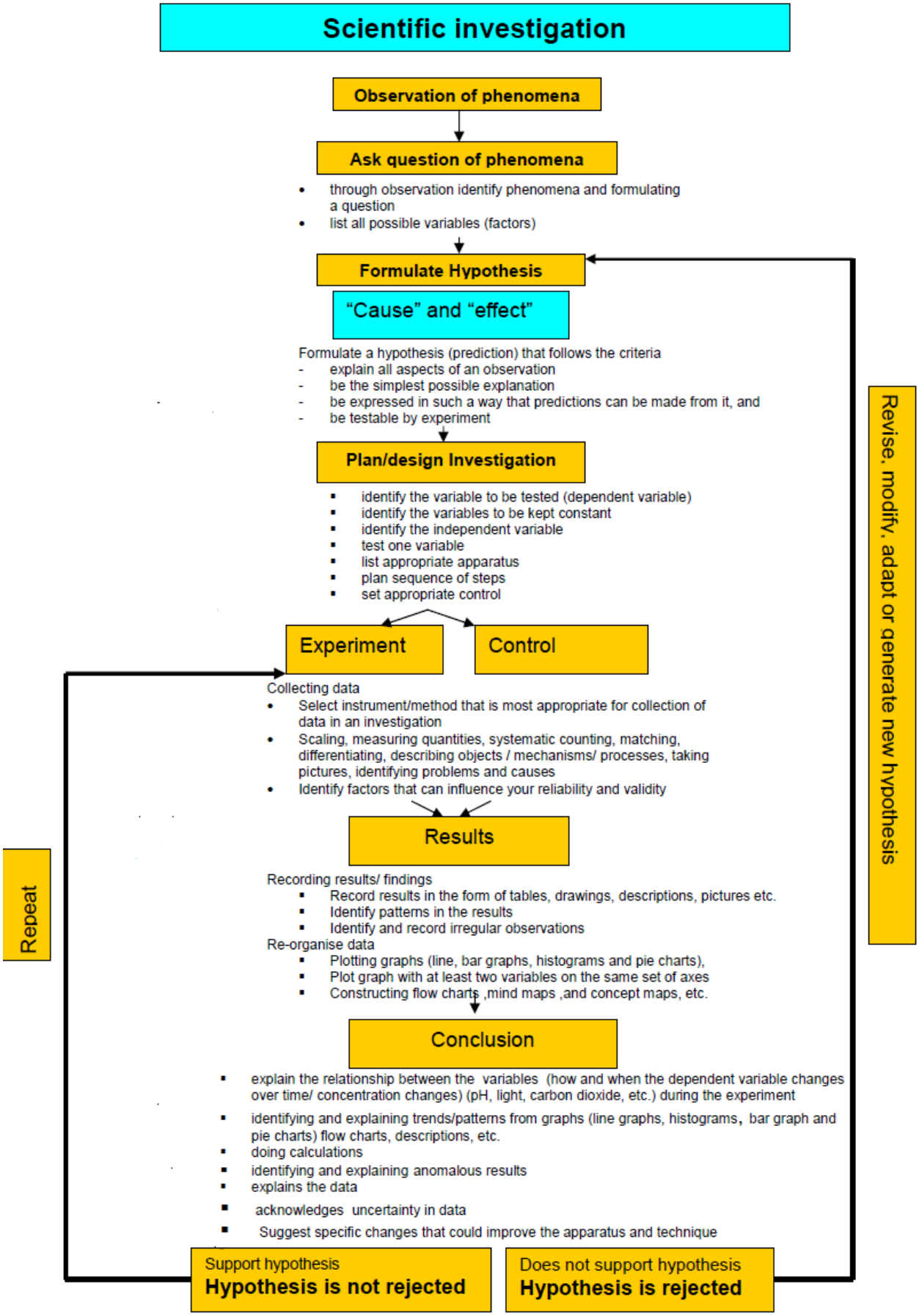
How to state a hypothesis:

1. There must be two variables.
2. State the relationship between the two variables.
3. It must be testable.
4. Independent variable first (cause) and the dependent variable (effect) second.

Notes:

- A hypothesis is an idea that a person gets from observations made. It is a suggested solution to a question. The hypothesis needs to be tested before one can draw any conclusions.
- In planning the investigation, you need to test various possibilities. (FACTORS); one at a time so that we can be sure which factor gives us the result.
- Each factor is known as a VARIABLE and each investigation should test only ONE variable.
- Generally a scientific investigation has an EXPERIMENT and a CONTROL.

4.3 Scientific Method



DESIGNING SCIENTIFIC INVESTIGATIONS

The scientific method generally has the following steps:

1. **State the problem (purpose)**
2. **Develop a hypothesis**
   - Consider the independent variable
   - Consider the dependent variable
   - How the 2 variables above are related
   - Which factors need to be controlled
3. **Plan an investigation**
   - Materials to be used
   - Method
   - How data will be collected, recorded, analysed and represented
4. **Set up and carry out the investigation** (procedure)
5. **Make observations and record information** (data) e.g. in a table
   - Translate/Reorganize the data e.g. draw a graph (bar, pie or line graph/s) from a table
6. **Analyse and discuss the data** (data analysis)
   - Look for trends/patterns and relationships between the two variables
7. **State conclusions**
   - Whether the hypothesis is rejected or not
8. List any shortcomings/limitations of the investigation

EXAMPLE:

The following example of a scientific investigation illustrates the above concepts:

- A researcher **observed** that the potted plants he covered with a brown box did not grow.
- His **hypothesis:** Sunlight is essential for plant growth.
- In **planning t**he investigation, he set up TWO sets of 50 plants as follows:
- **EXPERIMENT:** 50 plants placed in a greenhouse
- **CONTROL**: 50 plants placed in an identical greenhouse, blackened so that no light could enter.
- The plants in both the experiment and control received the **same soil, amount of water, temperature** etc. – in other words, they were given the same requirements.
- NB. The **experiment and control** differed in **only one factor** (VARIABLE) i.e. in the experiment plants were given light and the control plants were NOT exposed to light
- He **measured** the growth of the plants over a period of time in the experiment and in the control
- He found that those plants placed in sunlight (**EXPERIMENT**) grew.
- He found that those plants placed in darkness (**CONTROL**) did not grow.
- He concluded that his **hypothesis was correct** for the type of plant that he investigated.

4.4 Reliability and Validity

What is reliability?

The idea behind reliability is that any significant results of an investigation must be more than a once-off finding and be repeatable.

Other researchers must be able to perform exactly the same experiment, under the same condition and generate the same results. This will reinforce the findings of the experiment and ensure that the wider scientific community accepts the hypothesis.

In questions which ask learners to state how the reliability of the investigation could have been improved, the correct answers could generally be the following: **repeat the experiment/investigation OR increase the sample size.**

What is Validity?

Validity questions **how** the experiment/investigation was carried out. Have all the factors/variables been controlled/fixed except the variable/factor being tested? Have the samples been chosen randomly? Is the design for the investigation appropriate?

Validity therefore speaks to whether the scientific research method was done with the appropriate care and diligence.

In questions which ask learners to suggest some factors that might have decreased the validity of an investigation, the answers should centre around criticism of the scientific process, for example some factors/variables that were not fixed/controlled when carrying out the investigation.

TYPICAL EXAM QUESTIONS

QUESTION 1

A person took part in an experiment on the eye's response to light. A lamp was placed at seven different positions from the person's face. The diameter of the person's pupil was measured at each position.

The table below shows the diameter of the person's pupil when the light was placed at various distances from the person's face:

Distances of the lamp from the person (m)	Diameter of the pupil (mm)
1	1,2
2	1,8
3	2,4
4	3,0
5	3.6
6	4,2
7	4,8

Draw a line graph to represent the information given in the table above.

QUESTION 2

The table below shows the percentage of carbon dioxide (CO_2) emitted by different sectors in a certain city in South Africa.

SECTOR	CO_2 EMISSION (%)
Transport	25
Residential	27
Industrial	15
Commercial	28
Other	5

[Adapted from *Energy scenarios for CT to-2050,* 2011]

Draw a pie chart to represent the data in the table above. Show ALL calculations.

QUESTION 3

Research was done in Khayelitsha in site B and C on causes of death among children under the age of one year. The table below shows the percentages of the top four causes of death of children under the age of one year in 2008 and 2010 in site B and C in the two areas.

Category	2008	2010
Diarrhoea	19	21
HIV/AIDS	11	16
Pneumonia	9	6
TB	8	13

1. Draw a bar graph to show the top four causes of death of children under the age of one year in 2008.

2. Identify
   a. Dependant variable
   b. Independent variable

QUESTION 4

The grade 10 learners investigated the amount of decomposing bacteria found in soil with different pH levels. They represented the results in the following table.

Soil pH	No. of decomposing bacteria
1-2	0
3-4	2
5-6	10
7-8	22
9-10	31
11-12	45
13-14	30

1. Draw a histogram to show the number of decomposing bacteria found in soils of different pH levels.

QUESTION 5

1. Calculate the percentage decrease in the number of species from 1985 to 2005.

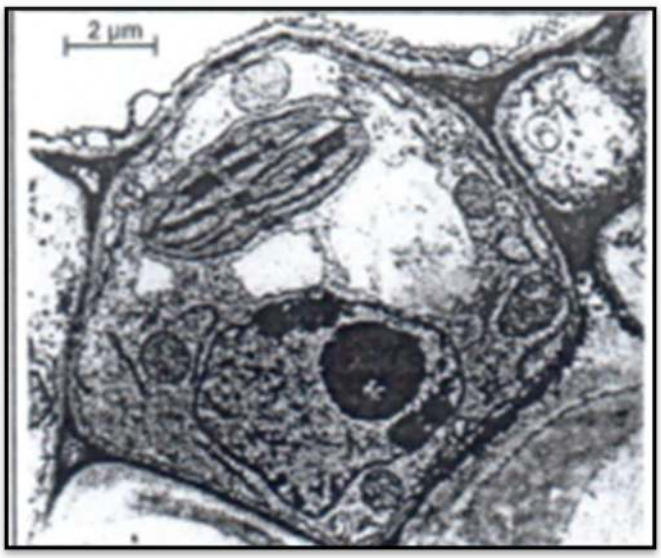
Group of organisms	Number of species in the year 1985	Number of species in the year 1995	Number of species in the year 2005
Flowering plants	45	38	32

2. A scientist studied sea-snails in two rock pools along the shoreline. During the first day he captured, counted and marked sea snails in the two pools and then released them (sample 1). A few days later he caught and counted the sea snails again (sample 2). The following table illustrates the results.

Number of sea snails	Pool A	Pool B
Sample 1	32	42
Sample 2	26	21
Marked in sample 2	4	6

a. Use the data in the table above and calculate the size of the population of sea snails in rock pool A.
b. Calculate the percentage of marked snails in the second sample in pool B.
c. Calculate the average amount of sea snails caught in the two pools during sample 1.

3. Look at the following micrograph and do the calculations that follow.



Calculate the actual size of the cell in µm.

If it is measured with a ruler it is 12 cm.

The scale bar is 1.2 cm in length.

QUESTION 6

1. The peppered-moth, *Biston betularia*, has two phenotypes for body colour, dark (blackish) and pale (whitish). An investigation was carried out to determine the number of dark and pale peppered moths present in polluted and unpolluted environments using a sampling technique.

The results of the investigation are shown in the table below.

TYPE OF ENVIRONMENT	DARK MOTHS	PALE MOTHS
Polluted	150	40
Unpolluted	30	170

1.1 Formulate a hypothesis for the above investigation. (2)

1.2 Suggest THREE factors that might have decreased the validity of this investigation. (3)
(6)

2. Two students decided to investigate the effect of different concentrations of sulphur dioxide on the germination of oats seeds. They set up trays of germinating seeds under a clear plastic cover along with five different concentrations of sodium disulphate(IV) solution.

Sodium disulphate(IV) breaks down to release sulphur dioxide into the atmosphere.

The table below shows the results after one week.

Concentration of sodium disulphate (IV) (%)	**Number of seeds germinated out of 20 (five replications)**					**Percentage germination**
0,00	19	19	17	20	18	93
0,05	16	17	15	15	17	80
0,10	12	13	14	11	12	62
0,50	0	1	0	0	1	2
2,50	0	0	0	0	0	0

2.1 Formulate a possible hypothesis for this investigation. (2)

2.2 State the independent variable in this investigation. (1)

2.3 Name TWO factors which might affect seed germination, and which must be kept constant. (2)

2.4 Why was the investigation repeated five times at each concentration? (2)

2.5 Draw a conclusion for this investigation from the results provided. (2)
(9)

Session 2: DNA: location, structure and function

EXAM GUIDELINE

- Revision of the structure of the cell with an emphasis on the ribosome, cytoplasm and the parts of the nucleus (Gr.10 content)

- Location of DNA:
  - Makes up the genes on chromosomes (nuclear DNA)
  - Present in mitochondria (mitochondrial DNA)
  - Present in chloroplasts (plants)

- Brief history of the discovery of the DNA molecule (Watson & Crick, Franklin & Wilkins)

- Structure of DNA
  - The natural shape of the DNA molecule is a double helix
  - Each strand of the helix is made up of a sequence of DNA nucleotides

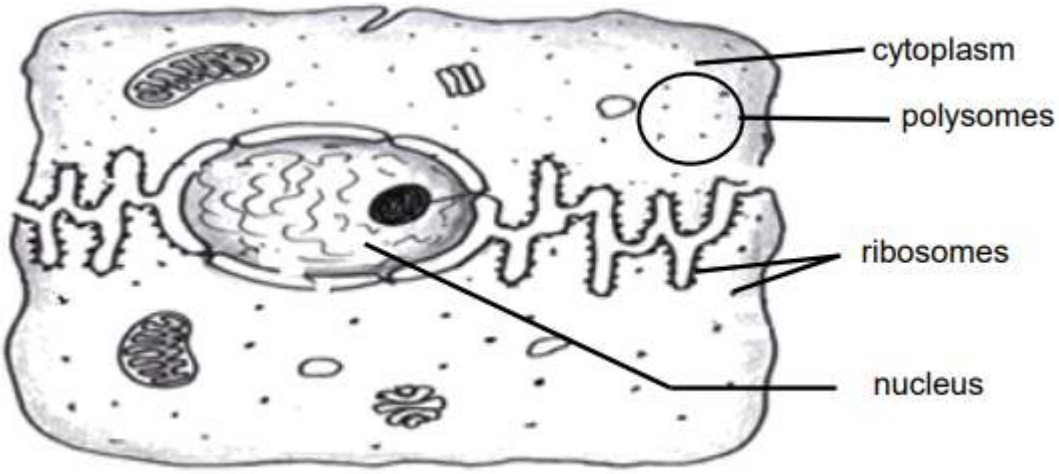
- Three components of a DNA nucleotide:
  - Nitrogenous bases linked by weak hydrogen bonds:
    - Four nitrogenous bases of DNA: adenine (A), thymine (T), cytosine (C), guanine (G)
    - Pairing of bases in DNA occur as follows: A: T and G: C
  - Sugar portion (deoxyribose in DNA)
  - Phosphate portion

- Stick diagram of DNA molecule to illustrate its structure

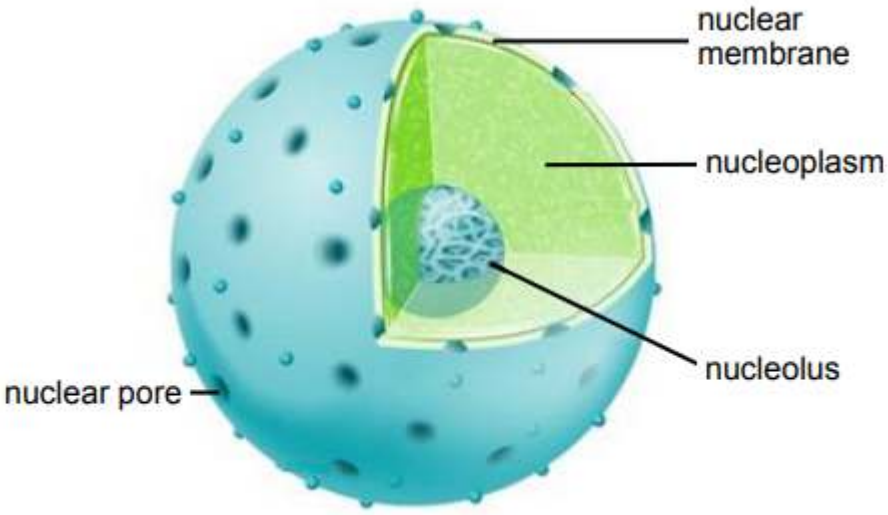
- Functions of DNA:
  - Sections of DNA-forming genes carry hereditary information
  - DNA contains coded information for protein synthesis

NOTES & EXAM TIPS

The structure of the cell



- **Cytoplasm** is the base substance in which the organelles of the cell are suspended. It is a watery substance and allows for metabolic reactions to take place.
- **Ribosomes** are small, round organelles which are mainly found attached to the endoplasmic reticulum or are free-floating in the cytoplasm. Ribosomes can also be found inside other organelles such as the chloroplast and mitochondria but in smaller numbers. They are the site of protein synthesis and consist of RNA and protein.
- The nucleus controls all of the cell's activities.



Parts of the nucleus

A nucleus has four main parts:

- the double nuclear membrane – it encloses the nucleus and contains small pores to allow for the passage of substances in and out of the nucleus
- the nucleoplasm – this is a jelly-like fluid within the nucleus
- the nucleolus – a dark body suspended in the nucleoplasm which contains free nucleotide bases and produces ribosomes
- the chromatin network – found in the nucleoplasm: contains the DNA which forms the chromosomes containing the genetic code of a person / organism

DNA is an important part of our make-up. The hereditary instruction carried within the DNA ensures that offspring resemble their parents and ensures that **genetic variation** can take place, resulting in survival of the fittest. The scientific field is doing on-going research on DNA and it has brought about a lot of new knowledge. Some examples of this are: the **human genome project**, **DNA profiling**, **cloning**, **identifying** the **genes** that are responsible for certain **diseases** and **isolating genes** to correct mistakes in our **genetic make-up**.

Location of DNA

- The DNA is located in the nucleus
- and mitochondria and
- chloroplasts

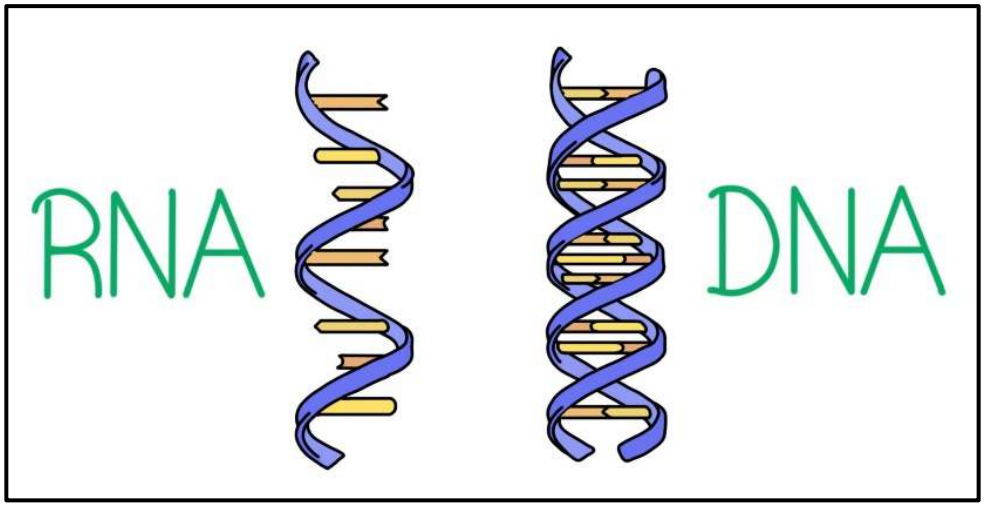
Brief history of the discovery of the DNA molecule

- 1952 – Rosalind Franklin and her assistant Maurice Wilkins researched the structure of DNA using X-ray diffraction images.
- Watson and Crick did independent research on DNA. Upon seeing Franklin's images, they proposed a 3-D double helix model for DNA in 1953.
- 1962 – Watson and Crick received the Nobel Prize for the discovery of the structure of DNA, and Wilkins received an award for his X-ray photography. Franklin had died of cancer.

The Structure of DNA and RNA

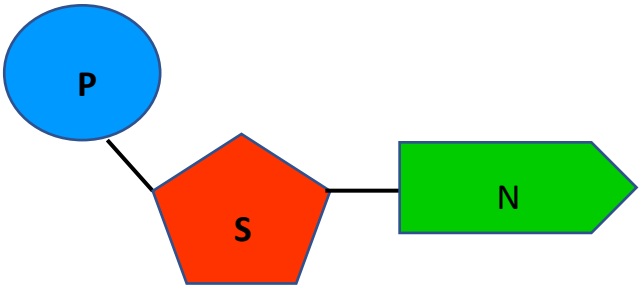
There are two kinds of **nucleic acids** found in a cell, namely **DNA** (deoxyribonucleic acid) and **RNA** (ribonucleic acid)**.**

DNA is a double stranded molecule. The natural shape of DNA is a **double helix.**
DNA is found in the nucleus (**nuclear DNA**) and mitochondria (**mitochondrial DNA**) of cells. **Nuclear DNA** occurs as chromosomes in the nucleus.
RNA is a single stranded molecule formed in the nucleus and functions at the ribosomes of the cell.



Both **DNA** and **RNA** are made of building blocks or **monomers** called **nucleotides**

A nucleotide

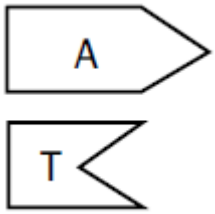
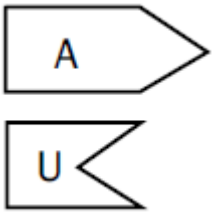
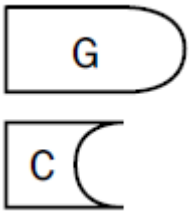
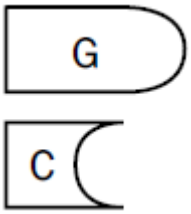


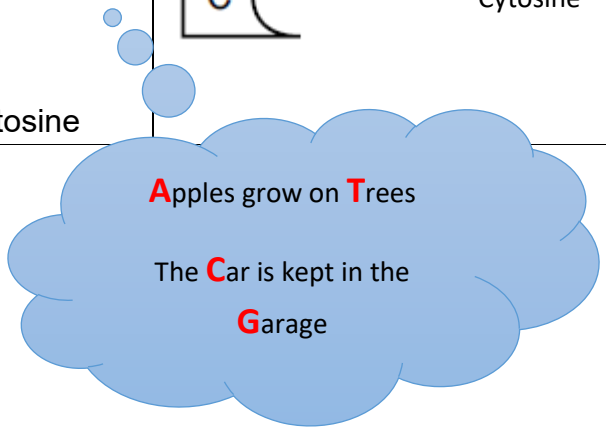
P – phosphate group

S – deoxyribose or ribose sugar

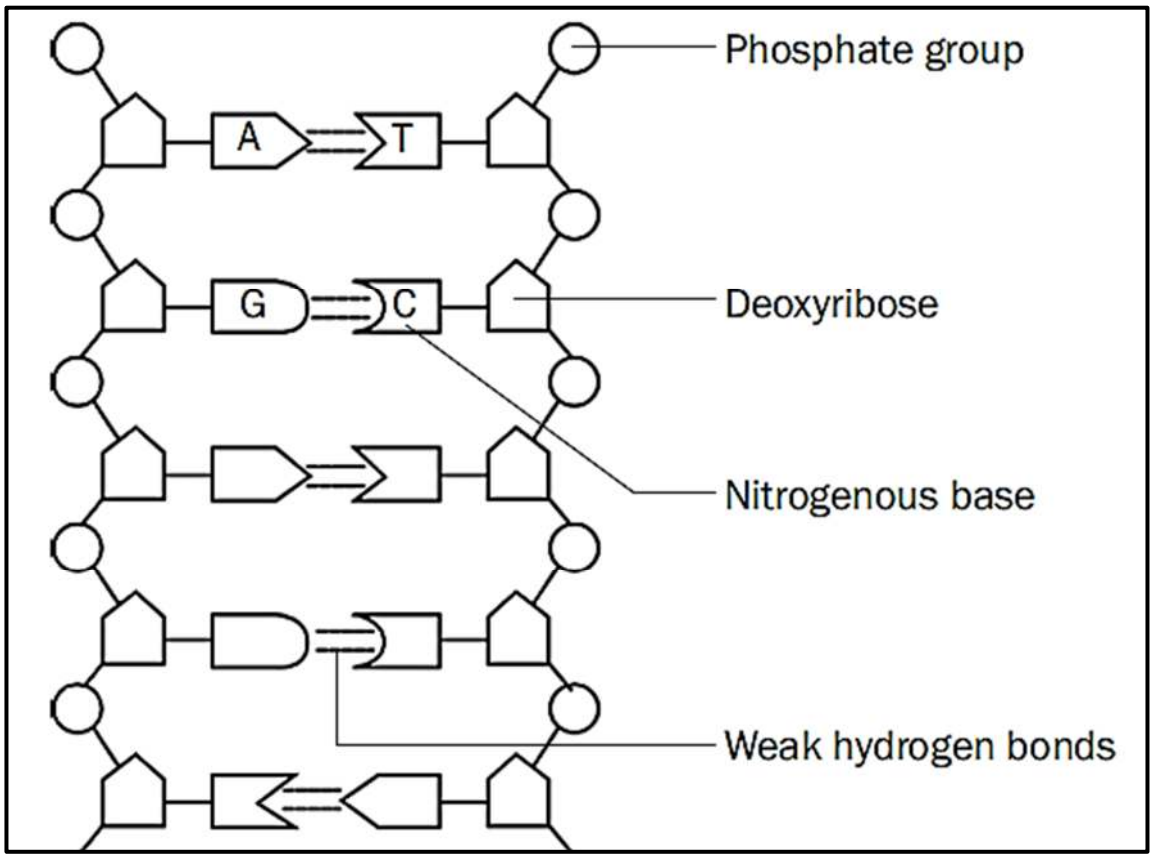
N – Nitrogenous base **(adenine, cytosine, guanine, thymine or uracil)**

Nitrogenous bases of DNA and RNA

DNA has **four** different nitrogenous bases – **adenine, thymine, guanine** and **cytosine**	**RNA** has **four** different nitrogenous bases – **adenine, uracil, guanine** and **cytosine**
 Adenine always pairs with thymine	 RNA contains uracil instead of thymine
 Guanine always pairs with cytosine	



Stick diagram of DNA



How to recognize a DNA molecule

- ✓ **Double-stranded** molecule
- ✓ Contains **thymine (T)** instead of **uracil (U)**
- ✓ **A** always joins to **T**
- ✓ **G** always joins to **C**

- DNA is a ladder-like molecule when it unwinds
- The phosphate and sugar form the backbone or sides of the ladder molecule, whereas the bases form the “rungs”.

Functions of DNA

- Sections of **DNA** form **genes** carrying **hereditary information**
- **DNA** contains coded information for **protein synthesis**

TYPICAL EXAM QUESTIONS

QUESTION 1 *(Questions taken from various sources)*

Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A to D) next to the question number (1.1 to 1.4) in your ANSWER BOOK, for example 1.5 D.

1.1 A dye stains a particular type of nucleic acid red. When this dye was used to identify which organelles in a cell contain this nucleic acid, only the nucleus and ribosomes stained red.
This result shows that the dye stains structures that contain …

A DNA.
B RNA.
C DNA and protein.
D both DNA and RNA.

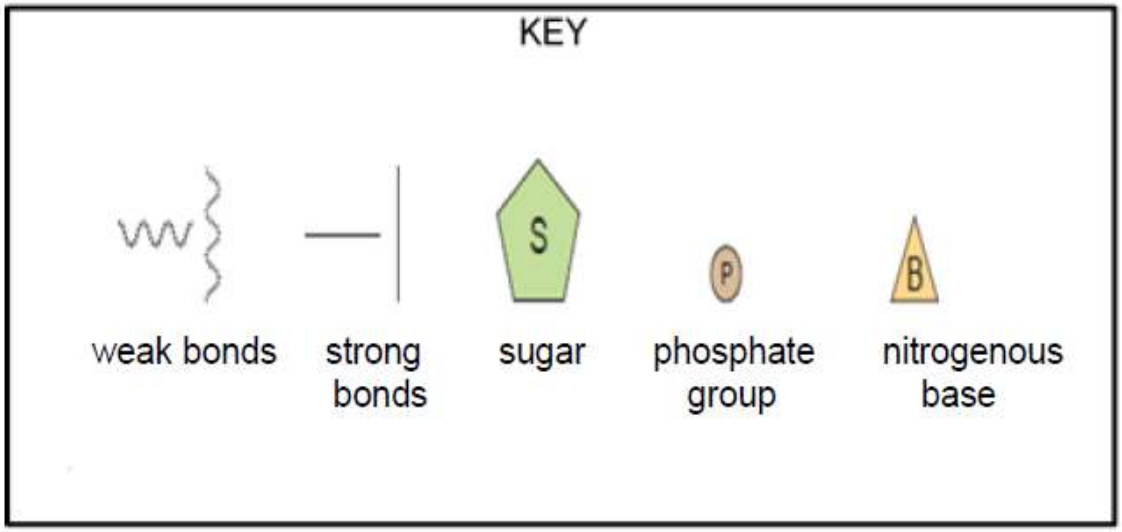
1.2 In an investigation it was found that 10% of the nitrogenous bases in a molecule of DNA was thymine. What was the ratio of thymine to guanine in the same molecule?

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

1.3 DNA was analysed and found to contain 14% T (thymine). What percentage of the molecule is cytosine?

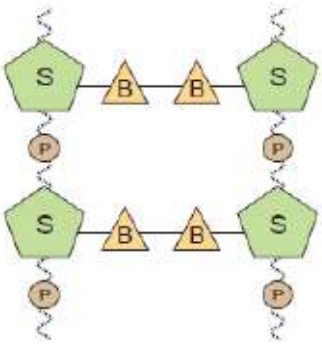
A 14%
B 28%
C 36%
D 72%

1.4 The key below shows the main components of a DNA molecule and the strength of the bonds that hold them together.

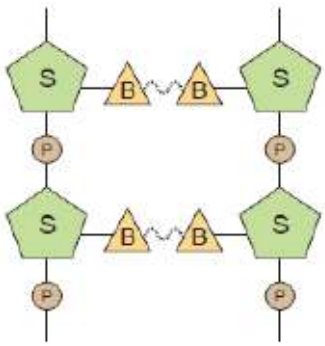


Which one of the following diagrams shows the correct combination of components of a DNA molecule?

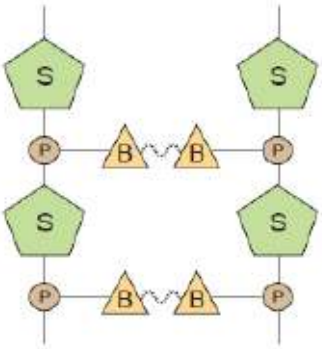
A



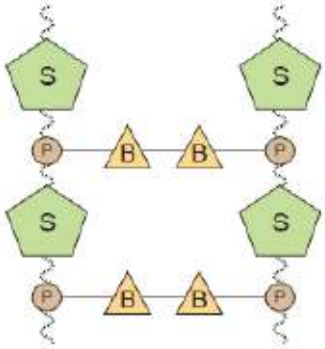
B



C



D



QUESTION 2 *(Questions taken from various sources)*

Give the correct **biological term** for each of the following descriptions. Write only the term next to the question number (2.1 to 2.3) in your ANSWER BOOK.

2.1 A segment of DNA coding for a particular characteristic
2.2 A sugar molecule found in a nucleotide of DNA
2.3 The weak bond between nitrogenous bases in a DNA molecule **(3)**

QUESTION 3 *(Questions taken from various sources)*

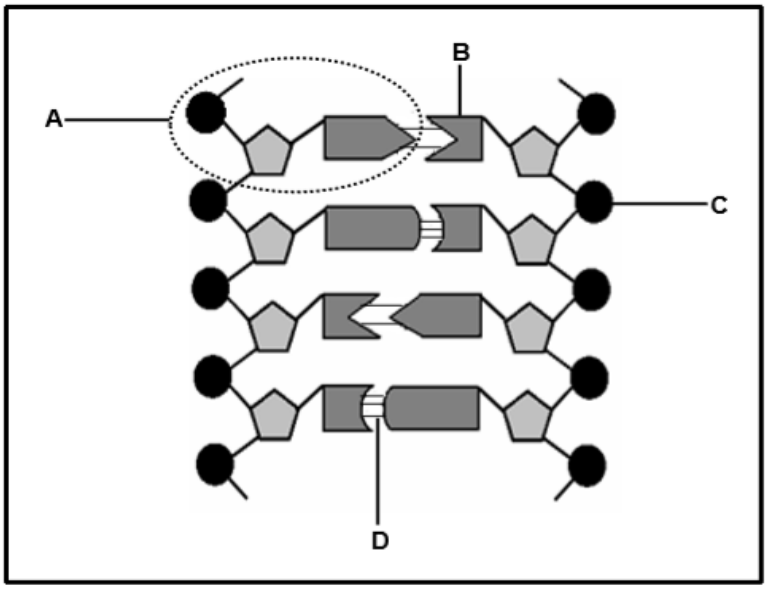
Indicate whether each of the statements in COLUMN I applies to **A ONLY**, **B ONLY**, **BOTH A AND B or NONE** of the items in COLUMN II. Write **A only**, **B only**, **both A and B,** or **none** next to the question number (3.1 to 3.3) in the ANSWER BOOK.

COLUMN I		COLUMN II	
3.1	Discovery of DNA	A B	Mendel Darwin
3.2	Structure of a DNA molecule	A B	Helix Double Helix
3.3	Location of DNA	A B	Nucleus Mitochondria

(3 x 2) **(6)**

QUESTION 4 *(GDE, Jun. 2019, Paper 2)*

The diagram below represents a portion of a DNA molecule.



6.1 Identify **B** and **C.** (2)

6.2 Name:

(a) Monomer **A** (1)

(b) TWO scientists who received a Nobel prize for discovering the DNA molecule **(2)**

(c) ONE organelle in a cell where DNA is located (1)

(6)

QUESTION 5 *(DBE, Nov. 2020, Paper 2)*

Describe the location and structure of DNA. **(9)**

Session 3: DNA replication and DNA profiling

EXAM GUIDELINE

- Process of DNA replication:
  - When in the cell cycle it takes place
  - Where in the cell it takes place
  - How DNA replication takes place (names of enzymes not required)
  - The significance of DNA replication
- Interpretation of DNA profiles
- Uses of DNA profiles

NOTES & EXAM TIPS

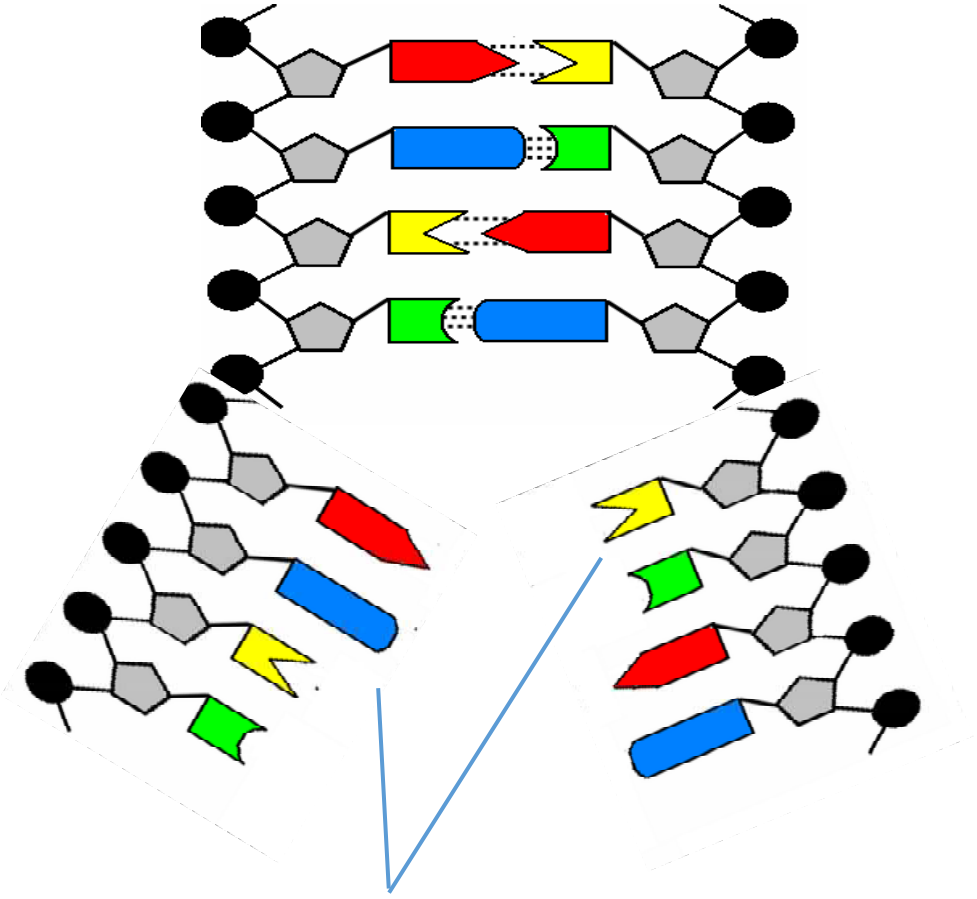
DNA replication

- Takes place during **interphase** before **mitosis** or **meiosis** begins.
- It is the process during which **DNA** makes another **exact copy** or **replica** of itself.

Process of DNA replication

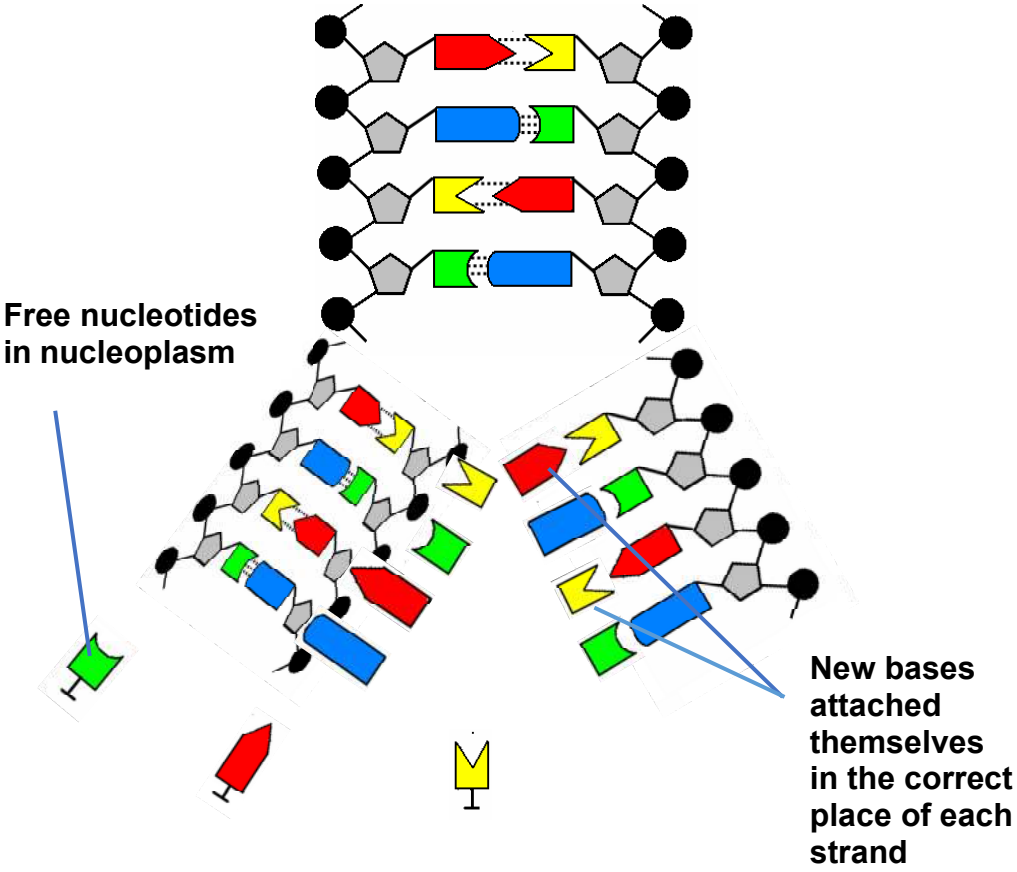
- The **DNA** helix **unwinds**.
- Weak **hydrogen bonds** between nitrogenous bases **break** and two DNA strands **unzip**(separate).
- Each **original DNA strand** serves as a **template** on which its **complementary strand** is built.
- Free **DNA nucleotides** build a DNA strand onto each of the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

Step 1: DNA molecule unwinds and unzips



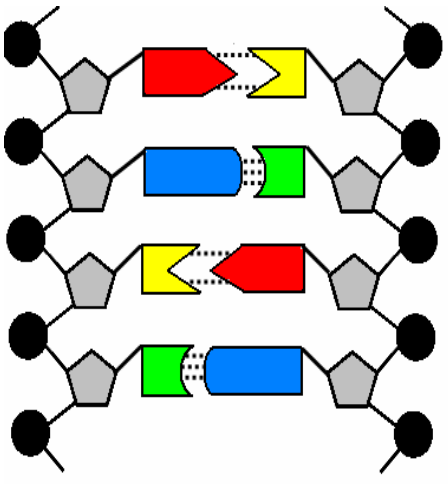
Weak hydrogen bonds break between the nitrogenous bases and the two strands separate.

Step 2: New bases attach themselves

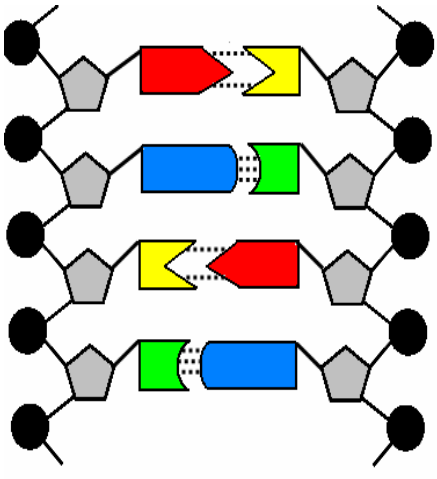


Step 3: TWO identical molecules are formed.

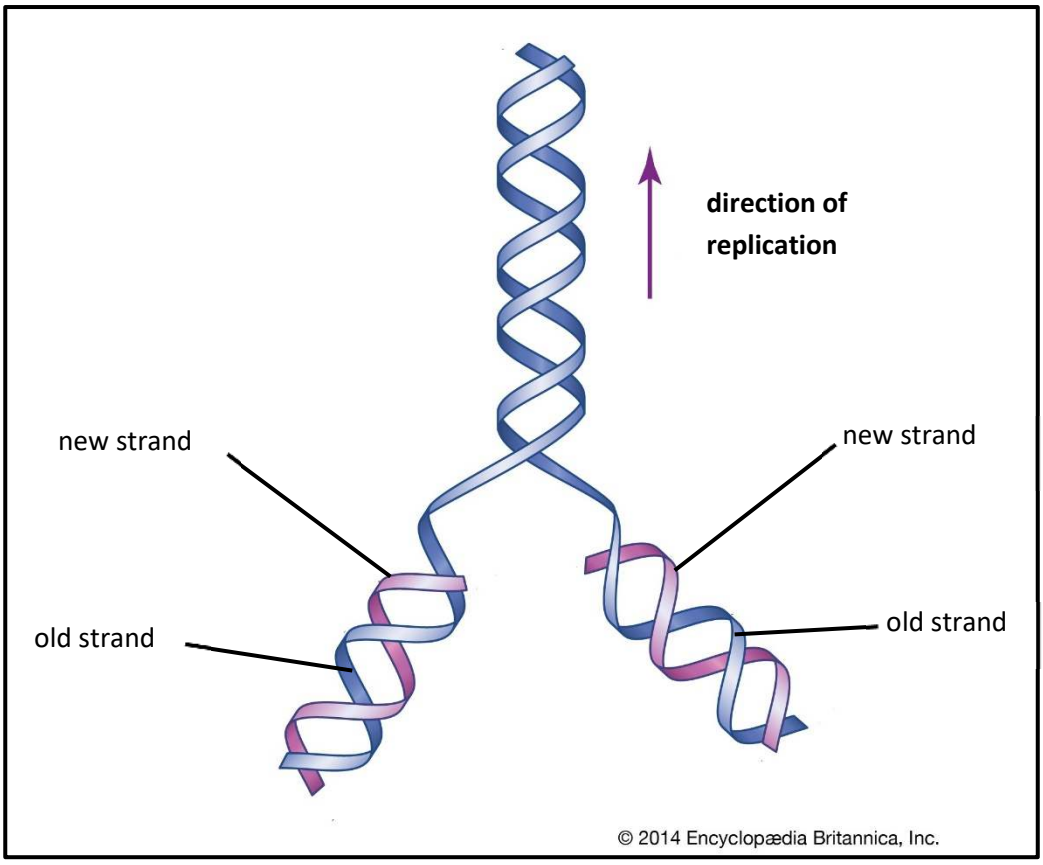
New DNA molecule 1



New DNA molecule 2



- **Each molecule now becomes a double helix.**



DNA profiling

- **DNA profiling** is the process where a specific **DNA pattern,** called a **profile,** is obtained from a **person** or sample of **bodily tissue.**
- it can be described as an arrangement of **black bars** representing **DNA fragments** of a person.
- **Remember:** DNA profiling is a forensic technique used for example in criminal investigations, comparing criminal suspects' profiles to DNA evidence so as to assess the likelihood of their involvement in the crime. Therefore, a DNA profile is a picture made from a DNA sample (hair, saliva, blood etc.) So, when answering a question based on DNA profiling it is important to say that the **DNA profile** of the suspect matches the **DNA profile** of the DNA found at the crime scene.
- It is used to**:**
    - Solve **crimes**
    - Identify **bodies**
    - Identify **relatives**
    - Identify **paternity**

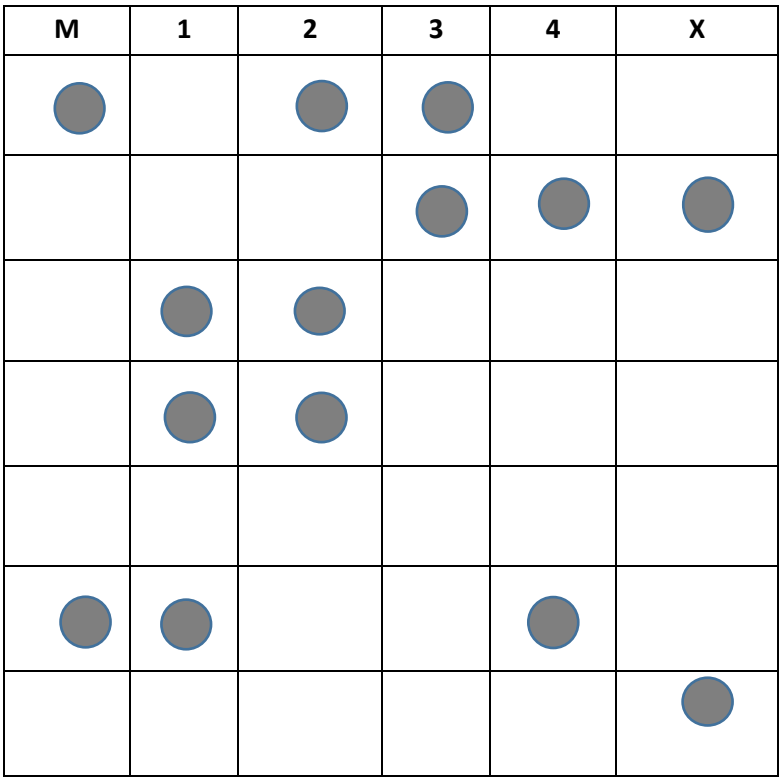
- A DNA profile of a sample of a suspect's bodily fluid or tissue is to be compared with a DNA profile of the sample found at the scene of a crime.
- The pattern of lines represents a person's specific genetic make-up.

TYPICAL EXAM QUESTIONS

QUESTION 1 *(Questions taken from various sources)*

Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A to D) next to the question number (1.1 to 1.5 in your ANSWER BOOK, for example 1.6 D.

1.1 The sample of a DNA profile shown below was used to determine if man **X** was the father of all four children. The sample shown are for the mother **M**, four children (1 to 4) and man **X**.



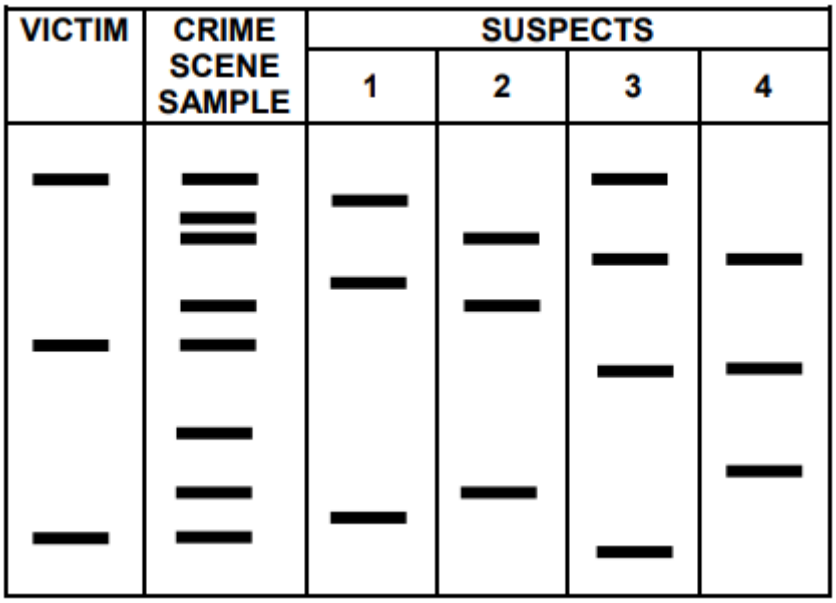
Which of the children have a different father?

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

1.2 Which ONE of the following indicates where the DNA molecule is likely to separate during DNA replication?

A Cytosine and guanine
B Phosphate ions and deoxyribose
C Ribose and adenine
D Ribose and thymine

1.3 A person was seriously injured during a fight. Samples of blood were taken from the injured man (victim) and the crime scene. These samples were compared with blood samples collected from four people (**1** to **4**) suspected of injuring the man. The results are shown below.



Which ONE of the suspects was definitely at the crime scene?

A 1
B 2
C 3
D 4

QUESTIONS 1.4 AND 1.5 ARE BASED ON THE DIAGRAM BELOW, SHOWING THE RESULTS OF A PARTICULAR PROCEDURE.

1.4 The procedure shown above is called …

A cloning.
B DNA replication.

C DNA profiling.
D fingerprinting.

1.5 Below is a list of possible uses of the procedure shown in the diagram above:
(i) Paternity testing
(ii) Matching of tissues for organ transplants
(iii) Identification from fingerprints
(iv) Screening for genetic disorders

Which combination shows the CORRECT uses of the procedure?

A (i), (ii), (iii) and (iv) Only
B (i), (ii) and (iv) Only
C (i), (ii) and (iii) Only
D (i) and (iv) **(10)**

QUESTION 2 *(Questions taken from various sources)*

Give the correct **biological term** for each of the following descriptions. Write only the term next to the question number (2.1 to 2.5) in your ANSWER BOOK.

2.1 The formation of an exact copy of the DNA in a cell (1)

2.2 The original strand upon which a new strand is developed (1)

2.3 The new strand that is made based on the sequence of nucleotides on the template (1)

2.4 Black bars representing DNA fragments of a person (1)

2.5 Phase in cell cycle when DNA replication occurs (1)
(5)

QUESTION 3 *(Questions taken from various sources)*

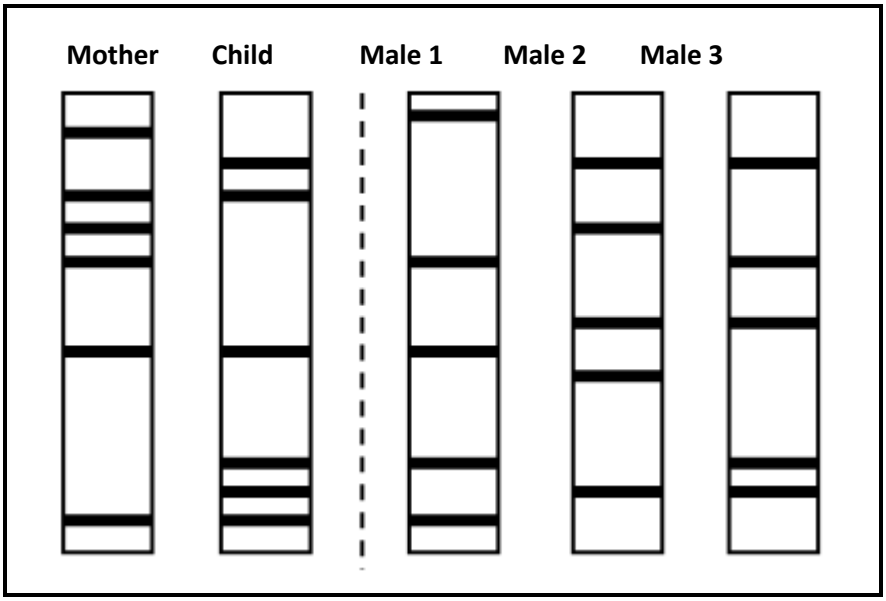
Indicate whether each of the statements in COLUMN I applies to **A ONLY**, **B ONLY**, **BOTH A AND B or NONE** of the items in COLUMN II. Write **A only**, **B only**, **both A and B,** or **none** next to the question number (3.1 to 3.3) in the ANSWER BOOK.

COLUMN I		COLUMN II
3.1	The phase in which DNA replication takes place	A: Interphase B: Anaphase
3.2	The place in the cell where DNA replication takes place	A: Mitochondrion B: Nucleus
3.3	DNA profiling	A: Paternity testing B: Identification of dead bodies

(3x2) **(6)**

QUESTION 4 *(DBE, May-June 2017, Paper 2)*

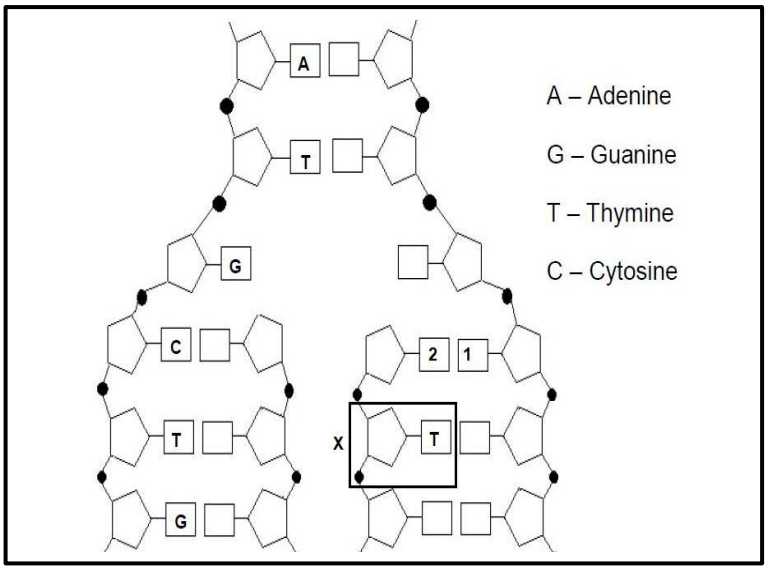
The diagram below shows a technique used in paternity testing.



4.1 Identify the technique shown above. (1)
4.2 Which male is the biological father of the child? (1)
4.3 Explain your answer to QUESTION 4.2. (3)
4.4 State TWO other uses of this technique. (2)
(7)

QUESTION 5 *(GDE, Sept. 2019, Paper 2)*

The diagram below represents a process involving DNA.



5.1 Identify the process illustrated in the diagram above. (1)

5.2 Identify the monomer **X.** (1)

5.3 Using the key provided, give the names for **1** and **2** respectively. (2)

5.4 What is the natural shape of the molecule represented? (1)

5.5 Name the type of bond that is formed between **1** and **2**. (1)

(6)

QUESTION 6 *(Limpopo, Sept. 2018, Paper 2)*

Read the text below and answer the questions

Watson and Crick were only two of many scientists working on figuring out the structure of DNA. They determined that the structure of DNA was a double-helix polymer, or a spiral of two DNA strands, each containing a long chain of monomer nucleotides, wound around each other.

According to their findings, DNA replicated itself. They, furthermore, discovered that DNA is the basis for heredity; it contains the patterns for constructing proteins in the body, including the various enzymes.

A new understanding of heredity and heredity disease was possible once it was determined that DNA consists of two chains twisted around each other, or double helixes, of alternating phosphate and sugar groups, and that the two chains are held together by bonds between pairs of nitrogenous bases – adenine (A); cytosine (C); thymine(T) and guanine(G).

6.1 Name the bond that joins two corresponding nitrogenous bases in a DNA molecule. (1)

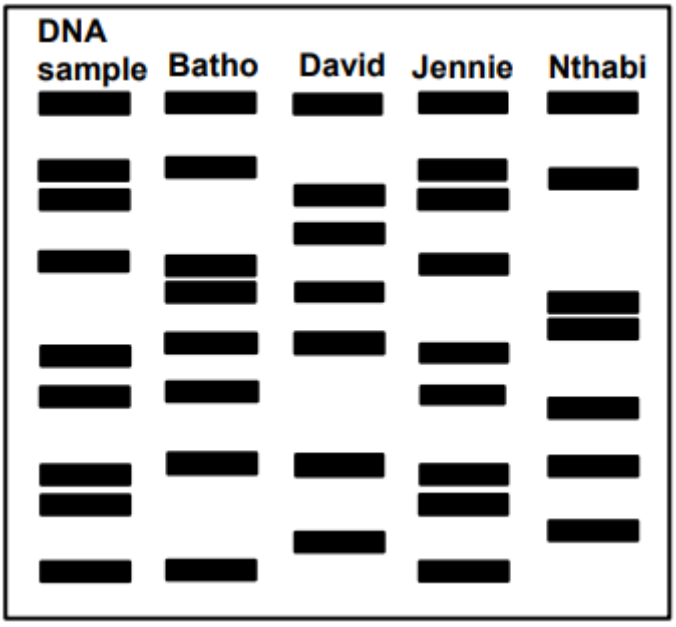
6.2 Arrange the nitrogenous bases in correct pairs as they were discovered by Watson and Crick. (2)

6.3 The scientists in the text discovered that DNA replicates itself.

(a) Describe how DNA replication occurs (4)
(b) Mention the phase of the cell cycle during which it occurs (1)
(c) Write down ONE importance of DNA replication (1)
(9)

QUESTION 7 *(GDE, Nov. 2020, Paper 2)*

Detectives were investigating a crime scene and found blood on a broken window. They suspected that the blood was that of the criminal. To identify the criminal, they analysed a DNA sample from the blood and compared it to that of four suspects.
The diagram below was produced:



7.1 Name the technique that was used to identify the criminal. (1)

7.2 Who is the possible criminal? (1)

7.3 Explain your answer to QUESTION 7.2. (2)

7.4 State ONE other use of the technique identified in QUESTION 7.1. (1)

(5)

QUESTION 8 *(GDE, Nov. 2019, Paper 2)*

Explain how DNA profiling is used in paternity testing. **(6)**

Session 4: RNA: location, structure and function.

Protein synthesis

EXAM GUIDELINE

RNA: location, structure and function

- Location of RNA:
  - mRNA is formed in the nucleus and functions on the ribosome
  - tRNA is located in the cytoplasm

- Structure of RNA
  - A single-stranded molecule consisting of nucleotides

- Three components of an RNA nucleotide:
  - Nitrogenous bases
    - Four nitrogenous bases of RNA:
    - adenine (A), uracil (U), cytosine (C), guanine (G)
  - Sugar portion (ribose in RNA)
  - Phosphate portion

- Stick diagram of mRNA and tRNA molecules to illustrate their structure
- Function of RNA:
  - RNA plays a role in protein synthesis

Protein synthesis

- The involvement of DNA and RNA in protein synthesis:
  - **Transcription**
    - The double helix DNA unwinds.
    - The double-stranded DNA unzips/weak hydrogen bonds break
    - to form two separate strands.
    - One strand is used as a template
    - to form mRNA
    - using free RNA nucleotides from the nucleoplasm.
    - The mRNA is complementary to the DNA.
    - mRNA now has the coded message for protein synthesis.

- mRNA moves from the nucleus to the cytoplasm and attaches to the ribosome.
- **Translation**
  - Each tRNA carries a specific amino acid.
  - When the anticodon on the tRNA
  - matches the codon on the mRNA
  - then tRNA brings the required amino acid to the ribosome.
    (Names of specific codons, anticodons and their amino acids are not to be memorised.)

  - Amino acids become attached to each other by peptide bonds
  - to form the required protein.

- Simple diagram to illustrate transcription and translation in protein synthesis

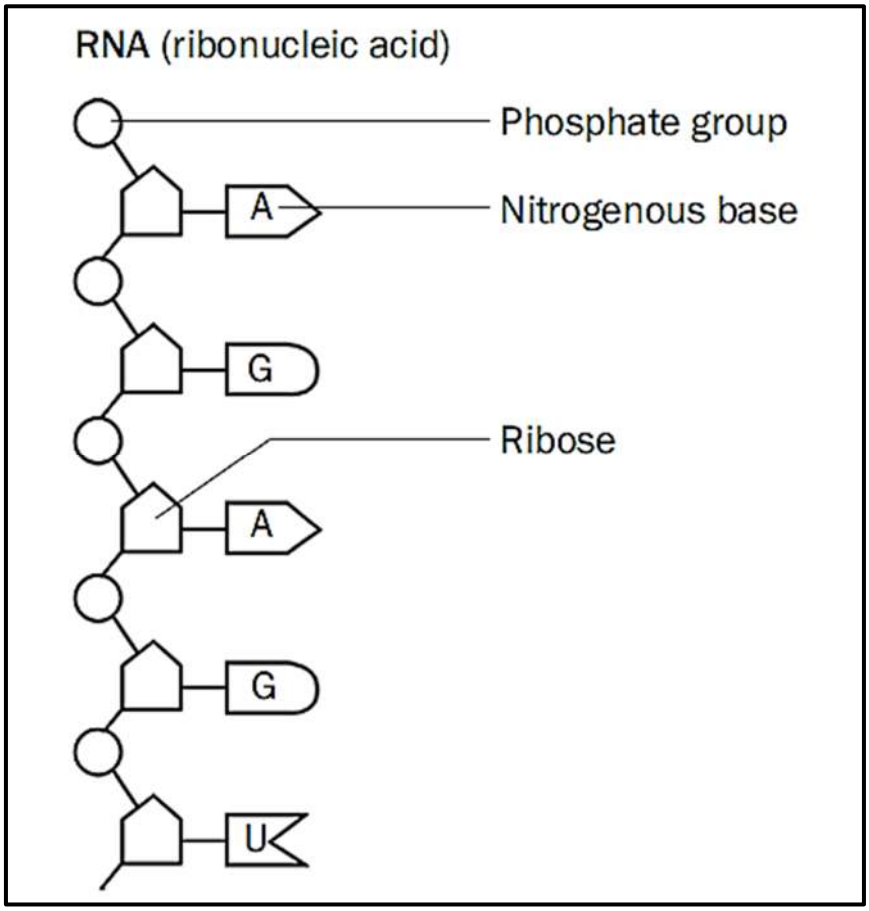
NOTES & EXAM TIPS

Location of RNA:

- Messenger RNA (mRNA) is formed in the nucleus but then enters the cytoplasm where it attaches to ribosomes.
- Ribosomal RNA (rRNA) is found in the ribosomes in the cytoplasm of the cell.
- Transfer RNA (tRNA) is found freely in the cytoplasm of the cell.

Structure of RNA

- RNA is a **single-stranded** molecule made up of **nucleotides**
- Each nucleotide is made up of a **ribose sugar**, a **phosphate group** and four different **nitrogenous bases**
- **adenine, uracil, guanine** and **cytosine** (**A, U, G** and **C**)
- The phosphate group alternates with the ribose sugar
- and the nitrogenous base is attached to the ribose sugar



How to recognize an RNA molecule

- ✓ **Single-stranded** molecule
- ✓ Contains **uracil (U)** instead of **thymine (T)**

- There are **three** types of **RNA:**
- **Messenger RNA (mRNA)**
  - Acts as a **template** for **protein synthesis**
  - mRNA is made up of many **bases** arranged in triplets called **codons**
- **Transfer RNA (tRNA)**
  - **Bases** in tRNA are arranged in triplets called **anticodons**
  - tRNA has a place of attachment for an **amino acid**
- **Ribosomal RNA (rRNA)**
  - Make up an integral **part** of the **ribosome**, the protein synthesis machinery in the cell. (Not examinable).

The role of RNA

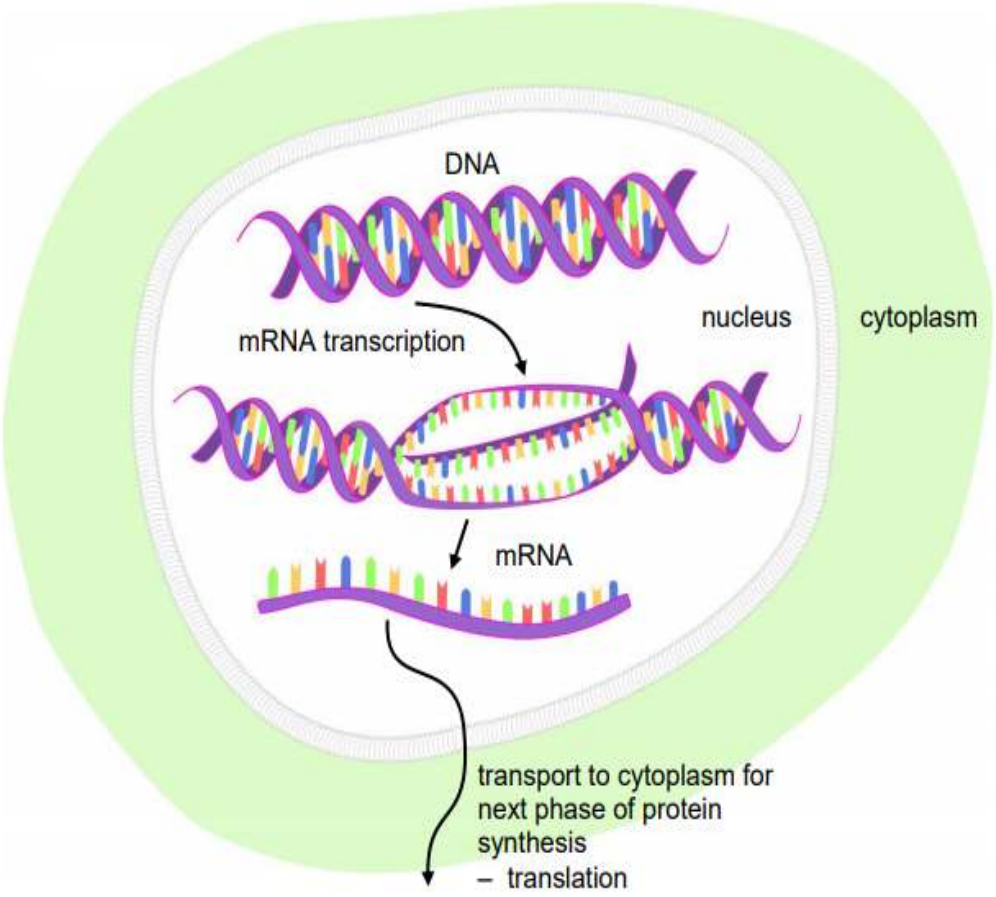
The three types of RNA are very important to the process of protein synthesis, with each type playing a unique role.

The process of protein synthesis

Protein synthesis takes place in two steps namely transcription and translation.

Transcription (Happens in nucleus)

- The double helix DNA unwinds.
- The double-stranded DNA unzips/weak hydrogen bonds break
- to form two separate strands.
- One strand is used as a template
- to form mRNA
- using free RNA nucleotides from the nucleoplasm.
- The mRNA is complementary to the DNA.
- mRNA now has the coded message for protein synthesis.

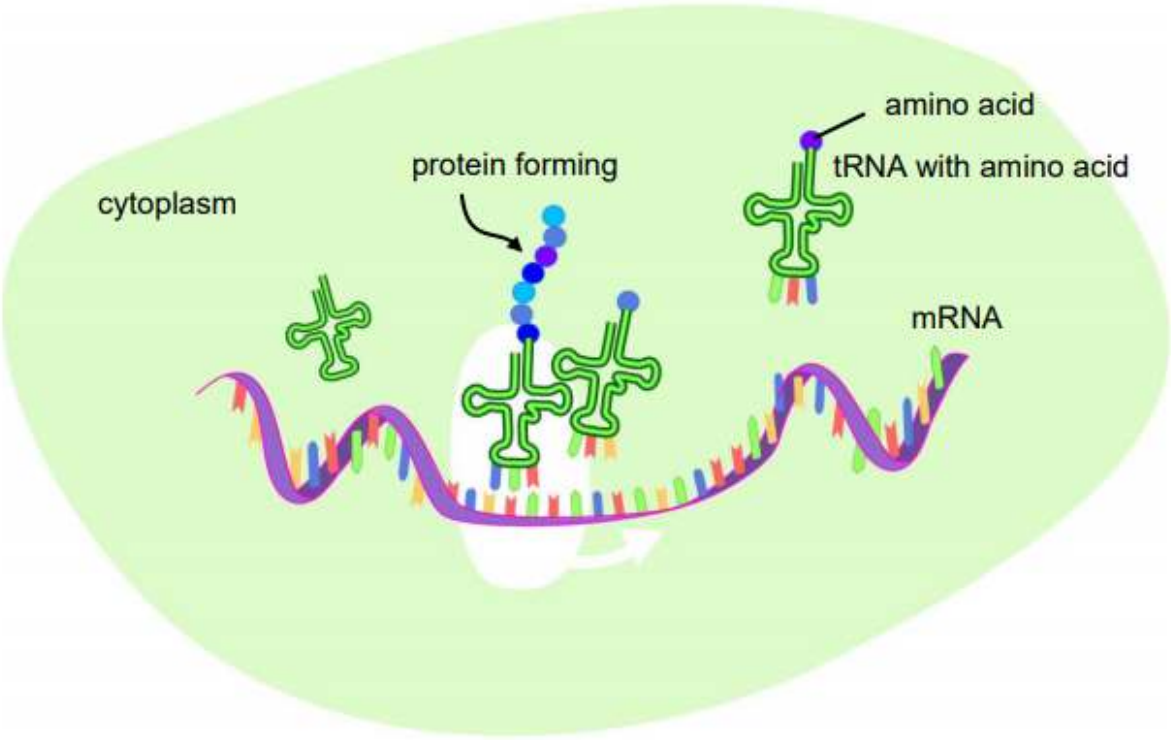


Transcription

Translation (Happens at the ribosome in the cytoplasm)

- Each tRNA carries a specific amino acid.
- When the anticodon on the tRNA
- matches the codon on the mRNA
- then tRNA brings the required amino acid to the ribosome.

- Amino acids become attached by peptide bonds to form the required protein



Translation

REMEMBER:

DNA	RNA
T – A	U – A
G – C	G - C

Three consecutive nitrogenous bases on the DNA strand are called the base triplet.
The three corresponding nitrogenous bases on the mRNA strand are called a codon.
The three corresponding nitrogenous bases on the tRNA strand are called an anti-codon.

TERMINOLOGY

Biological term	Description
Base pairing	Adenine (A) always bonds to thymine (T) and guanine (G) with cytosine (C) in DNA molecule, to ensure the precision of DNA replication
Chromatin	Tangled network of chromosomes located within the nucleus
Chromatid	The individual threads that form a chromosome
Centromere	Structure joining two threads of a chromosome
Chromosome	A structure made up of two chromatids joined by a centromere that carries the hereditary characteristics within the DNA
Chromatin network	Visible as thread-like structures in the nucleus of an inactive cell
Nucleolus	Structure in the nucleus responsible for forming ribosomal RNA
Nucleoplasm	That part of the protoplasm within the nucleus
Cytoplasm	That part of the protoplasm outside the nucleus.
Ribosome	Structure that is the site of protein synthesis
Gene	Segment of a chromosome that controls each characteristic/ a unit of sequenced pieces of DNA that carry the genetic information that will determine the hereditary characteristics of an organism.
Hereditary	Characteristics that are passed from parents to offspring
DNA	Nucleic acid that is a constituent of chromosomes
Helix	Coiled (natural) shape of a DNA molecule
RNA	Type of nucleic acid that occurs as a single strand / nucleic acid that contains uracil

Nucleotide	Building blocks of nucleic acids consisting of a sugar, a base and a phosphate
Replication	The formation of an exact copy of the DNA in a cell
Template	The original strand upon which a new strand is developed
Complementary strand	The new strand that is made based on the sequence of nucleotides on the template
Cytosine	The base that pairs off with guanine
Thymine	The base that pairs off with adenine
Uracil	The base found in RNA and not DNA
Hydrogen bonds	The chemical bonds which link base pairs in the DNA molecule
DNA	(Deoxyribonucleic acid) forms the chromosomes in the nuclei of all living cells and carries the hereditary information of the organism. The DNA molecule is a double helix (twisted) strand.
DNA Replication	Process involving the formation of two new identical DNA molecules from an original DNA.
Enzyme	A protein that speeds up a chemical reaction / a catalyst
Codon	The three adjacent bases found on a mRNA molecule
Anticodon	The three adjacent bases found on a tRNA molecule that will determine which amino acid will be brought to the ribosome
Transcription	The synthesis of mRNA from a DNA template
Translation	The process of converting the information carried by m-RNA to the correct sequence of amino acids to form a particular protein
RNA	(Ribose nucleic acid) a single strand, located in the nucleoplasm and cytoplasm. The RNA molecule is always a single strand of nucleotides. Remember that the RNA contains **Uracil** instead of Thymine (**A, G, C** and **U**). RNA is responsible for protein synthesis.
Synthesis	Building up of separate parts into a whole

Amino acid	The basic building block of a protein molecule
Peptide link	A link between two adjacent amino acids
Monomer	A single unit that makes up a larger molecule
Polymer	A large molecule which is formed from many small molecules (monomers)
Mutation	A sudden and relatively permanent gene / chromosomal change
Mitochondrial DNA	The type of DNA found only in the mitochondrion
Messenger RNA (mRNA):	Responsible for carrying the genetic code that is transcribed from DNA, to specialized sites of the ribosomes where the information is translated for protein synthesis
Nitrogenous bases:	These are nitrogen containing molecules viz. Adenine, (A); Thymine (T); Guanine (G); Cytosine (C) and Uracil (U).
Nucleotide:	The building block (monomers) of RNA and DNA. Each nucleotide consists of a pentose sugar, a phosphate ion and a nitrogenous base.
Ribosomal RNA (rRNA)	Form the ribosomes and produce the proteins, based on the information received from the tRNA
Transfer RNA (tRNA)	Has anticodons, which codes for a specific amino acid. The anticodons are complementary to the mRNA codon, during the production of proteins.
Genome	All the genes present in an organism

TYPICAL EXAM QUESTIONS

QUESTION 1 *(Questions taken from various sources)*

Various options are provided as possible answers to the following questions. Choose the correct answer and write only the letter (A to D) next to the question number (1.1 to 1.5 in your ANSWER BOOK, for example 1.6 D.

1.1 The three molecules that make up a nucleotide are ...

A water, sugar and a phosphate group.
B a nitrogenous base, water and sugar.
C a phosphate group, sugar and a nitrogenous base.
D water, a nitrogenous base and a phosphate group.

1.2 During translation, the type of amino acid that is added to the growing polypeptide depends on the …

A codon on the mRNA only.
B anticodon on the tRNA to which the amino acid is attached only.
C codon on the mRNA and the anticodon on the tRNA to which the amino acid is attached.
D anticodon on the mRNA only.

1.3 How many nitrogenous bases form a codon?

A 9
B 12
C 3
D 6

1.4 The table below shows the anti codons of tRNA that code for different amino acids found in human protein.

ANTI-CODONS OF tRNA	AMINO ACIDS
CAA	Valine
CCC	Glycine
CGU	Alanine
AAA	Phenylalanine
UCG	Asparagine
UAC	Methionine
GGU	Proline
AGC	Tryptophan
UCA	Serine

What is the corresponding amino acid for the DNA base triplet **TCG**?

A Alanine
B Tryptophan
C Serine
D Asparagine

1.5 A structural difference between DNA and RNA is …

A DNA is shorter than RNA.
B DNA has 4 different nitrogenous bases and RNA only 2.
C the sugar in RNA is ribose and in DNA deoxyribose.
D RNA is a double strand and DNA a single strand.

QUESTION 2 *(Questions taken from various sources)*

Give the correct **biological term** for each of the following descriptions. Write only the term next to the question number (2.1 to 2.5) in your ANSWER BOOK.

2.1	Synthesis of mRNA from DNA	(1)
2.2	The nitrogenous base found in RNA but not in DNA	(1)
2.3	The bonds between amino acids in a protein molecule	(1)
2.4	The process of converting the information carried by m-RNA to the correct sequence of amino acids to form a particular protein	(1)
2.5	The basic building block of a protein molecule	(1)
		(5)

QUESTION 3 *(Questions taken from various sources)*

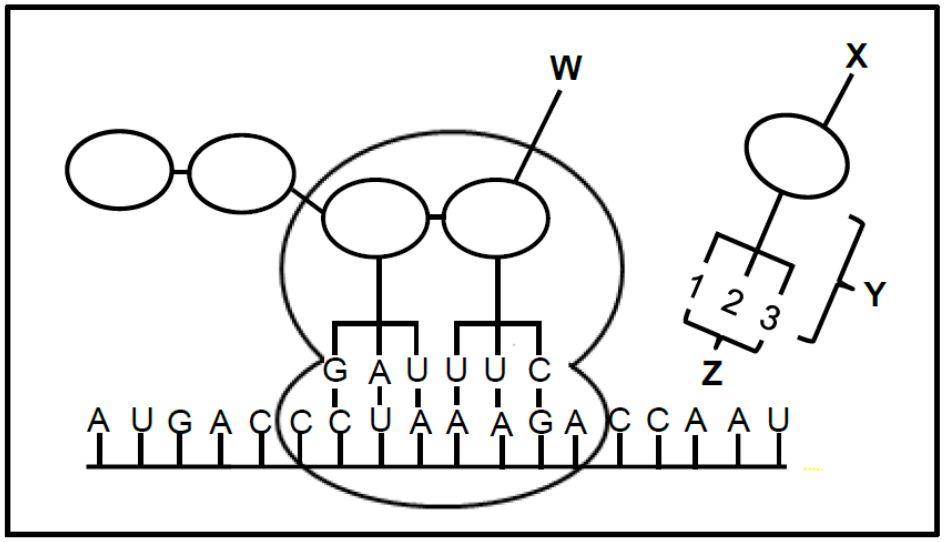
Indicate whether each of the statements in COLUMN I applies to **A ONLY**, **B ONLY**, **BOTH A AND B or NONE** of the items in COLUMN II. Write **A only**, **B only**, **both A and B,** or **none** next to the question number (3.1 to 3.3) in the ANSWER BOOK.

COLUMN I	COLUMN II
3.1 Contains uracil	A: DNA B: RNA
3.2 tRNA	A: Cytoplasm B: Nucleus
3.3 mRNA	A: Transcription B: Translation

(3x2) **(6)**

QUESTION 4 *(DBE, Nov. 2019, Paper 2)*

The diagram below shows part of a process involved in the production of a protein.



4.1 Identify:

(a) Molecule **Y** (1)

(b) The group of nitrogenous bases **Z** (1)

4.2 If **X** is the next amino acid required after **W,** then identify:

(a) Nitrogenous bases **1, 2** and **3** (2)

(b) The base triplet that codes for **X** (2)

(6)

QUESTION 5 *(DBE, Nov. 2019, Paper 2)*

Describe the process of transcription **(6)**

QUESTION 6 *(DBE, Nov. 2018, Paper 2)*

Describe the structure of RNA in a cell. . **(10)**