



# Etege Menen Girls' Boarding Secondary School

## Biology Department

### Grade 11



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# UNIT 1

## THE SCIENCE OF BIOLOGY

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# UNIT ONE

## THE SCIENCE OF BIOLOGY

### 1.1 The methods of science

#### 1.1.1 What is the science of biology?

- ❖ Biology is the science of life and living organisms.
- ❖ Biology deals **structure, function, growth, evolution** and **distribution** of organisms
- ❖ An organism is a living things made from **one cell** or **many cells**.
  - **Unicellular organisms;** made up of one cells  
E.g. Amoeba, bacteria
  - **Multicellular organisms;** made of many cells  
including animals, plants and fungi

# Some of the sub-disciplines of biology:

- ❖ **Astrobiologists;** investigation of the possibility of life on other planets
- ❖ **Biomedical research** including the development of new drugs and vaccines.
- ❖ **Microbiologist;** study on micro-organisms of all kinds function.
- ❖ **Paleontologist; deal about ancient life.**
  - is try to find out the way in which **life began on Earth** and how it has evolved from simple life forms into more complex ones.
  - Mainly concerned with the **study of fossils**
  - Use evidence from studies of chemistry of ancient rocks to estimates when and how new life forms appeared on the planet.

# Contd.

- ❖ **Physiologist:** the study of physical and chemical functions of tissue, organs and organ system of the body.
- ❖ **Ethologist:** is the study of **animal behaviour** in their natural habitat
- ❖ **Ethnologist:** distribution, relationship and origin of the race of mankind
- ❖ **Entomologist:** the study of insects
- ❖ **Oncologist:** deal with the **prevention, diagnosis** and **treatment** of **cancer**
- ❖ **Geneticist;** deals with heredity and variation
- ❖ **Neurologist:** study the complex structure of neuron and its coordination
- ❖ **Parasitologists:** the study of parasites
- ❖ **Biochemists:** the scientific study of the **chemical substance, process** and **reaction** that occur in living organisms.

# What is science?

- ❖ The word science comes from the Latin word **scientia**, which means **'knowledge'**.
- ❖ Science is a unique system of acquiring knowledge based on the **scientific method**.
- ❖ Science is a systematic enterprise that builds and organizes knowledge in the form of testable explanation and prediction about the universe
  - **Experimental science** the use of experiments to obtain information
  - **Applied science** the use of scientific research to meet certain human needs

## 1.1.2 Scientific methods

- ❖ Scientific method is the **process by which scientists approach their work.**
- ❖ It is a process by which **scientist approach to solve problems.**
- ❖ Biologist use scientific methods to **study living world**
- ❖ It is a way to **ask and answer scientific question** by making and doing experiment.
- ❖ It is **scientific procedures** adopted by the scientists to find out facts and scientific truth

# The steps of the scientific method are as follows;

## 1. Ask a question or identify problems

- ❖ Refer to the explanation of a specific observation.
- ❖ E.g. **why tomato seeds don't grow inside tomatoes?**

## 2. Background of research:

- ❖ Collect data or information on scientific question (s).
- ❖ The data can be obtained from book, journals, magazines and internets
- ❖ It is used to formulate hypothesis
- ❖ **E.g. we find out that there are substances in plants that control growth, called growth regulators.**



# 3. Hypothesis:

- ❖ **Hypothesis** an educated guess about what will be the explanation of an observation.
- ❖ for example hypothesis for the above question
  - *'There are chemicals in tomatoes that stop the seeds from growing whilst they are still in the tomatoes themselves.'*
- ❖ **Important thing about hypothesis**
  - **Tentative explanation** for the observation
  - **Reflect experience** based on previous knowledge, facts and general principles
  - **Are testable** by an experiment.
  - Always lead to **make predictions**
- ❖ **Prediction** an educated guess for what will be the out come of an experiment.
  - *For example 'Seeds covered in tomato juice will not germinate as well as seeds covered in water'*

# Two pattern of reasoning to develop hypothesis

- ❖ In developing hypothesis, two pattern of reasoning are required
  - 1. Inductive reasoning:** logic precedes from specific observations to general conclusions.
  - 2. Deductive reasoning;** logic precedes from general to specific condition

# 5. Experimentation to test the hypothesis

- ❖ Is the process of testing hypothesis or prediction by gathering data under controlled condition
- ❖ It determine whether the observations agree with or conflict with hypothesis.

## Controlled experiment consists

### 1) Control group

- Untreated group in an experiment in which the experimental groups are compared with.
- Acts as a **'standard' for comparison.**

### 2) Experimental group

- Group in an experiment which is being experimented on in order to compare with the control group
- Only differ in the presence of independent variable

### E.g. Investigate saliva has an effect to bring any change on starch

- Test tube A=have 2% starch and 2cc saliva; **experimental group**
- Test tube B= have 2% starch and 2ccwater ; **control group**

# Contd.

## **6. Analyse results and draw conclusions:**

- ❖ The results are usually written in the form of a statement that explains or interprets the data.

## **7. Accept or reject the hypothesis;**

- ❖ It seems as though the hypothesis is along the right lines;

## **8. Report results:**

- ❖ It is important that the scientist reports the hypothesis, experiments and conclusion to other scientists.

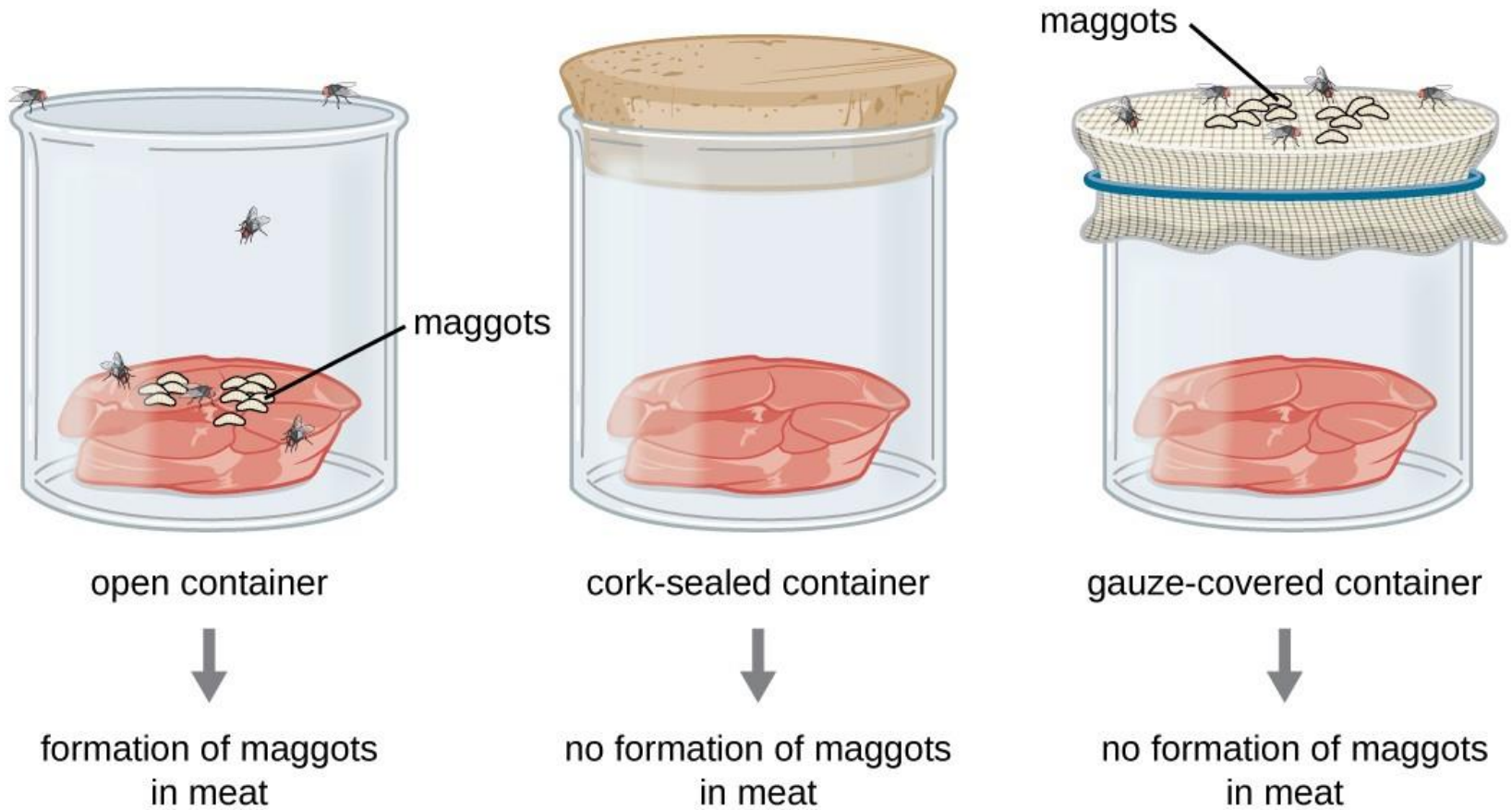
# How scientific method disprove the idea of spontaneous generation?

- ❖ **Spontaneous generation** states the appearance of living organisms from non-living matter.
- ❖ **Spontaneous generation** suggest that;
  - Non-living object can gives rise to living organisms
  - An organisms could arise from lifeless matter
    - ✓ **E.g. rotten meat had turned into flies!**
    - ✓ **Muddy soil gives rise to frogs!**
- ❖ **Francesco Redi, Lazzaro Spallanzani** and **Louis Pasteur** used the scientific method to disprove the idea of spontaneous generation. How?

# Francesco Redi experiment on spontaneous generation

- ❖ He used wide-mouth jars containing meat. Some jars were left open to the air. Others were covered with a piece of gauze.
- ❖ After several days, maggots and then flies could be seen in the open jars, but none appeared in the closed jars.
- ❖ Redi hypothesized that only flies could produce more flies.
- ❖ Redi was able to **conclude that flies cannot be produced from rotting meat.**

# Francesco Redi experiment disprove the idea of spontaneous generation

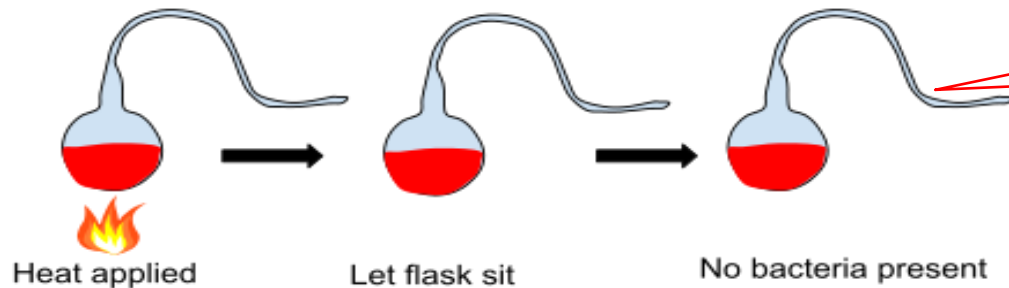


# Louis Pasteur; swan neck flask experiments

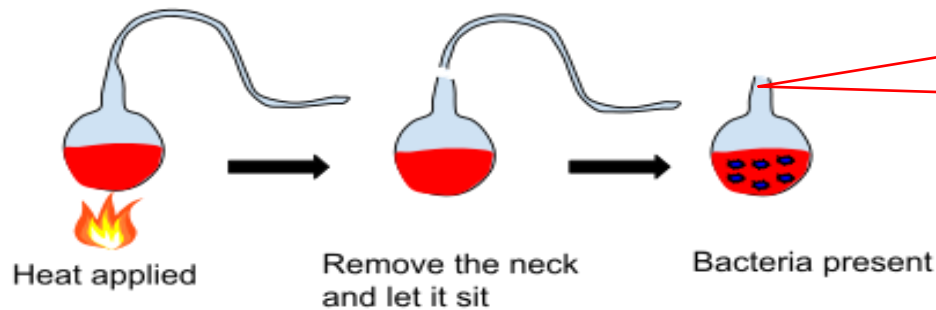
- ❖ Many people still believed that micro-organisms could arise by spontaneous generation.
- ❖ Louis Pasteur to disprove this. In 1859,
- ❖ **Pasteur carried out experiments to show that the micro-organisms that caused wine and broth to go cloudy came from the air and was not made from the broth itself.**
- ❖ Pasteur boiled broths in swan-necked flasks to kill any microorganisms
- ❖ **Pasteur use swan-necked flasks on his experiment because.**
  - ❖ To trap particles from the air that might enter the flask before reaching broth
- ❖ **He treated the flasks in one of three ways:**
  - ❖ **He left some of them as they were.**
  - ❖ **He broke** the necks on some.
  - ❖ **He tilted** others to allow the dust in the low part of the neck to mix with the broths.
- ❖ The broths in the second two groups of flasks turned cloudy (due to the presence of micro-organisms) within days.
- ❖ The broths in the first group remained clear.



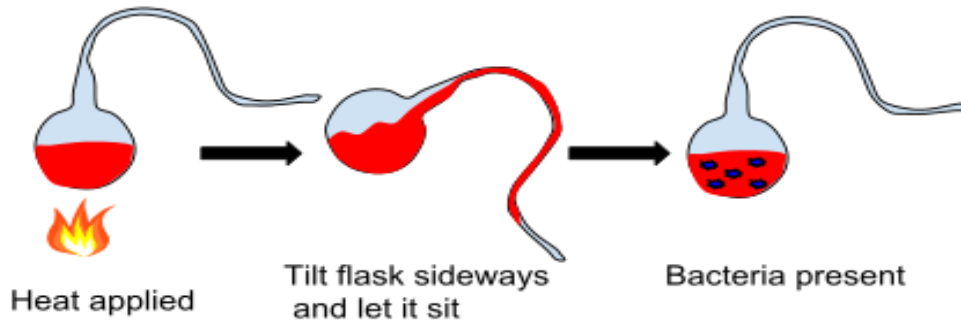
# Louis Pasteur; swan neck flask experiments



'Swan' neck traps microorganisms



Microorganisms enter the open flask and grow rapidly



## 1.1.3 Scientific experiments

- ❖ Scientific experiments try to **establish cause and effect** relationship in nature.
- ❖ The factor that can change in an experiment is called **Variable**.
- ❖ There are three basic experimental variables
  - **Independent variable(IV): is changed (manipulated) by the experimenter**
  - **Dependent variable(DV): is measured by the experimenter**
  - **Controlled variables (CV):** variable have been **kept constant (controlled)** to avoid influencing results
  - **Confounding variable** a factor that can't be controlled which may influence the result of the experiment

# Contd.

- ❖ **E.g. Investigate saliva has an effect to bring any change on starch**
  - **Independent variable (IV)**=Saliva
  - **Dependent variable (DV)**= Starch
  - **Confounding variable (CV)**=Temperature, pH condition, concentration of saliva
- ❖ **The effect of fertilizer on plant growth**
  - **Independent variable (IV)**= Fertilizer
  - **Dependent variable (DV)**=Plant growth
  - **Confounding variable (CV)**= Temperature, Nutrients, CO<sub>2</sub> concentration, water

# Contd.

- ❖ **Fair test** is an experiment in which the **only** difference between different repeats of the experiment is the **different values of the independent variable, all other factors** that could affect the outcome have been **kept constant** (they have been controlled)
- ❖ Fair test is an experiment in which all factor that could affect the out come of an experiment remain constant expect independent variable

# 1.1.4 Accuracy, reliability and validity in scientific experiments

## Accuracy

- ❖ Accuracy **how precisely something** has been measured or counted
- ❖ Refers to how close an experimental observation lies to the true value
- ❖ To measure volume, you could use:
  - a syringe
  - a measuring cylinder
  - Pipette
  - a burette

# Reliability

- ❖ **Reliability** is a measure of how dependable and consistent the results of an experiment0.
- ❖ It concern with the repeatability and dependability of results of the experiment
- ❖ So, reliability is ‘**consistency**’ or ‘**repeatability**’ of an experiment

# There are several things to increase the reliability of experiments.

- 1) **Standardise all our procedures;** so that we always do exactly the same thing.
- 2) **Performing repeated experiments** this allows us to
  - Spot any **anomalous results**
    - ✓ **anomalous results** are really odd results that do not fit the general pattern
  - Calculate an average result, which is likely to be more representative than any individual result
- 3) **Not to use personal judgment.**
- 4) **Have a 'standard'** to compare our experiment.

# Validity

- ❖ For our experiment to be valid, our result should be only due to the change in independent variable.
- ❖ A valid test refers to **whether an experiment measures what it says it is measuring.**
- ❖ **Controlled experiment** is used to increase the validity of an experiment
- ❖ It a state of being valid or genuine
- ❖ For the experiment to be valid, the results were only due to the changes in the independent variable.



# 1.1.5 Report writing on scientific experiments

- ❖ Biologists write a report on an investigation with a view to having it published in a scientific journal, such as **nature or science**.
- 1. **A title**, which states clearly what is being investigated
- 2. **A hypothesis**, stated clearly in terms of how the independent variable is expected to influence the dependent variable, often extended to a prediction for the particular experiment
- 3. **Procedure**; a clear description of the experimental procedure
- 4. **Results**; a full account of the results obtained
- 5. **Conclusion**; the conclusions that have been drawn from the results
- 6. **Evaluation**;
  - this is an honest assessment of the limitations of the procedure that has been used,
  - pointing out any unavoidable limitations and inaccuracies that arose
- 7. **Acknowledgements**

## 1.2 The tools of a biologist

### 1.2.1 Tools biologists use in the laboratory



#### 1. Microscope

- ❖ An instrument used to provides a magnified image of a tiny object

#### **Resolution;**

- ❖ Is the ability to distinguish between two points that are close together
- ❖ If resolution is poor, it will merge into one point and the detail of the image will be limited.

# Optical (Light) microscope

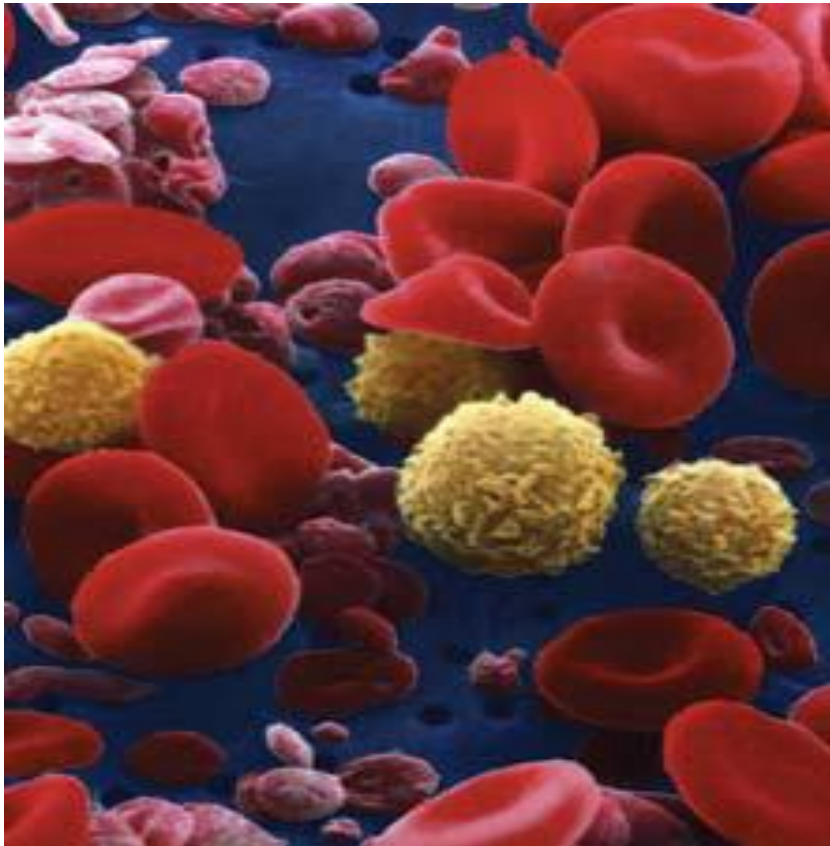
- ❖ **Use beams of light** to produce magnified images
- ❖ Relatively **less magnification** and **resolution power**
- ❖ Due to its low resolution power light microscope **is not used to see** cellular organelle such as **ribosome, mitochondria, chloroplast, endoplasmic reticulum**
- ❖ Used to study cell, tissues or individual organism
- ❖ **Used to study living material directly** through light microscope

# Electron microscope

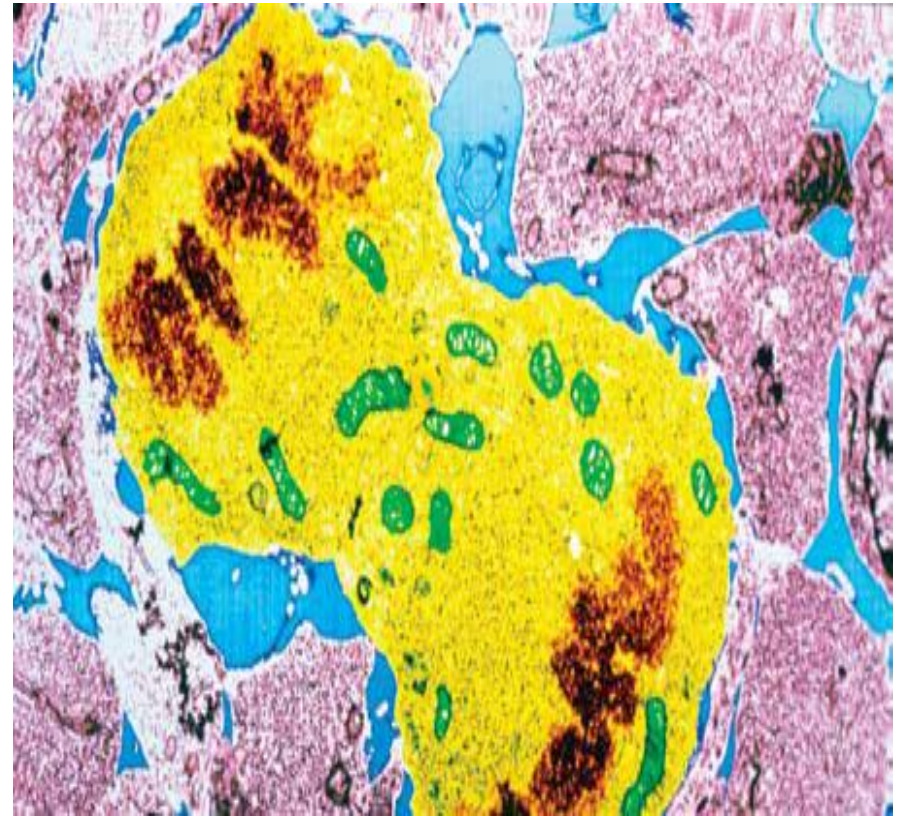
- ❖ Use a beam of electron to produce magnified images.
- ❖ It has highest magnification and resolution power.
- ❖ Its maximum **magnification power** is **2,000,000**.
- ❖ Resolving power of an electron microscope is **1000 times greater** than the resolving power of **optical microscope**.

## Scanning electron microscope    Transmission electron microscope

- ❖ Can show us three-dimensional shapes **surface** of cell (blood cells below).



- ❖ Shows the inside details of a cell



## 2. Dissecting equipment

- ❖ **Dissect** specimens to find out what they are like inside.
- ❖ **Dissect** to cut apart or separate tissue for anatomical study.
- ❖ Dissect used to study **internal organs**, such as the **heart ,kidney, lungs**.



# 3. Petri dishes

- ❖ Used especially to **grow bacterial cultures in the laboratory**
- ❖ Bacteria growing on **agar** in a Petri dish.
- ❖ Agar is a solid nutrient medium that is mainly extracted from red algae
- ❖ **Micropropagation** is technique of growing plants from just a few cells on special agars in Petri dishes.
  - It allows thousands of plants to be produced from just one 'parent' plant.
  - All the plants produced are genetically identical.
- ❖ **Petri dishes can also be used to:**
  - Show how effective different antibiotics are against certain types of bacteria
  - Show how well different concentrations of enzymes digest a substance

# Contd.

## 4. Balances

- Is apparatus used for measuring mass

## 5. Centrifuges

- Centrifuge machine that spins to separate solids from liquids
- **Separate solid particles from the liquid without the need to filter.**

### ❖ Ultracentrifuges

- Used to spin the tubes at a faster speed to separate extremely light particles in the bottom of the tube
- Used to separate the various components of animal and plant cells.

## 6. Measuring cylinders

- Used to measure volume liquids and gases



## 1.2.2. Tools of biologists use in the field

### 1. Quadrats

- ❖ It is placed randomly on the ground in order to count the number and type of organisms
- ❖ Quadrat a small frame used for **ecological or population studies**
- ❖ Used to estimate **the abundance of the organisms** in the area.
- ❖ Quadrats can also be used underwater.
- ❖ Biologists also use quadrats to show **how the numbers of a particular species changes across an area**



# Contd.

## 2. Transect line.

- **Transect line** a straight line through an area random having no specific pattern, purpose or objective **bias** tending towards a specific result
- Place the quadrat by the side of the transect line and record the abundance of the organisms in the quadrat.

## 3. Pitfall traps

- Used to catch many ground beetles and other insects that live on or in the soil

## 4. An insect net

- ❖ A type net used to collect flying insects
- ❖ A sweep net used to collect insects from grass and brush



## 5. A flow meter

- ❖ Used to measure the rate of flow of water



## 6. A pH kit

- ❖ Used to measure the pH of soil or water



## 7. A data logger

- ❖ Used to record information



## 8. A theodolite

- ❖ Used to measure the height of trees or of slopes in the area



## 9. GPS (Global Positioning System)

- ❖ Used to record positions quickly and accurately

## 10. A field microscope

- ❖ Used to investigate the structure of specimens in the field, whilst still fresh



# 1.3 The relevance and promise of biological science

- ❖ Some of the areas in which the relevance of biological science are involved
  - Agricultural
  - Medicine
  - Environments

# Biology and agriculture

- ❖ Biological science increase food supply through agricultural productivity.
- ❖ Biologists are carrying out research into how to produce crop plants that:
  - can **adapted** to the new conditions
  - are capable of **producing crop in short period of time**
  - are **resistant disease and drought**
  - are capable of giving **high quality products**



# Biology and medicine

- ❖ Some of biological Knowledge in medicine are;
  - Advise on effective methods of contraception
  - Educating people about the need to limit population growth.
- ❖ **Medical professional** have specialized biological knowledge. some of these are
  - **Medical laboratory technicians** who test samples required and provide reports for doctors
  - **Medical researchers** who work the ways in which disease-causing organisms function and are spread
  - **Radiographers**, who produce X-rays the diagnosis of disease
  - **Drug development researchers**, who develop new drugs to treat diseases

# Biotechnology

- ❖ Use microorganisms to make things people want. such as;
  - Cures for genetic diseases
  - Treatments for **degenerative diseases**, such as **Parkinson's disease** and **Alzheimer's disease**
  - Industrial processes to manufacture more biological products such as insulin
  - Producing drugs that are '**tailor-made**' to suit an individual's needs
  - Genetically modifying plants to meet a specific need.
  - **Cloning** of productive animals and plants
  - Production of **monoclonal antibodies**
  - Using **stem cells** to repair damaged organs

# 1.4 Biology and HIV /AIDS

- ❖ **AIDS** is short for acquired immune deficiency syndrome
- ❖ Caused by the human immuno deficiency virus (**HIV**).
- ❖ HIV infects **T-helper cells** that enable us to fight off other diseases.
- ❖ The reduction in the number of T-helper cells, many **opportunistic infections may occur** (including **pneumonia** and **tuberculosis**), together with rare cancers like **Kaposi's sarcoma**

## Contd.

- ❖ AIDS is largely a sexually transmitted disease (STD); there are **four main ways in which HIV can be transmitted**. These are:
  - **Unprotected intercourse with an infected person**
  - **Transfusion of infected blood or blood products**
  - **Sharing infected needles**
  - **From mother to child**

# How can biology help in the fight against AIDS?

- ❖ There are several methods of combating the spread of a disease. These are described below.
- ❖ Break the transmission pathway
- ❖ Produce drugs that kill the virus or at least stop it from reproducing.
- ❖ Produce a vaccine against the virus.

# Contd.

## ❖ **life cycle of HIV:**

- The entry phase
- Viral genetic material is converted to DNA
- The new DNA enters the host cell DNA
- The new DNA 'instructs' the cell to make more HIV

❖ **HIV** is a **retroviruses** can be treated by **antiretroviral drugs**

❖ **Retroviruses** is an RNA virus that converts its genetic information from RNA into DNA, this process is called **reverse transcription;**

# Contd.

- ❖ **Anti-retroviral drugs** slow down the progression infection to AIDS
- ❖ Different antiretroviral drugs target different stages in the life cycle of HIV.
- ❖ **High Activity Anti-Retroviral Treatment (HAART)** using anti-retro viral drugs in combination to act on different stages of the HIV life cycle.
- ❖ **The main advantage of HAART** breaking the life cycle of HIV in different stages
- ❖ **To reduce the spread of AIDS we should;**
  - Restricting the number of sexual partners.
  - Encourage men to be circumcised.
  - Not sharing infected needles.