BIOLOGY EXPERIMENTS USER GUIDE

ADVANCED SECONDARY LEVEL

Senior 6

FOREWORD

Dear teacher,

Rwanda Basic Education Board (REB) is honoured to present the user guide for Biology experiments and practical activities for advanced Level (S6). This booklet will serve as a guide to competence-based teaching and learning to ensure consistency and coherence in the learning of Biology.

In this booklet, special attention was paid to practical activities that facilitate the learning process in which students can manipulate concrete materials, develop ideas, and make new discoveries during activities carried out individually or in pairs/ small groups.

In competence-based curriculum, practical activities open students' minds and provide them with the opportunities to interact with the world, use available tools, collect data, and effectively model real life problems.

For efficiency use of this booklet, your role as a teacher is to:

- Plan your lessons and prepare appropriate teaching materials. \
- Engage students through active learning methods.
- Organize groups for students considering the importance of social constructivism.
- Provide supervised opportunities for students to develop different competences by giving tasks which enhance critical thinking, problem solving, research, creativity and innovation, communication, and cooperation.
- Support and facilitate the learning process by valuing students' contributions in the practical activities.
- Guide students towards the conclusion on the results of the experiments.
- Encourage individual, peer, and group evaluation of the work done and use appropriate competence-based assessment approaches and methods.

To facilitate you in your teaching activities, the content of this guide is self-explanatory so that you can easily use it. It is divided in 3 parts:

The part I explains the structure of this guide and gives you the general introduction on the role of practical activities and lab experiments in the implementation of CBC.

The part II gives the list of purchased Biology kits.

The part III explains selected practical activities and how you can facilitate them in lessons.

Even though this guide contains practical activities, they are not enough, as expert and experienced teacher, you can guide students to carry out more practical activities using improvised teaching resources.

I wish to sincerely extend my appreciation to the people who contributed towards the development of this guide, particularly REB and SPIU staff who organized the whole process from its inception. Special appreciation goes also to UR-CE , IEE and AIMS staff, teachers and independent experts in education who supported the exercise throughout. Any comment or contribution would be welcome for the improvement of this booklet for next versions.

Dr. MBARUSHIMANA Nelson

Director General, REB

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I wish to express my appreciation to the people who played a major role in the development and the editing of the Biology Experiments User Guide for Advanced secondary Level S6. It would not have been successful without their active participation.

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MURUNGI Joan

Head of CTLR Department

LIST OF ACRONYMS

REB: Rwanda Basic Education Board

CBC: Competence-based curriculum

ICT: Information Communication Technology

Lab: Laboratory

STEM: Science Technology Engineering and Mathematics

KBC: Knowledge Based Curriculum

SET: Science and Elementary Technology

IEE: Inspire, Educate and Empower Rwanda

AIMS: African Institute for Mathematical and Sciences

UR-CE: University of Rwanda - College of Education

Table of Contents

FOREWORD iii

ACKNOWLEDGEMENT v

LIST OF ACRONYMS vi

PART 1: GENERAL INTRODUCTION 1

1. Structure of the user guide 1

2. Laboratory experiments in the Competence Based Curriculum 1

3. Type of lab experiments 2

4. Organization, analysis, and interpretation of data 3

5. Organising lab experiments 3

PART II: LIST OF MATERIALS FOR BIOLOGY LAB 13

II.1 List of the Lab apparatus in schools 13

II.2 List of biology chemicals 26

PART III: EXPERIMENTS FOR S6 27

UNIT 1: Introduction to biodiversity 28

Use of quadrats and line transects to estimate populations in a local area 28

Estimate population using capture and recapture methods and Lincoln index 31

UNIT 3: Effect of human activities on ecosystem 34

Make trip to polluted sites and assess the impact of industrial sewage and fertilizer application on nearby land to wetlands and water bodies 34

UNIT 4: Blood circulatory system in animals 37

Investigate the effect of physical activity on the pulse rate and blood pressure 37

Dissection of grasshopper to indicate the major structures of circulatory systems in insects 39

Conduct dissection of rabbit to indicate the major structures of circulatory system in mammals 42

Observe permanent slides of blood vessels using a microscope and make comparisons 46

Observation of blood smear and draw the structure of blood cells 48

UNIT 5: Energy from respiration 52

Use simple combustion experiments with calorimeter to determine the relative energy values of different food substances 52

Carry out investigation showing the respiratory rate of germinating seeds or woodlice using respirometer 56

UNIT 6: Cellular respiration 60

Perform investigations to determine the effect of temperature and substrate concentration on the rate of respiration 60

Research on the quantity of ATP produced from anaerobic respiration 63

UNIT: 7: Excretion and osmoregulation 67

Conduct dissection to indicate the major structures of the kidney in rabbit 67

UNIT: 8: General principles of reception and response in animals 71

Dissection of eye of mammals (cow, goat) to identify the three layers of the human eyeball 71

Learners carry out activities on reverse color sense by cones 75

UNIT: 9: NERVOUS COORDINATION 78

Demonstrate electrical activity in the nerve of a frog 78

UNIT: 10: Phormonal coordination in animals 82

Simulation/video on the mode of function of endocrine glands 82

Simulation/video on hormonal disorders (gigantism and dwarfism) 84

Video / Simulations on negative feedback mechanism of hormonal action 87

Research on the necessity of hormone balance and the effects of imbalance and write a report 91

UNIT: 11: Skeletons, muscles and movement 95

Observe earthworms and insects to compare a hydrostatic skeleton and exoskeleton respectively 95

Use prepared slides of the three types of muscles and compare their characteristics. 99

Dissect a frog/toad heart to observe myogenic contraction 103

Use prepared slides and micrographs to compare structures of cardiac, smooth and skeletal muscles 106

Simulations/videos to demonstrate the structure and functioning of the sarcomere during muscle contraction 110

UNIT: 12: Human reproduction 114

Simulations/Video of the stages that bring about the fertilization and development of an embryo 114

Simulations/Video showing the stages of birth 117

UNIT: 13: Principles of gene technology 120

Visit local university, health center or forensic lab to observe the gel electrophoresis used to analyze proteins and nucleic acids. 120

UNIT: 14: Applications of gene technology 123

Find out how gene technology is applied in the modernization of agriculture. ...123

UNIT: 15: Variation..... 126

Test for the significant differences between 2 populations by using t-test 126

Use continuous and discontinuous variations among organisms to analyze graphs 129

UNIT: 16: Artificial and natural selection..... 133

Advantages of selective breeding in comparison with natural selection 133

Similarities of closely related organisms using mitochondrial DNA and protein sequences 135

PART 1: GENERAL INTRODUCTION

1. Structure of the user guide

The Biology Experiments User Guide is divided into 3 main parts:

The part I explains the structure of this book and gives you the general introduction on the role of practical activities and lab experiments in the implementation of CBC.

The part II gives the list of materials (apparatuses and chemicals)

The part III details the practical activities and how you can facilitate them in lessons.

2. Laboratory experiments in the Competence Based Curriculum

A competence-based curriculum (CBC) focuses on what learners can do and apply in different situations by developing skills, attitudes, and values in addition to knowledge and understanding. This learning process is learner-focused, where a learner is engaged in active and participatory learning activities, and learners finally build new knowledge from prior knowledge. Since 2015, the Rwanda Education system has changed from KBC to CBC for preparing students that meet the national and international job market requirements and job creation. Therefore, implementing the CBC education system necessitates qualitative laboratory practical works for mathematics and science as more highlighted aspects.

In addressing this necessity, laboratory experiments play a major role. A learner is motivated to learn sciences by getting involved in handling various concrete manipulative in various activities. In addition to activities, games in sciences also help the child's involvement in learning by strategizing and reasoning.

For learning biology concepts through the above-mentioned approach, a learner-centred science kits have been developed for the learners of lower and advanced Secondary schools. The kits include various kit items along with a manual for performing activities.

The kit broadly covers the activities in the areas of biology, chemistry and physics.

The kit has the following advantages:

- Availability of necessary and common materials at one place
- Multipurpose use of items
- Economy of time in doing the activities

- Portability from one place to another
- Provision for teacher's innovation
- Low-cost material and use of indigenous resources.

Apart from the kit, the user guide for laboratory and practical activities to be used by teachers was developed. This biology lab experiment user guide is designed to help biology teachers to perform high-quality lab experiments for biology subject. This user guide structure induces learner's interest, achievement, and motivation through the qualitative science lab experiments offered by their teachers and will finally lead to the targeted goals of the CBC education system, particularly in the field of Biology.

In CBC, learners hand on the materials and reveal the theory behind the experiment done. Here, experiments are done inductively, where experiments serve as an insight towards revealing the theory. Thus, the experiment starts, and theory is produced from the results of the experiment.

3. Type of lab experiments

The goal of the practical work defines the type of practical work and how it is organized. Therefore, before doing practical work, it is important to have a clear idea of the objective.

The three types of practical work that correspond with its three main goals are:

1. **Equipment-based practical work:** the goal is for students to learn to handle scientific equipment like using a microscope, doing titrations, making an electric circuit, etc.
2. **Concept-based practical work:** learning new concepts.
3. **Inquiry-based practical work:** learning process skills. Examples of process skills are defining the problem and good research question (s), installing an experimental setup, observing, measuring, processing data in tables and graphs, identifying conclusions, defining limitations of the experiment etc.

Note

– To learn the new concept by practical work, the lesson should start with the practical work, and the theory can be explained by the teacher afterward (explore – explain).

Starting by teaching the theory and then doing the practical work to prove what they have learned is demotivating and offers little added value for student learning.

- Try to avoid complex arrangements or procedures. Use simple equipment or handling skills to make it not too complicated and keep the focus on learning of the new concept.
- If this is not possible and is necessary to use new equipment or handling skills, then first exercise these skills before starting the concept-based practical work experiments.
- The experiments should be useful for all learners and not only for aspiring scientists. Try to link the practical work as much as possible with their daily life and preconceptions.

4. Organization, analysis, and interpretation of data

Once collected, data must be ordered in a form that can reveal patterns and relationships and allows results to be communicated to others. We list goals about analysing and interpreting data. By the end of secondary education, students should be able to:

- Analyze data systematically, either look for relevant patterns or test whether data are consistent with the initial hypothesis.
- Recognize when data conflict with expectations and consider what revisions in the initial model are needed.
- Use spreadsheets, databases, tables, charts, graphs, statistics, mathematics, and ICT to compare, analyze, summarize, and display data and explore relationships between variables, especially those representing input and output.
- Evaluate the strength of a conclusion that can be inferred from any data set, using appropriate grade-level mathematical and statistical techniques.
- Recognize patterns in data that suggest relationships worth investigating further. Distinguish between causal and correlational relationships.
- Collect data from physical models and analyze the performance of a design under a range of conditions.

5. Organising lab experiments

a) Methods of organizing a practical work

There are 3 methods of organizing practical work:

- **Each group does the same experiments at the same time**

All learners can follow the logical sequence of the experiments, but this implies that a lot of material is needed. The best group size is 3, as all learners will be involved. With bigger groups, you can ask to do the experiment twice, where learners change roles.

– **Experiments are divided among groups with group rotation**

Each group does the assigned experiment and moves to the next experiment upon a signal by the teacher. At the end of the lesson, each group has done every experiment. This method saves material but is not perfect when experiments are ordered in a logical way. In some cases, the conclusion of an experiment provides the research question for the next experiment. In that case, this method is not very suitable.

The organization is also more complex. Before starting the lesson, the materials for each experiment should be placed in the different places where the groups will work. Also, the required time for each experiment should be about the same. Use a timer to show learners the time left for each experiment. Provide an extra exercise for fast groups.

– **All experiments are divided among groups without group rotation**

Each group does only one or two experiments. The other experiments are done by other groups. Afterward, the results are brought together and discussed with the whole class. This saves time and materials, but it means that each learner does only one experiment and 'listens' to the other experiments' description. The method is suitable for experiments that are optional or like each other. It is not a good method for experiments that all learners need to master.

b. Preparation of a practical work

When preparing a practical work, do the following:

- Have a look at the available material at school and make a list of what you can use and what you need to improvise.
- Determine the required quantities by determining the method (see above).
- Collect all materials for the experiments in one place. If learners' group is small, they can come to get the materials on that spot, but with more than 15 learners, this will create disorder. In that case, prepare for each group a set of materials and place it on their desk.
- Test all experiments and measure the required time for each experiment.
- Prepare a nice but educational extra task for learners who are ready before the end of the lesson.
- Write on the blackboard how groups of learners are formed.

c) Preparation of a lesson for practical work

In the lesson plan of a lesson with practical work, there should be the following phases:

1. **The introduction of the practical work or the 'excite' phase** consists of formulation of a key question, discrepant event, or a small conversation to motivate learners and make connections with daily life and learners' prior knowledge.
2. **The discussion of safety rules for the practical work:**
   - Only work at the assigned place; do not walk around in the class if this is not asked.
   - Long hairs should be tied together, and safety eyeglasses should be worn for chemical experiments.
   - Only the material needed for the experiment should be on the table.
   - The practical work instructions: how groups are formed, where they get the materials, special treatment of materials (if relevant), what they must write down…
   - When the practical work materials aren't yet at the correct location, then distribute them now. Once learners have the materials, it is more difficult to get their attention.
3. **How to conduct a practical work:**
   - Learners do the experiments, while the teacher coaches by asking questions (Explore phase).
   - The practical work should preferably be processed immediately with an explain phase. If not, this should happen in the next lesson.
4. **How to conclude the lesson of a practical work:**
   - Learners refer to instructions and conduct the experiment,
   - Learners record and interpret recorded data,
   - Cleaning the workspace after the practical work (by the learners as much as possible).
5. **Role and responsibilities of teacher and learners in lab experiment**

Roles and responsibilities of teacher during a lab experiment

Before conducting an experiment, the teacher will do the following:

- Decide how to incorporate experiments into class content best,
- Prepare in advance materials needed in the experiment,
- Prepare protocol for the experiment,
- Perform in advance the experiment to ensure that everything works as expected,
- Designate an appropriate amount of time for the experiment - some experiments might be adapted to take more than one class period, while others may be adapted to take only a few minutes.

- Match the experiment to the class level, course atmosphere, and your students' personalities and learning styles.
- Verify lab equipment before lab practices.
- Provide the working sheet and give instructions to learners during lab session.

During practical work, the teacher's role is to coach instead of helping with advice or questions. It is better to answer a learner's question with another question than to immediately give the answer or advice. The additional question should help learners to find the answer themselves.

- Prepare some pre-lab questions for each practical work, no matter what the type is.
- Try and start the practical work: start with a discrepant event or questions that help define the problem or questions that link the practical work with students' daily life or their initial conceptions about the topic.
- Use coaching questions during the practical work: 'Why do you do this?', 'What is a control tube?', ''What is the purpose of the experiment?', 'How do you call this product?', 'What are your results?' etc.
- Use some questions to end the practical work: 'What was the meaning of the experiment?', 'What did we learn?', 'What do we know now that we didn't know at the start?', 'What surprised you?'etc.
- Announce the end of the practical work 10 minutes before giving learners enough time to finish their work and clean their space.

Role of a lab technician during a laboratory-based lesson

In schools having laboratory technicians, they assist the science teachers in the following tasks:

- Maintaining, calibrating, cleaning, and testing the sterility of the equipment,
- Collecting, preparing and/or testing samples,
- Demonstrating procedures.

Learners' responsibilities in the lab work

During the lab experiment, both learners have different activities to do; the table barrow summarizes them. General learner's activities are:

- Experiment and obtain data themselves,
- Record data using the equipment provided by the teacher,
- Analyze the data often this involves graphing it to produce the related graph,

- Interpret the obtained results and deduct the theory behind the concept under the experimentation,
- Discuss the error in the experiment and suggest improvements,
- Cleaning and arranging material after a lab experiment.

6. Safety rules and precautions during lab experiments

Regardless of the type of lab you are in, there are general rules enforced as safety precautions. Each lab member must learn and adhere to the rules and guidelines set, to minimize the risks of harm that may happen to them within the working environment. These encompass dress' code, use of personal protection equipment, and general behaviour in the lab. It is important to know that some laboratories contain certain inherent dangers and hazards.

Therefore, when working in a laboratory, you must learn how to work safely with these hazards to prevent injury to yourself and other lab mates around you. You must make a constant effort to think about the potential hazards associated with what you are doing and think about how to work safely to prevent or minimize these hazards as much as possible.

Before doing any scientific experiment, you should make sure that you know where the fire extinguishers are in your laboratory, and there should also be a bucket of sand to extinguish fires. You must ensure that you are appropriately dressed whenever you are near chemicals or performing experiments. Please make sure you are familiar with the safety precautions, hazard warnings, and procedures of the experiment you perform on a given day before you start any work. Experiments should not be performed without an instructor in attendance and must not be left unattended while in progress.

A. Hygiene plan

A laboratory is a shared workspace, and everyone has the responsibility to ensure that it is organized, clean, well-maintained, and free of contamination that might interfere with the lab members' work or safety.

For waste disposal, all chemicals and used materials must be discarded in designated containers. Keep the container closed when not in use. When in doubt, check with your instructor.

B. Hazard warning symbols

To maintain a safe workplace and avoid accidents, lab safety symbols and signs need to be posted throughout the workplace.

Chemicals pose health and safety hazards to personnel due to innate chemical, physical, and toxicological properties. Chemicals can be grouped into several different hazard classes. The hazard class will determine how similar materials should be stored and handled and what special equipment and procedures are needed to use them safely.

Each of these hazards has a different set of safety precautions associated with them.

The annex 1 shows hazard symbols found in laboratories and the corresponding explanations.

C. Safety rules

Safety is the number one priority in any laboratory. All students are required to know and comply with good laboratory practices and safety norms; otherwise, they will be asked to leave the laboratory. Make sure you understand all the safety precautions before starting your experiments, and you are requested to help your learners to understand too.

The following are some general guidelines that should always be followed:

Lab coat

While working in the lab, everyone must always wear a lab coat (Figure 1) to prevent incidental and unexpected exposures to the skin and clothing. The primary purpose of a lab coat is to protect against splashes and spills. The lab coat must be wrist-fitted and must always keep buttoned. A lab coat should be non-flammable and should be easily removed.

Safety glasses

For eyes protection, goggles must always be worn over by all persons in the laboratory while students are working with chemicals. Safety glasses, with or without side-shields, are not acceptable. The eyes protection safety indicates the possibility of chemical, environmental, radiological, or mechanical irritants and hazards in the laboratory.

Breathing Masks

Respirators are designed to prevent contamination from volatile compounds that may enter in your body through the respiratory system. “Half mask” respirators (Figure3) cover just the nose and mouth; “full face” respirators cover the entire face, and “hood” or “helmet” style respirators cover the entire head. The breathing mask safety sign lets you know that you are working in an area with potentially contaminated air.

Eye Wash Station

Eyes wash stations consist of a mirror and a set of bottles containing saline solution that can be used to wash the injured eye with water. The eye wash station is intended to flood the eye with a continuous stream of water.

Eyes wash stations provide a continuous, low-pressure stream of aerated water in laboratories where chemical or biological agents are used or stored and in facilities where non-human primates are handled. The eyewash stations should easily be accessed from any part of the laboratory, and if possible, located near the safety shower so that, if necessary, the eyes can be washed while the body is showered.

Footwear

Shoes that cover entirely the toes, heel, and top of the foot provide the best general protection (Figure 1.5). Closed shoes must always be worn while in the laboratory, regardless of the experiment or curricular activity. Shoes must fully cover your feet up to the ankles, and no skin should be shown. Socks do not constitute a cover replacement for shoes. Sandals, backless and open shoes are unacceptable.

Gloves

When handling chemical, physical, or biological hazards that can enter the body through the skin, it is important to wear the proper protective gloves. Butyl, neoprene and nitrile gloves are resistant to most chemicals, e.g., alcohols, aldehydes, ketones, most inorganic acids, and caustics.

Hair dressing

If hair is long, it must be tied back. It is good to report all accidents including minor incidents to your instructor immediately.

Eat and drink

Never drink, eat, taste, or smell anything in the laboratory unless you are allowed by the lab instructor.

Hot objects

Never hold very hot objects with your bare hands. Always hold them with a test tube holder, tongs, or a piece of cloth or paper.

7. **Guidance on the Management of lab materials (**Storage Management, Repairing and Disposal of Lab equipment and chemicals)

Keeping and cleaning up

Working spaces must always be kept neat and cleaned up before leaving. Equipment must be returned to its proper place. Keep backpacks or bags off the floor as they represent a tripping hazard. Open flames of any kind are prohibited in the laboratory unless specific permission is granted to use them during an experiment.

Management of lab materials

A science laboratory is a place where basic experimental skills are learned only by performing a set of prescribed experiments. Safety procedures usually involve chemical hygiene plans and waste disposal procedures. When providing chemicals, you must read the label carefully before starting the experiment. To avoid contamination and possibly violent reaction, do never return unwanted chemicals to their container. In the laboratory, chemicals should be stored in their original containers, and cabinets should be suitably ventilated. It is important to notify students that chemicals cannot be stored in containers on the floor. Sharp and pointed tools should be stored properly.

Students should always behave maturely and responsibly in the laboratory or wherever chemicals are stored or handled.

Hot equipment and glassware handling

Hazard symbols should be used as a guide for the handling of chemical reagents. Chemicals should be labeled as explosives, flammable, oxidizers, toxic and infectious substances, radioactive materials, corrosives etc. All glassware should be inspected before use, and any broken, cracked, or chipped glassware should be disposed of in an appropriate container. All hot equipment should be allowed to cool before storing it.

All glassware must be handled carefully and stored in its appropriate place after use. All chemical glass containers should be transported in rubber or polyethylene bottle carriers when leaving one lab area to enter another. When working in a lab, do never leave a hot plate unattended while it is turned on. It is recommended to handle hot equipment with safety gloves and other appropriate aids but never with bare hands. You must ensure that hands, hair, and clothing are kept away from the flame or heating area and turn heating devices off when they are not in use in the laboratories.

Waste disposal considerations

Waste disposal is a normal part of any science laboratory. As teachers or students perform demonstrations or laboratory experiments, chemical waste is generated.

These wastes should be collected in appropriate containers and disposed of according to local, state, and federal regulations. All schools should have a person with the responsibility of being familiar with this waste disposal. In order to minimize the amount of waste generated and handle it safely, there are several steps to consider.

Sinks with water taps for washing purposes and liquid waste disposal are usually provided on the working table. It is essential to clean the sink regularly. Notice that you should never put broken glass or ceramics in a regular waste container. Use a dustpan, a brush, and heavy gloves to carefully pick-up broken pieces, and dispose of them in a container specifically provided for this purpose. Hazardous chemical waste, including solvents, acids, and reagents, should never be disposed of down sewer drains. All chemical waste must be identified properly before it can be disposed of. Bottles containing chemical waste must be labeled appropriately. Labeling should include the words "hazardous waste." Chemical waste should be disposed of in glass or polyethylene bottles. Plastic coated glass bottles are best for this purpose. Aluminum cans that are easily corroded should not be used for waste disposal and storage.

Equipment Maintenance

Maintenance consists of preventative care and corrective repair. Both approaches should be used to keep equipment in working order. Records of all maintenance, service, repairs, and histories of any damage, malfunction, or equipment modification must be maintained in the equipment logs. The record must describe hardware and software changes and/or updates and show the dates when these occurred. Each laboratory must maintain a chemical inventory that should be updated at least once a year.

8. Student Experiment Work Sheet

There should be a sheet to guide students about how they will conduct the experiment, materials to be used, procedures to be followed and the way of recording data. The following is a structure of the student experiment worksheet. It can be prepared by teacher or be availed from the other level.

a. Date
b. Name of student/group
c. The title of experiment
d. Type of experiment (concept, equipment and inquiry based)
e. Objective(s) of the experiment
f. Key question(s)
g. Materials (equipment/instrument, resources, etc…)
h. Procedures & Steps of experiment

i. Schematic reference if required.

j. Data recording and presentation

Number of tests	Types/Item/Variables	Comments/Observations
1		
2		
3		
Etc		

a. Reflective questions and answers

Question1

Question 2

Question 3

b. Answer for the key question

9. Report Template for Learner

After conducting a laboratory experiment, students should write a report about their findings and the conclusion they took.

The report to be made depends on the level of students. The report done by primary school learners is not the same us the one to be made by secondary school learners.

The following is a structure of the report to be made by a group of secondary school learners.

1. Introduction (details related to the experiment: Students identification, date, year, topic area, unit title and lesson).
2. The title of experiment.
3. Type of experiment (concept, equipment and inquiry based)
4. Objective(s) of the experiment.
5. Key question(s)
6. Materials (equipment/instrument, resources, etc…)
7. Procedures & Steps of experiment
8. Schematic reference if required.
9. Data recording
10. Data analysis and presentation (Plots, tables, pictures, graphs)

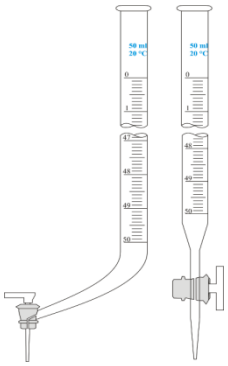
11. Interpretation/discussion of the results, student alternative ideas form observation.
12. Theory or Main ideas concept, formulas, and application).
13. Conclusion (answer reflective questions and the key question).

As a conclusion, there are safety rules and precautions to consider before, during and at the end of a lab experiment. We hope teachers are inspired to conduct lab experiments in a conducive Competence Based Curriculum way.

PART II: LIST OF MATERIALS FOR BIOLOGY LAB

II.1 List of the Lab apparatus in schools

#	Item	Picture	Description of uses
1	Beaker		Used to hold and heat liquids. Multipurpose and essential in the laboratory.
2	Brushes		Used to easily clean the inside of a test tubes and other glassware.
3	Buchner funnel		Used with vacuum flask for performing vacuum filtration.
4	Bunsen burner		First, make sure your workspace is free of potential fire hazards. Connect the gas line and ignite the burner. Adjust the metal collar and needle gas valve at the burner's base. When you're finished, close the air and gas ports, shut off the gas main line, and put the burner away once it's cool. Bunsen burner is used for heating and exposing items to flame.

5	Burette		Before delivering any solution, record the initial burette reading in your notebook. Open the stopcock by twisting it 90 degrees into the vertical position and allow the solution to drain. As you near the desired volume, slow the flow by turning the stopcock back toward the closed position. You should be able to control the burette to deliver one drop at a time. When the desired volume has been delivered, close the stopcock. Wait a couple of seconds, then record the final burette reading.
6	Burette clamp		Used to hold burette on a ring stand.
7	Clay triangle		Used to hold crucibles when they are being heated. They usually sit on a ring stand.
8	Crucible with lid		Used to heat small quantities to very high temperatures.
19	Crucible tong		Used to hold crucibles and evaporating dishes when they are hot.
10	Disposable pipette		Used for moving small amounts of liquid from place to place. They are usually made of plastic and are disposable.

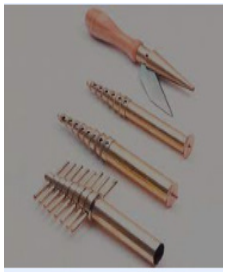
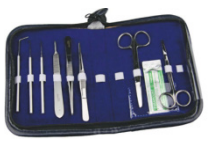
11	Electronic balance		Used for weighing substances or objects, usually in grams. Place the electronic balance on a flat, stable surface indoors. Press the "ON" button and wait for the balance to show zeroes on the digital screen. Place the empty container you will use for the substance to be measured on the balance platform. Press the "Tare" or "Zero" button to cancel automatically the weight of the container. The digital display will show zero again. Carefully add the substance to the container. Ideally this is done with the container still on the platform, but it may be removed if necessary. Avoid placing the container on surfaces that may have substances which will add mass to the container such as powders or grease. Place the container with the substance back on the balance platform if necessary and record the mass as indicated by the digital display.
12	Erlenmeyer flasks/ Conical flask		Used to heat, mix, and store liquids. The advantage to the Erlenmeyer Flask is that the bottom is wider than the top so it will heat quicker because of the greater surface area exposed to the heat.

13	Evaporating dish		Used to recover dissolved solids by evaporation.
14	Forceps		Used for picking up and moving small objects.
15	Glass funnel & Polypropylene funnel	 	Used to pour liquids into any container so they will not be lost or spilled. They are also used with folded filter paper for filtration.
16	Glass stir rod		Used to stir liquids. They are usually made of glass.
17	Graduated cylinder/ measuring cylinder		Used to measure the volumes of liquids.
18	Micropipette		Used for accurately measuring and delivering very small volumes of liquid-usually 1 mL or less. Steps to follow when using a micropipette. Select the volume. Set the tip. Press and hold the plunger at the first stop. Place the tip in the liquid. Slowly release the plunger. Pause for a second and then move the tip. Insert the tip into the delivery vessel. Press the plunger to the second stop.
19	Mortar and pestle		Used to crush solids into powders for experiments, usually to better dissolve the solids.

20	Pipette filler		How does a pipette filler work? Siphon liquid into the pipette to the desired level by squeezing valve "S" on the bottom of the pipette filler. This uses the vacuum created in the bulb to draw liquid into the pipette. Be careful not to draw liquid into the pipette filler. ... This allows you to release liquid at the desired rate and to the desired level.
21	Pipette with pump		Used for accurately measuring and delivering small volumes of liquid-usually 0.1-10 mL.
22	Ring clamp		Attached to a retort stand and with wire gauze used to hold beakers or flasks while they are heated by a gas burner.
23	Retort stand and accessories		Used to hold items being heated. Clamps or rings can be used so that items may be placed above the lab table for heating by Bunsen burners or other items. Used also to hold burette
24	Rubber stopper		Stoppers come in many different sizes. The sizes are from 0 to 8. Stoppers can have holes for thermometers and for other probes that may be used.
25	Spatula		Used for moving small amounts of solid from place to place.
26	Test tube		Used for storing, mixing, and heating small amounts of chemicals.

27	Test tube holder		Used to hold test tubes while heating.
28	Test tube rack		Used to hold test tubes while reactions happen in them or while they are not needed.
29	Thermometer		Used to take temperature of solids, liquids, and gases.
30	Utility clamp		Used to attach test tubes and other glassware to retort stand.
31	Vacuum filter flask		Used with vacuum line and Buchner funnel for vacuum filtration.
32	Volumetric flask		Used to prepare solutions with accurate concentration.
33	Wash bottle		Used to wash; rinse containers
34	Watch glass		Used to hold solids when being weighed or transported. They should never be heated. Can also be used to cover beakers or other containers.
35	Wire gauze		Used with a ring clamp to support glassware over a Bunsen burner.
36	Borosilicate glass tube		Used to connect to other items of glassware or equipment to deliver chemicals, solvents, liquids, gases and other products.

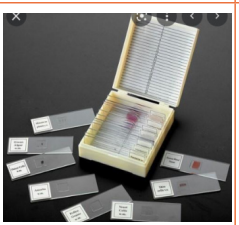
37	Rubber tube		Rubber tubing is often connected to a condenser, which is a laboratory tool used in the process of distillation. The rubber tubing helps cool water to flow in and out of the condenser and helps the heated water vapor in the condenser return to its liquid state.
38	Borosilicate delivery tube		The delivery tube is particularly useful for bubbling a gas from a gas cylinder or stoppered vessel through a liquid.
39	Rough		The rough is used for collecting gases, such as hydrogen, oxygen and nitrogen. Troughs require a liquid such as water.
40	Beehive shelf		A beehive shelf is usually used to support a receiving jar or tube while a gas is being collected over water with a pneumatic trough.
41	Syringe		They are often used for measuring and transferring solvents and reagents where a high precision is not required.
42	Gas jar and cover		A container used for collecting gas from experiments.
43	Clinostat		A clinostat is a device which uses rotation to negate the effects of gravitational pull on plant growth and development.

44	Cork borers		used in a biology laboratory, is a metal tool for cutting a hole in a cork or rubber stopper to insert glass tubing. Cork borers usually come in a set of nested sizes along with a solid pin for pushing the removed cork (or rubber) out of the borer.
45	Cover glasses		The cover glass serves two purposes: It protects the microscope's objective lens from contacting the specimen, and (2) It creates an even thickness (in wet mounts) for viewing.
46	Dark blue plastic modelling clay pack of 500g		used for sculpting and building by children, students, etc.
47	Visking (dialysis) tubing or suitable, size 2,normal diameter 14mm roll of 30 meters		Dialysis tubing, also known as Visking tubing, is an artificial semi-permeable membrane tubing used in separation techniques based on differential diffusion
48	Dissecting kits		used for dissection, includes scissors, pins, scalpel handle; dressing forceps, 16 cm; mayo hager needle holder, 16 cm; teaser needle; angled teaser needle straight; tissue Forceps, 1:2, 16 cm. ets

49	First aid Education response		In laboratory first aid kit includes:Triangle bandages;bandages;pins for bandages; sterile dressings;plasters;antiseptic wipes;eye pad dressings and gloves
50	**Microbiological inoculating loop handles** for inoculating wire		The inoculation handle can be used for a variety of applications in microbiology: inoculation, serial dilution, sterile sampling, transfer and spreading of microbiological samples. The inoculating loop is sterilised by passing it at an angle through the flame of a gas burner until the entire length of the wire becomes orange from the heat. In this way all contaminants on the wire are incinerated. Never lay the loop down once it is sterilised, or it may again become contaminated.
51	**Microscope slides**		A microscope slide is a thin flat piece of glass, typically 75 by 26 mm (3 by 1 inches) and about 1 mm thick, used to hold objects for examination under a microscope. Typically the object is mounted (secured) on the slide, and then both are inserted together in the microscope for viewing.

52	**Microscope**		A light microscope is a biology laboratory instrument or tool, that uses visible light to detect and magnify very small objects and enlarge them. They use lenses to focus light on the specimen, magnifying it thus producing an image. The specimen is normally placed close to the microscopic lens. Steps on how to use a light microscope: Step 1: Connect the light microscope to a power source. Step 2: Turn the revolving nosepiece so the lowest objective lens is in position. Step 3: Mount your specimen onto the stage. Step 4: Use the metal clips to keep your slide in place. Step 5: Look into the eyepiece and slowly rotate the coarse adjustment knob to bring your specimen to focus. Step 6: Adjust the condenser for the maximum amount of light. Step 7: Now slowly rotate the fine adjustment knob until you obtain a clearer image of your specimen. Step 8: Examine your specimen.

			Step 9: After you're done viewing with the lowest power objective, switch to the medium power objective and re-adjust the focus with the fine adjustment knob. Step 10: Proceed to the high power objective once you have it focused.
53	S**tirring rod**, glass, one end round, other flat, length 200 mm		A glass stirring rod is used to stir or mix solutions. One of their main uses is to "scratch" the side of glassware (such as an Erlenmeyer Flask) to start the crystallization process in many experiments.
54	**Stopwatch.** 2 buttons with laps and 1/100 second functions. 12 hour setting, lcd count/ down/up		It is commonly used in laboratories, it can measure a time interval up to 0.01 second. It starts to indicate the time lapsed as the start/stop button is pressed. As soon as the start/ stop button is pressed again, it stops and indicates the time interval recorded by it between the start and stop of an event.
55	**Sweeping net** (muslin)insect nets, a light weight, robust insect net with 800mm long handle		Sweep nets are used to sweep through vegetation to collect random insects not easily seen
56	**Spotting tile**		A spotting tile is a piece of observational equipment used to observe the colour changes of small quantities of a reacting mixture

57	**Water bath**		It is made from a container filled with heated water and used to incubate samples in water at a constant temperature over a long period of time
58	**Autoclave**		A machine used to carry out and scientific processes requiring elevated temperature and pressure in relation to ambient pressure and/or temperature
59	**Tripod stands triangular top**, length of side arm 150 mm, height 200 mm, cast iron		A tripod is a portable three-legged frame or stand, used as a platform for supporting the weight and maintaining the stability of some other object. Ideal for the science laboratory or classroom to elevate Beakers or Flasks. They're perfect for use with Bunsen burners to support the object to be heated. Work best in conjunction with wire gauze mats.
60	**Sets of permanent** slides (Transverse section (ts) of bronchioles, permanent slides with cover slip;Transverse section (ts)of veins, permanent slide with cover slip;Transverse section (ts)of artery, permanent slides with cover slip; Transverse section(ts) of kidney-(adrenal gland t.s.		A microscope slide is a thin flat piece of glass, typically 75 by 26 mm (3 by 1 inches) and about 1 mm thick, used to hold objects for examination under a microscope. Typically the object is permanently mounted (secured) on the slide, and then both are inserted together in the microscope for viewing. When using a microscope, slides that are permanent can be examined and stored for a long time, (Permanent slides must be properly made for successful long-term storage)

	cortex and medulla) permanent slides with cover slip;Slides of the sense organs, permanent slides for different sense organs; Penicillium microscope slide;Prepared slide of urinary system with slide cover;Prepared slide on mitosis, permanent slides with cover slip;Prepared slides of white blood cells, permanent slides with cover slip;Slides of neurons, sensory, motor and rely neurons;Ts leaf of dicotyledonous mesophyte (such as ligustrum or prunus or local equivalent), maize;Ts lungs to show alveoli permanent slides with cover slip;Ts ovule permanent slides with cover slip;Ts spinal cord, permanent slides with cover slip;Ts trachea permanent slides with cover slip;Nerve muscle junction, permanent slides covered with cover slip).		

II.2 List of biology chemicals

No	Name of chemical and quantities
1	Set of bottles as follows: Amylase enzyme - 1 lb (445g), trypsin/ edta solution(100ml), protease (pack size: 500g), 1 for each sample: (Each set should contain 3 bottles, one for each type)
2	L -ascorbic acid (vitamin c) powder,100g
3	Benedict's solution,500ml
4	Sodium bicarbonate, 500g
5	Biuret reagent, laboratory grade, 100 ml
6	Bromothymol blue,500ml
7	2,6-dichloroindophenol is a dye used as a reagent in the determination of vitamin c. 1bottle
8	Eosin/red ink, dye content, ~99%,
9	Dextrose, monohydrate, powder, laboratory grade, 500 g
10	Iodine solution 2% in potassium iodide(aqueous), 30ml
11	Calcium hydroxide 500 g
12	Lugol's iodine solution 5% (1 oz.) Twin pack (2 bottles)
13	Methylated spirit (for extraction of chlorophyll),50ml
14	Methylene blue solution, 0.1% aqueous, laboratory grade, 500 ml
15	Millons' reagent ,500ml
16	Nutrient broth, 125ml
17	Agar powder, 100g
18	Potassium oxide, 250g
19	Starch 2%w/v solution 6.58, 500ml
20	Sucrose, molecular formula: c12h22o11, molecular weight: 342.30 (500g)
21	Toluidine blue stains for preparing slides to show mitosis,100g
22	Active dry yeast powder, 100g - lab grade chemical reagent
23	2,4-dinitrophenylhydrazine (brady's reagent),500g
24	Copper (II) carbonate, 250 g
25	Fehling's no1 copper solution,250 ml

26	Fehling's solution no 2, 250 ml
27	Distilled water, 25 l in high density, plastic container
28	Methyl orange sensitive,250ml
29	Sodium hydroxide pellets,250g
30	Hydrochloric acid, commercial, 500ml
31	Glucose,250g, pure solid cristals

PART III: EXPERIMENTS FOR S6

UNIT: 1 Introduction to biodiversity

Activity 1.1: Use of quadrats and line transects to estimate populations in a local area

This activity can be done when teaching the concept or topic related to the methods or techniques for measuring population density specifically by using quadrats and line transects.

Rationale

To estimate the population size is very important since it allows to know their needs and to limit the adversity of overpopulation. There are several methods of estimating the population density over a wide space. Frame quadrats and line transect can be used. This activity will equip students with skills to measure the population density by using quadrats and line transects techniques.

Objective

To estimate the population size and density in a local area using quadrats and line transects.

Materials

- Notebooks
- Calculators
- Quadrat frame
- Tape measure 50 m

Experiment setup

Steps and procedure of the experiment

- Move around the school compound and identify the 225 m^2 area (15m x 15m = 225m^2) with variety of small flowering plants such as blackjack, *Oxalis*, gallant soldier (*Galinsoga parviflora*)
- Throw gently a 1m^2 frame quadrat toward the intended area of research
- Record the number of individual plants for each species
- Move 5m forwards and throw again another quadrat
- Repeat the same process up to 5 times
- Record the number of individual plants for each species in each established quadrat
- Record your samples with respect to each quadrat

Reflection question

Do all plant species evenly distributed in all quadrats?

Data recording

This data serves just a model but can be changed based on what is found on ground

Species	Number of individuals in each quadrat					TOTAL
	Quadrat 1	Quadrat 2	Quadrat 3	Quadrat 4	Quadrat 5	
A	3	5	2	0	2	**12**
B	8	6	8	4	7	**33**
C	4	4	3	6	5	**22**
Total	**15**	**15**	**13**	10	14	67

Species B is the dominant species compared to other plant species. The population density of $species\ B = \frac{mean}{area} = \frac{\frac{33}{5}}{225} = \mathbf{0.029/m^2}$

Interpretation of results and conclusion

The number of individuals living within a specific location determines the population density, calculated by taking the number of individuals divided by the size of the area. In the above experiment, the species B is dominant because it has an average of 6.6 per quadrat calculated by taking the total number of individuals over the number of quadrats, for example: 33/5= 6.6. Therefore, its density is the mean (average) over the surface area of 225 m^2.

Source of errors

Calculations imply the accuracy of records. A careful process when counting the number of individuals of each species must be taken.

Guidance on the evaluation

Assess learners by focusing on the use of frame quadrats and line transect. Specifically, ask students to make quadrat frames following the same procedures used above. Communication skills and interpersonal management during the group work activity will be considered too.

Activity 1.2: Estimate population using capture and recapture methods and Lincoln index

This activity can be used when teaching the concept or topic related to methods or techniques of measuring population density by using capture and recapture method and Lincoln index

Rationale

Populations are subject to continual change in numbers through natality, mortality, immigration, and emigration. In this regard, populations keep on changing in size. Sir Lincoln suggested a simple technique of estimating the population size using the capture-mark-release-recapture method. This experiment allows us to know how we can estimate the population using capture and recapture methods and Lincoln index.

Objective

To estimate the population size in a local area using capture and recapture methods and Lincoln index

Materials

- Sweep net
- Permanent marker pens, pencils and pens
- Specimen bottles
- Notebooks
- calculators

Experiment setup

Steps and procedure of the experiment

- Select an appropriate area within the school compound covered by grasses
- Prepare a specimen bottle with many small holes that cannot allow collected specimens to fly away but to get air
- Use a sweep net to capture grasshoppers, and this within 20 minutes
- Put a harmless mark on each collected specimen and keep it in the specimen bottles
- Record the total number of collected specimens and mark them as collection 1 (C1)
- Release them back into their environment (habitat) so that they may mix with the remain of their population
- After 1 to 4 hours, catch another group from the same environment within 20 minutes
- Record the total number of collected specimens and mark them as collection 2 (C2)
- From the number C2, record how many have a mark and call this number marked (m)
- Estimate the population size using the Lincoln index

  formula: N = $\frac{n1xn2}{m}$, where N: population size, n1: number of individuals captured for the first time, n2: number of individuals captured for the second time, and m: number of recaptured and marked individuals.

Data recording

Individuals	Number	Population size using Lincoln index
C1	16	$N = \frac{n1xn2}{m} = \frac{16x18}{12} = 24\ grasshoppers$
C2	18	
M	12	

The following is an example of specific case that should not be generalized

Interpretation of results and conclusion

- The estimated population is 24 grasshoppers. But this number is not the actual size of population because of other factors that can increase or decrease the number of individuals.
- The capture-release-recapture has some side effects such as damaging or traumatizing the animals.

Precaution:

- This approach should be carried with care or precaution to avoid the bites of poisonous species.
- -Application of Lincoln index is better practically applied on field work rather than the theoretical questions in the textbooks

Source of errors

- Wrong counting of the individual species during capturing and recapturing will lead to wrong estimation of the population size.
- The result can be wrong if you invert the formula of Lincoln index. You need to understand it instead of cramming.

Guidance on the evaluation

- Assess learners by focusing on the use of capture and recapture method and Lincoln index. Ask them to repeat the activity in another area and on other animals.

UNIT: 3 EFFECT OF HUMAN ACTIVITIES ON ECOSYSTEM

Activity 3.1: Make trip to polluted sites and assess the impact of industrial sewage and fertilizer application on nearby land to wetlands and water bodies

This activity can be done when teaching the concept or topic related to pollution, specifically the effect of human activities including industrialization and fertilizer application to wetlands and water bodies.

Rationale

Modernization and progress have had numerous negative impacts on various ecosystems. With increase in the global population and the rising demand for food and other essentials, there has been a rise in the amount of waste being generated daily from industries and agricultural activities especially from fertilizer application. When industrial sewage and fertilizers are improperly disposed to wetlands and water bodies they are dangerous to aquatic life. Assessing the impact of industrial sewage and fertilizer application on nearby land to wetlands and water bodies will impose new measures of wetland and water bodies' protection and conservation. This activity aims to equip the students with skills to assess impact of industrial sewage and fertilizer application on nearby land to wetlands and water bodies.

Objective

To assess the impact of industrial sewage and fertilizer application on nearby land to wetlands and water bodies.

Materials

- Gloves
- Notebooks
- Pen or pencils
- Protective clothes and boots
- Camera

Experiment setup

Procedures

- Make a field trip to wetland and water bodies that receive industrial sewage and fertilizers
- observe water bodies' color and compare to normal water
- observe the aquatic plants and animals there
- Make an observation report.

Reflection questions

Is there any impact of releasing industrial sewage in water bodies to aquatic organisms?

Data recording

Contaminant	Impact on water	Impact on aquatic plants	Impact on aquatic animals
Fertilizers	Eutrophication	Death	Death
Sewage	Water contamination	Wilting or death	Death

Interpretation of results and conclusion

Disposal of untreated sewages from industries contain compounds of harmful metals such as mercury, cadmium, lead, arsenic and nickel. These may also include detergents, polychlorinated biphenyls (PCBs) and pathogenic microorganisms. These harmful chemicals and microorganisms kill aquatic animals and plants.

As plant nutrients, fertilizers cause rapid growth of tiny, green, water plants called algae in the water body. Algae cover the entire water surface in the form of a green sheet, thus blocking light from penetrating the water body. Furthermore, algae compete with other organisms in the water for dissolved oxygen. As a result, there is a threat to aquatic life.

Guidance on the evaluation

Let learners visit various polluted and unpolluted water bodies and wetlands.

Ask them to observe and compare the two places to easily notice the impact of polluting water bodies and wetlands.

You may ask students some questions, such as:

What are the contaminants released by industrial sewage and what is their effect on aquatic living organisms?

UNIT: 4 BLOOD CIRCULATORY SYSTEM IN ANIMALS

Activity 4.1: Investigate the effect of physical activity on the pulse rate and blood pressure

This experiment can be done when teaching the concept or topic related to the effects of exercise on the pulse rate and blood pressure.

Rationale

Physical activity will cause your blood pressure to rise for a short time. For most people, this is nothing to worry about, and when you stop the activity, it should quickly return to normal. If your blood pressure is relatively high, your doctor or nurse may prefer to lower it with medicines before you start exercising. Pulse rate is the number of times your heart beats in one minute. It varies from person to another. This experiment aims to help learners be aware of impact of physical activities on blood pressure.

Objective

To investigate the effect of physical activity on the pulse rate and blood pressure

Materials

- Sphygmomanometer
- Notebook and pen

Experiment setup

Before exercise

After exercise

Procedures

- Ask your partner to take your pulse before exercise by placing the sphygmomanometer over the major artery in your upper arm.
- Run round the classroom block, and then ask your partner to take your pulse once more. Repeat this several times and record your observations.

Data recording

Condition	Observations	
	Systole	Diastole
Before physical exercise	120	75
After physical exercise	133	93

Interpretation of results and conclusion

Sphygmomanometer is an instrument used to determine the blood pressure based on the contraction and relaxation of heart during blood flowing in the body. Statoscope also is used to determine the number of beat a heart can accomplish in one minute. It is expected that the blood pressure of a normal person to be 120 systole/80 diastole in one minute.

In this activity, we are demonstrating physical activity as one of the factors that contribute to high blood pressure and high beat rate. On the other side it is one of the factors that regulate blood pressure as you do it regularly.

Guidance on the evaluation

Let learners be in pairs, provide them with a sphygmomanometer, ask them to go out of class and run in the school compound, let them record their pulse rate immediately after exercise, and after a rest of 15 minutes, let them record and explain the changes in their pulse rate.

Activity 4.2: Dissection of grasshopper to indicate the major structures of circulatory systems in insects

This experiment can be done when teaching the concept or topic related to circulatory system in insects, specifically when distinguishing between open and closed, single and double circulation with reference to insects, earthworm, fish and mammals.

Rationale

Insects and other arthropods have a heart which is in the form of a dorsally elongated tube. The internal organs are suspended in a network of blood-filled sinuses which collectively form the haemocoel.

Grasshoppers like other insects have an open circulatory system. Their blood just bathes over their cells. Dissection of grasshoppers will help to indicate the major structures of circulatory systems in insects.

Objective

To indicate the major structures of circulatory system in insects by dissection of grasshopper.

Materials

- Lab apron
- Gloves
- Eyeglasses
- Dissecting tray
- Dissecting kit with forceps & scalpel
- T-pins
- Magnifying glass
- Preserved grasshopper

Experiment setup



Procedures

- Obtain a preserved grasshopper & rinse off any preservative with water.
- Remove all six legs of the insect
- Use scissors to throw the coxa of each leg.
- Discard the legs and pin the body down to a dissecting tray Generally, four pins, two at the rear of the abdomen, and two go through the pronotum, are required.
- With a sharp pointed scalpel cut carefully through the exoskeleton at the top of the eighth abdominal segment.
- Take this cut all the way forward and around returning to the starting point
- Observe the inner parts using a magnifying glass
- Do this carefully and your specimen will not be ruined.

Reflection question

Are there inner parts observed after dissection?

Data recording

Major structural component of circulatory systems	Observation
Heart	Restricted to the abdomen
Dorsal vessels	Extends from the hind end through the thorax to the head
Ostia	• Base of antennae and wings • Femero-tibial joint • Dorsal region of the meso- and metathorax
Hemocoel	Body cavity

Interpretation of results and conclusion

Grasshoppers like other insects possess an open circulatory system. In this system, blood is pumped into a hemocoel where it comes into direct contact with body cells and thereafter goes back to the 'tubular heart' via openings called ostia/pores. Insects and other arthropods have a heart which is an elongated tube located dorsally. The internal organs are suspended in a network of blood-filled sinuses which collectively form the haemocoel. Blood from the heart mixes with the interstitial fluid in the haemocoel to form haemolymph. In most insect, the dorsal vessel is a fragile membranous structure that collects haemolymph in the abdomen and conducts it forward to the head. The advantage this open circulatory system is the direct exchange of materials between body cells and haemolymph.

Guidance on the evaluation

Provide learners with cockroach as other example of insects and tell them to dissect them to verify if they have similar circulatory system with grasshoppers.

Experiment 4.3: Conduct dissection of rabbit to indicate the major structures of circulatory system in mammals

This experiment can be done when teaching the concept or topic related to circulatory system in mammals.

Rationale

Mammals and birds have a four-chambered heart and a complete double circulation. The primary function of the circulatory system in mammals is to transport heat and chemical substances, oxygen, carbon dioxide, and nutrients.

We need to dissect a rabbit to indicate the major structures of circulatory systems in mammals.

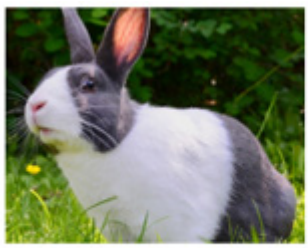
Objective

To indicate the major structures of circulatory system in mammals by dissecting a rabbit.

Materials

- Live rabbit
- Chloroform
- 5 Disposable Dissecting Pads
- Plastic Storage Bag
- Moist Towelettes
- Dissecting Scissors
- Dissecting Forceps
- Disposable Scalpel
- Teasing Needle
- Dissecting "T" Pins
- Dropping Pipet
- Gloves
- Hands lens to visualize circulatory structures

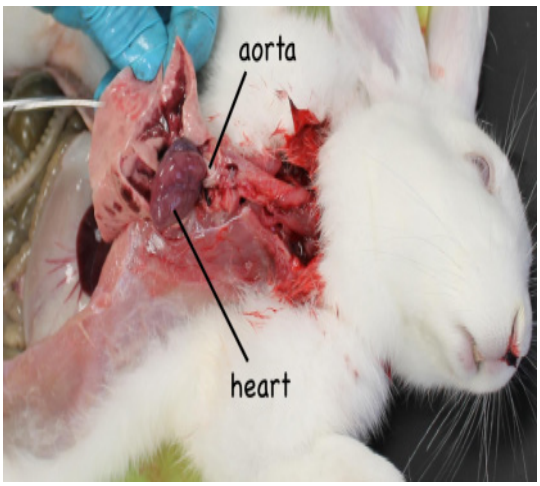
Experiment setup



Rabbit

Dissecting tray

Dissecting tools



the **thymus**
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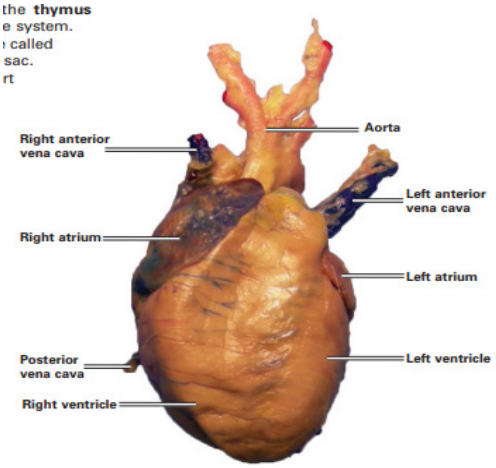
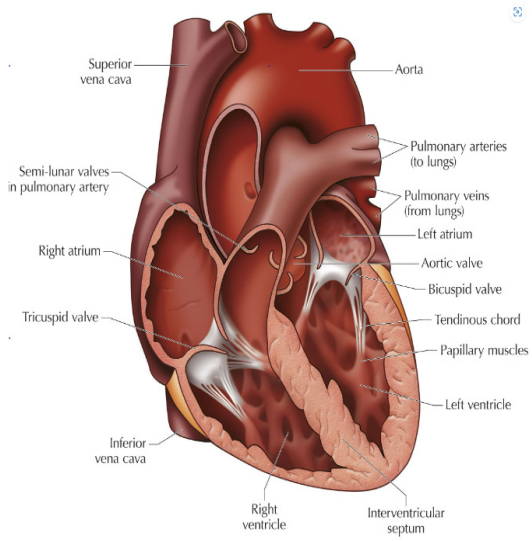




Procedures

1. Set up your work bench and pin down the rabbit. Place a pin through the limbs. If your pins can't penetrate the rabbits' limbs, tie a string to the rabbits' limbs and pin the string down;
2. Make an incision at the centre bottom of the rabbit and cut towards the top. Make sure not to puncture the abdominal wall. As you cut, you will need to strip the connective tissue and skin from the abdominal wall;
3. Peal back the skin and pin it to the board;
4. Again make an incision at the bottom of the abdominal wall. Cut up the abdominal wall till you feel some resistance.
5. Again make an incision at the bottom of the abdominal wall. Cut up the abdominal wall till you feel some resistance. The area which is still covered is the rib cage, housing the heart and lungs. Right now you should be able to see most of the organs in the digestive system. Once you have observed all the organs in the digestive system, continue cutting. There should be some resistance because you are cutting through the rib cage. Now you should be able to see the heart and lungs;
6. Cut the digestive track out. You will notice the large intestine is attached to the anus;
7. Completely remove the lungs, heart and digestive system. At the back you should see the kidneys and uterus;
8. Observe the heart and the blood vessels where blood circulates.

   The blood vessels may have been cut off, but it is possible to identify where these would have been attached later in the dissection
9. You should wear safety goggles, gloves, and a lab coat during dissection.

Reflection question

What are the observed parts after dissection?

Data recording

Major structural component of circulatory systems	Observation
Heart	• A pear-shaped between the lungs in the thoracic cavity. • A muscular organ that pumps blood throughout the body.
Blood vessels	Include arteries, veins and capillaries
Blood	Red liquid

Interpretation of results and conclusion

Heart, blood vessels (including arteries, veins and capillaries), and blood are the structural components of the circulatory system in mammals. The heart is pear-shaped and sits between the lungs in the thoracic cavity and surrounded by a double-layered membrane called pericardium.

In mammals, the circulatory system is a closed type and blood is transported through blood vessels. The heart of mammals and birds is composed of 4 chambers including 2 upper atria and 2 lower ventricles. The right-side deals with deoxygenated blood and the left side with oxygenated blood.

Source of errors

Learners should be aware that damaging internal organs during dissection will hinder the visibility of major structures of rabbit circulatory system.

Guidance on the evaluation

The learner must know that dissection is different from cutting. They have to dissect with aim of observing the structures of interest and their connection.

Experiment 4.4: Observe permanent slides of blood vessels using a microscope and make comparisons

This experiment can be done when teaching the concept or topic related to the circulatory system

Rationale

The circulatory system is made up of blood vessels that carry blood away from and towards the heart. Arteries carry blood away from the heart and veins carry blood back to the heart. The circulatory system carries oxygen, nutrients, and hormones to cells, and removes waste products, like carbon dioxide. Capillaries are delicate blood vessels that exist throughout your body. They transport blood, nutrients and oxygen to cells in your organs and body systems. This experiment will provide room to fleshly observe blood vessels and compare them.

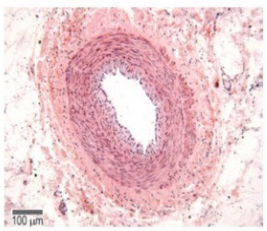
Objective

To compare blood vessels as observed under a microscope

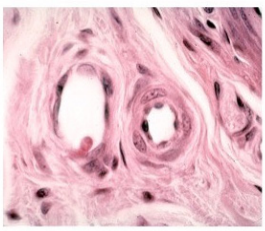
Materials

- Microscope
- Permanent slide of blood vessels

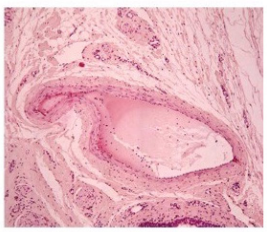
Experiment setup



Artery



Capillary*



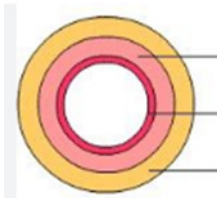
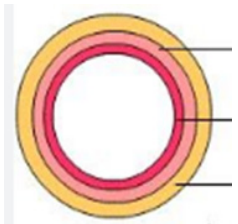
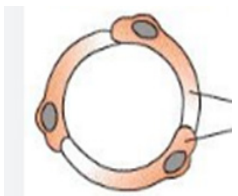
Vein

Procedures

- Mount the slide on the stage
- Observe by starting with lower magnification.
- Compare the observed blood vessels

Data recording

A comparison between arteries, capillaries and veins.

Blood vessels	Structures of wall	Lumen	Valves	Branching	Images
Arteries	Thick	Narrow	Absent	Branched into arterioles	
Veins	Thin	Wide compared to diameter	present	Branched into venules	
Capillaries	Very thin	Very narrow	Absent	No branches	

Interpretation of results and conclusion

Blood vessels can be identified from histological slides or images according to the thickness of their walls. Arteries have thick walls composed of three distinct layers (tunica). Veins have thin walls but typically have wider lumen (lumen size may vary depending on specific artery or vein). Capillaries are very small and will not be easily detected under the same magnification as arteries and veins.

Source of errors

- Dirtiness of the eyepiece lenses or slides, may lead to lack of clear images.
- Amount of light used during the specimen visualization

Guidance on the evaluation

Assess learners on the comparison of blood vessels by asking them to observe carefully and compare them by using microscope. Give them enough time to discuss on their observation. You may ask them some questions such as:

1. Compare those blood vessels observed
2. Relate each blood vessel structure to its function.

Experiment 4.5: Observation of blood smear and draw the structure of blood cells

This experiment can be done when teaching the concept or topic related to the circulatory system specifically when teaching composition and functions of blood.

Rationale

Blood is a specialized body fluid. It has four main components: plasma, red blood cells, white blood cells, and platelets. It has many different functions, including: transporting oxygen and nutrients to the lungs and tissues; forming blood clots to prevent excess blood loss; carrying cells and antibodies that fight infection; bringing waste products to the kidneys and liver; and regulating body temperature. This experiment aims at observing structure of blood components and derive their respective functions.

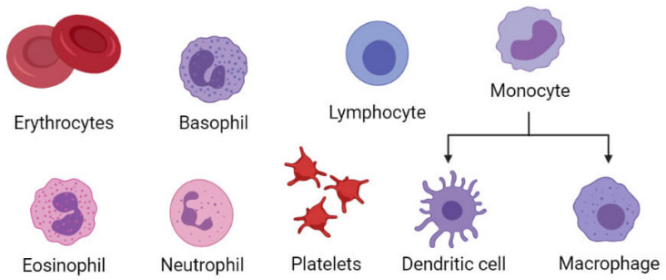
Objective

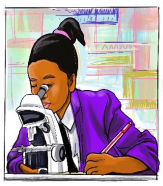
To observe blood cells under a microscope and differentiate them based on their structure

Materials

- Microscope
- Permanent slide of blood smear
- Pencils
- Papers or notebooks
- Rubbers

Experiment setup

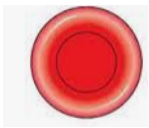
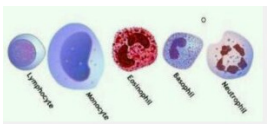
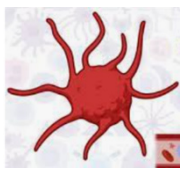




Procedures

- Set the microscope on the appropriate table in classroom or laboratory
- Fix the permanent slides of blood smear
- Start by low power objective to scan a large area of the specimen and observe the mounted slide under light microscope.
- Draw the observed images

Data recording

Types of blood cells	Structure	Composition
Red blood cells	 Bi-concave disc in shape	Have no nucleus, Cytoplasm packed with haemoglobin
White blood cells	 Irregular shape	• Have nucleus, • Different types, some with granules in the cytoplasm, some without
Platelets	 Star shape with tentacles	No nucleus

Interpretation of results and conclusion

There are three main types of blood cells: red blood cells, white blood cells and blood platelets. White blood cells are of different types; monocytes, lymphocytes, neutrophils, eosinophils, basophils, and macrophages which are different based on their shape, size, composition, and structure. Observation of blood smear allows to visualize many of the structural differences among the blood cells. Red blood cells are adapted for the transport of oxygen. They are small and flexible so they can fit through narrow vessels. White blood cells are irregular shape and help the body to fight infections and other diseases. Platelets are able to change shape. They often form a star shape with tentacles that help to plug any broken blood vessels.

Source of errors

- Dirtiness of the eyepiece lenses or slides, may lead to lack of clear images.
- Amount of light used during the specimen visualization

Guidance on the evaluation

Assess learners on the structure of blood cells by asking them to observe carefully their structures under microscope and differentiate them based on their structures. Give them enough time to discuss on their observation. You may ask them some questions such as: Based on their structures, differentiate the types of blood cells?

UNIT: 5 ENERGY FROM RESPIRATION

Experiment 5.1: Use simple combustion experiments with calorimeter to determine the relative energy values of different food substances

This experiment can be done when teaching the concept or topic related to energy from respiration specifically when teaching respiratory substrates and their relative energy values.

Rationale

Food is composed of three major constituents which release energy when oxidized inside the body cells. These are carbohydrates and lipids (fat). The quantity of energy released per gram of a substrate is measured and usually expressed in kcal/gram. The same amount of energy is released in the form of heat when food is burned outside our bodies.

Food calorimetry allows us to determine the number of calories per gram of food. In this activity, a piece of food is burned and the released energy is used to heat a known quantity of water. The temperature change (ΔT) of the water is then used to determine the amount of energy in the food. This experiment is intending to determine the relative amount of energy released from food nutrients via combustion.

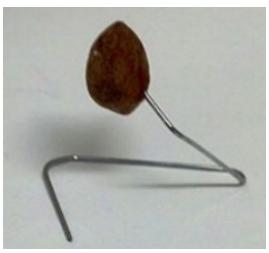
Objective

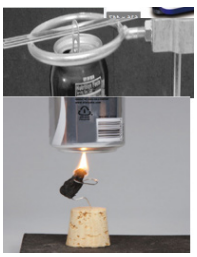
To determine the relative energy values of different food substances via combustion.

Materials

- Soda Can (empty)
- Stirring Rod
- Ring Stand and Ring
- Thermometer
- Graduated Cylinder, 100 mL
- Large Paper Clip
- 2 Twist Ties
- 3 Food Samples
- Water
- Matches
- Aluminum Foil (small piece)
- Electronic Balance

Experiment setup





Procedures

- Using the graduated cylinder, measure water and carefully pour it into the soda can.
- Determine the mass of water and record your finding in the data table
- Hold the paper clip horizontally and bend the outer end upwards until it is at a 90° angle to the rest of the paper clip.
- Obtain a food sample.

- Place the food sample on the paper clip's upward-extending end. The sample should be freestanding, supported by the bottom of the paper clip. Determine the initial mass of the food sample and paper clip, and record your findings in the data table.
- Place a small piece of aluminum foil underneath the paper clip in a space that has been cleared of all flammables.
- Insert the stirring rod through the soda can tab and position the can in the ring stand so the stirring rod supports it
- Adjust the ring stand until the can is approximately 4 cm above the food sample.
- Suspend the thermometer inside the can a few centimeters above the can's bottom. Secure with 2 twist ties.
- Determine the initial temperature of the water in the can and record this value in the data table.
- Carefully light a match and use it to light the food sample.
- Allow the lit sample to heat the water in the can. Gently stir the water periodically with the thermometer.
- Monitor the temperature change of the water and record the highest observed temperature in the data table.
- Once the food sample has burned, find the mass of the remaining food sample and paper clip. Record this value in the data table.
- Repeat steps 1 through 14 for each of the remaining food samples.

Reflection question

What changes will occur on water temperature and food sample after heating?

Data recording

Sample measurements			
Items	**Sample 1**	**Sample 2**	**Sample 3**
Mass of water (g)	4	9	9
Initial mass of food sample and paper clip (g)	20	15	25
Initial water Temperature (°C)	17	17	18
Final water Temperature(°C)	37	95	87

Final mass of food sample and paper clip after burning (g)	15	13	20

Interpretation of results and conclusion

1. Determine the mass of food that actually burned. (Initial Mass of Food Sample and Paper Clip – Final Mass of Food Sample and Paper Clip After Burning) _____ g

   Sample 1(20-15=5g)

   Sample2 (15-13=2g)

   Sample3 (25-20=5 g)

2. Determine the change in temperature of water, (Final temperature – Initial temperature) ΔT. _____ °C

   Sample 1(37-17=20°C)

   Sample 2(95-17=78°C)

   Sample3 (87-18=69°C)

3. Calculate the energy (in calories) released by the burning food sample and absorbed by the water.

   $Q = mCp\Delta T$
   Q = heat absorbed by water, m = mass of water in grams, Cp = 1 calg X °C, ΔT = change in temperature

   Q = _____ calories

   Sample 1(4gX1cal/g°C *X20*°C =80cal*)*

   Sample2 (9gX1cal/g°CX78°C=702cal)

   Sample 3 (9gX1cal/g°CX69°C=621cal)

4. Determine the number of kilocalories (food Calories) released by the burning food sample (1 kilocalorie, or **Calorie = 1,000 calories).**

   Sample 1($80X10^{-3}$Kcal)

   Sample2 ($702X10^{-3}$Kcal)

   Sample 3($621\ X10^{-3}$Kcal)

5. Calculate the energy content of the food in kilocalories/gram.

   Sample 1($80X10^{-3}$Kcal/4g=$2.0X10^{-2}$Kcal/g)

   Sample2 ($702X10^{-3}$Kcal/9g=$78X10^{-3}$Kcal/g)

   Sample 3 ($621\ X10^{-3}$Kcal/9g=69X10-3Kcal/g)

You can determine energy content of food by burning a portion of it and capturing the heat released. This technique is called calorimetry. The energy content of the food is the amount of heat produced by the combustion of 1 gram of the food.

Source of errors

Unwanted heat loss to the surroundings

Guidance on the evaluation

Ask leaners to repeat the experiment using the procedures above on carbohydrate, lipids and proteins food samples to determine their relative energy values

Experiment 5.2: Carry out investigation showing the respiratory rate of germinating seeds or woodlice using respirometer

This experiment can be done when teaching the concept or topic related to respiratory rate of germinating seeds or/and other parts of plant tissues or woodlice by using the respirometer

Rationale

Respiration is a crucial physiological process by which the living organisms get needed energy. During seed germination, the seeds consume oxygen and release CO_2. This experiment aims to measure the respiratory rate of a germinating seed.

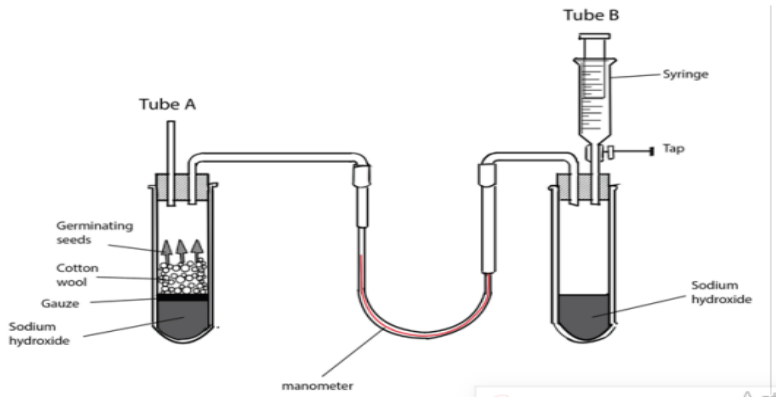
Objective

This activity aims at investigating the rate of respiration in a germinating seed

Materials

- Respirometer
- Germinating seeds
- Cotton wool
- Sodium hydroxide/or Potassium hydroxide
- Syringe
- Manometer

Experiment setup



Procedures

- Place the germinating seeds in the tube which is connected to a U-tube.
- Connect the end of the U-tube to a control tube which is treated in exactly the same way as the first tube
- Keep two boiling tubes in a water bath at constant temperature.
- Make sure that the U-tube contains a colored liquid which moves according to the pressure exerted on it by the gases in the two boiling tubes.
- Repeat the experiment by replacing the potassium hydroxide solution with water.
- Comparing the changes in manometer liquid level with and without potassium hydroxide solution

Data recording

Respirometer parts	Observation
Tube A	• Pressure reduces • If water replaces the sodium hydroxide, When the germinating seeds respire aerobically, the liquid move in the U- tube
Tube B	• Manometer fluid levels is turned to normal by syringe
Manometer	• Contains a coloured liquid which its level nearest to the seeds rises according to the pressure exerted on it

Reflection questions

1. On your own observation, why does the pressure reduces in tube A?
2. Is there any role of syringe fixed on tube B?

Interpretation of results and conclusion

During seed germination, the seeds use oxygen and release CO_2. To test g this, the chemicals including Sodium hydroxide or Potassium hydroxide are used due to their ability to absorb CO_2. When the germinating seeds respire aerobically, they consume oxygen, which causes the liquid to move in the U- tube in the direction of arrows, reducing the pressure in tube A. The syringe fixed on tube B is used to return the manometer fluid levels to normal. Therefore, the volume of oxygen used is calculated by measuring the volume of gas needed from the syringe to return the levels to the original values.

The rate of oxygen consumption can be estimated by timing how long it takes for the liquid to rise through a certain height. If the internal radius of the manometer tube is known, the volumes of gases can be calculated using the equation:

Volume of gases = π r2 h, where π is equal to 3.14, **r** is the internal radius of the tube and h is the distance moved by the liquid.

If water replaces the sodium hydroxide, then the carbon dioxide evolved can be also measured.

Source of errors

- The non-use of germinating seeds and lack of mentioned chemicals my leads to bad results.
- Respirometer should be well connected and functioning

Guidance on the evaluation

Assess the learners on investigating the respiratory rate of germinating seeds or woodlice by using a respirometer. Let learners interpret the results by themselves, and help them to calculate the respiratory intensity by asking some questions such as:

1. Calculate the volume of gases in a manometer tube having a radius of 1.7cm, knowing that the gas was displaced about 3cm distance.
2. Based on your observation, what causes the liquid to move in the U- tube in the direction of arrows?

UNIT: 6 CELLULAR RESPIRATION

Experiment 6.1: Perform investigations to determine the effect of temperature and substrate concentration on the rate of respiration

This experiment can be done when studying the factors affecting the rate of respiration

Rationale

The rate of respiration can be affected by different factors namely temperature and substrate concentration among others. In this regard the experiment of investigating the effect of temperature on the rate of respiration is worthwhile.

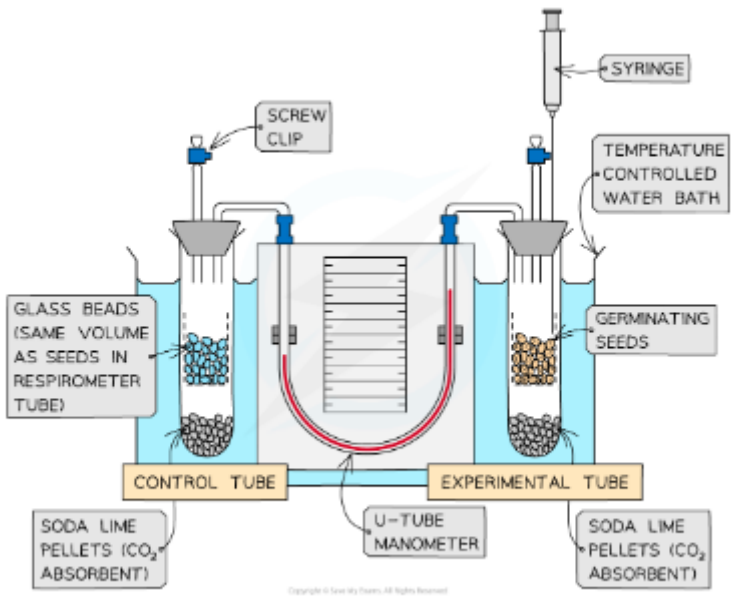
Objective

To investigate the effects of temperature on the rate of respiration.

Materials

- Respirometer
- Germinating seeds
- Glass beads
- Soda lime
- Two test tube
- temperature controlled water
- Glass beads of the same volume as seeds.
- Manometer
- Syringe
- Retort stand
- Burette clamp
- Stop watch

Experiment setup



Respirometer set up with temperature controlled water bath

Procedures

- Measure the same volume of germinating seeds and glass beads
- Prepare two test tubes
- Poor glass beads in one tube
- Put germinating seeds in the second test tube
- Add the same volume of sodium hydroxide in each test tube
- Connect two test tube with manometer and rubbers
- Fix the syringe on the top of test tube containing germinating seeds
- Place all apparatus in temperature controlled water bath and fix it with resort stand and buret cramp
- Observe and note down your observation after 5 minutes,10 minutes, and 15 minutes
- Repeat the experiment with different temperature: 40, 60,80,100,120,140 degree fahreneit

Reflection question

Is there any effect of changing temperature on the rate of respiration?

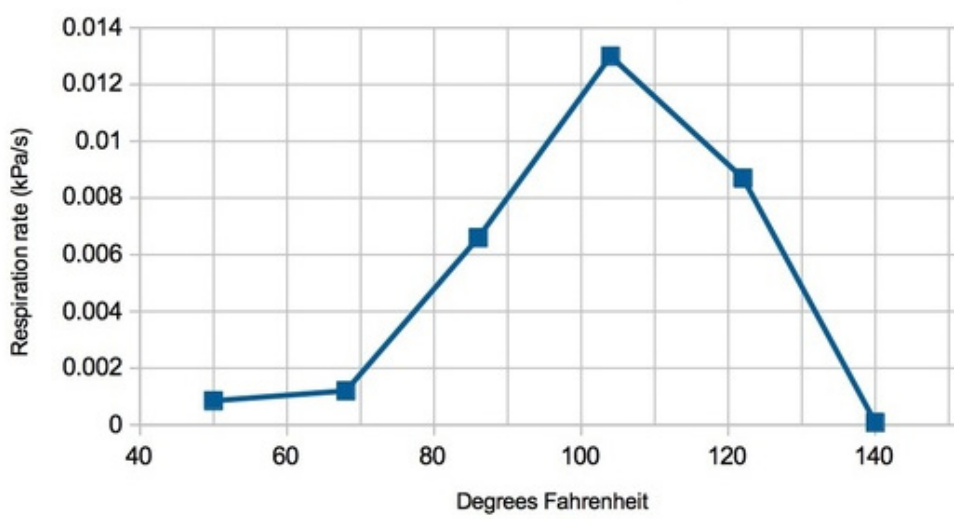
Data recording

Increase of temperature (degree Fahrenheit)	Changes of Respiratory rate (Kpa/s)
40	0.001
60	0.002
80	0.007
100	0.008
120	0.013
140	0.00

Note that during the experimentation you may get results different from what provided in the table above. This was provided as an example, so you will interpret accordingly

Interpretation of results and conclusion

The rate of the cellular respiration increases with body temperature until the optimum and then decreases as the temperature continues to increase. This is because the respiratory enzymes work better at their optimum temperature. Above this optimum temperature the enzyme activity starts to decrease until it stops. This is because high temperatures denature enzymes and when the respiratory enzymes are denatured, the respiration process stops.



On the above figure, the initial temperature was 50 degrees, the respiration rate increased to the optimum temperature of 105 degrees from where it started to decrease. It stops at 140 degrees

Source of errors

The errors may result from the organism, chemicals or the respirometer used.

Guidance on the evaluation

Assess learners on the effects of temperature on the rate of respiration and let them interpret the results by themselves. You can ask them some questions such as:

How does the temperature affect the rate of respiration?

Experiment 6.2: Research on the quantity of ATP produced from anaerobic respiration

This activity can be done when studying the concept or topic related to the efficiency of anaerobic respiration.

Rationale

This process of anaerobic breakdown of glucose is relatively less energy yielding compared to the aerobic processes. This activity aims to measure the quantity of ATP produced during the anaerobic respiration.

Objective

To count the ATP's quantity produced during anaerobic respiration

Materials

- Internet
- Computer
- Books

Procedures

Guide the learners on how to find enough information about the energy produced during the anaerobic respiration. By doing this, you may help them by providing some links and books that give them more information about anaerobic respiration.

For example:

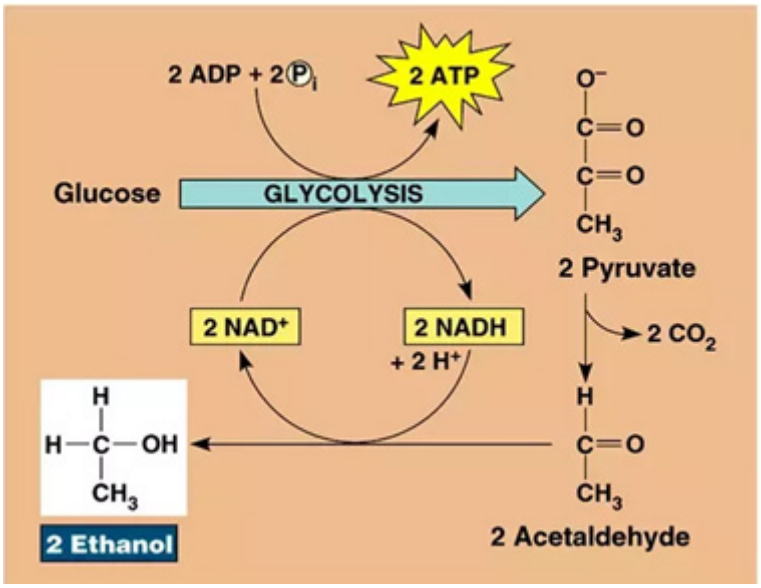
- *The link: What Is Anaerobic Respiration | Physiology | Biology | FuseSchool - Bing video*
- *https://www.bing.com/videos/search?q=anaerobic+respiration&&view=detail&mid=5D5BC328BBC6B578C6E65D5BC328BBC6B578C6E6&&FORM=VRDGAR&ru=%2Fvideos%*
- *The book: Bacterial Physiology and Metabolism by Byung Hong Kim and Geoffrey Michael Gadd*
- *On the problem of anaerobic methane oxidation. Microbiology-Moscow 73, 599–608.CrossRefGoogle Scholar*

Note that, the sources provided above are some examples that can help you on how you can guide learners. They can find other sources by themselves.

Data recording

Types of anaerobic respiration	ATP produced
Alcoholic fermentation	2 ATP
Lactic fermentation	2 ATP

Interpretation of results and conclusion



Alcohol and lactic acid fermentation are two types of anaerobic respiration. The key difference between these two types of fermentation is the end product. In alcohol fermentation, the end product is ethanol, while in lactic acid fermentation, the end product is lactate.

Equation of anaerobic respiration: Glucose→ Ethanol + Carbon Dioxide (CO_2) + Energy (2 ATP)

Anaerobic respiration refers to the type of respiration that takes place in the absence of oxygen. This form of respiration is carried out in bacteria, yeasts, some prokaryotes, and muscle cells. The anaerobic respiration taking place in muscles during hard physical exercises breaks to form lactic acid which accumulates in the muscles and causes muscle cramps. During anaerobic respiration energy, carbon dioxide, and lactic acid or alcohol are produced by the breakdown of glucose molecules. It uses electron acceptors other than oxygen, and involves the processes of glycolysis and fermentation.

As the substrate is never totally oxidized, the energy generated by both alcoholic and lactic fermentation (2ATP) is less than that generated during aerobic respiration (38 ATP). This is because the waste products of fermentation still contain chemical potential energy.

Guidance on the evaluation

Assess learners on the quantity of ATP produced during the anaerobic respiration. Give learners time to present their findings about the research conducted on anaerobic respiration.

Ask them questions related to their findings:

1. What is anaerobic respiration?
2. Explain why the ATP produced during anaerobic respiration is less than the one produced in aerobic respiration?
3. What are the applications of anaerobic respiration in everyday life?

UNIT: 7 EXCRETION AND OSMOREGULATION

Experiment 7.1: Conduct dissection to indicate the major structures of the kidney in rabbit

This experiment can be conducted when teaching the topic or concept related to structure and functions of excretory organs in mammals.

Rationale

Excretion is an essential process in all forms of life. When cells metabolize or break down nutrients, waste products are produced. For example, when cells metabolize amino acids, nitrogen wastes such as ammonia are produced. Ammonia is a toxic substance and must be removed from the blood and excreted from the body. The kidneys work together with other urinary system organs in the function of excretion. It is of crucial importance to conduct this experiment to help learners understand the kidney structure.

Objective

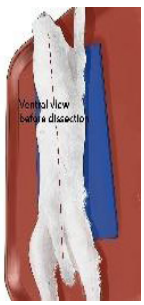
To indicate the major structures of the kidney in mammals

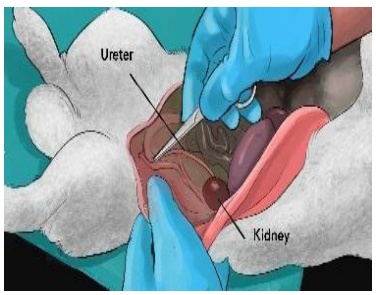
Materials

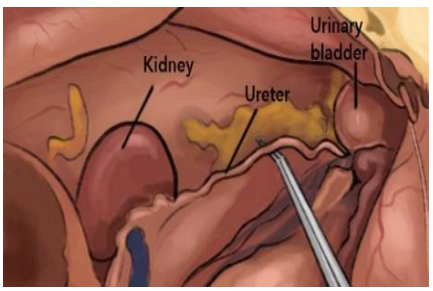
- Live rabbit
- Chloroform
- 5 Disposable Dissecting Pads
- Plastic Storage Bag
- Moist Towelettes
- Dissecting Scissors
- Dissecting Forceps

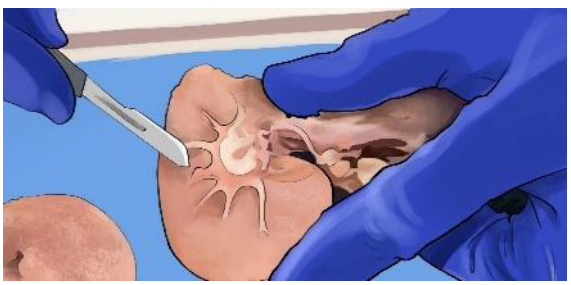
- Disposable Scalpel
- Teasing Needle
- Dissecting “T” Pins
- Dropping Pipet
- Dissection of Rabbit Manual
- Gloves
- Cotton wool
- Bucket
- Hands lens to visualize kidney internal organ\

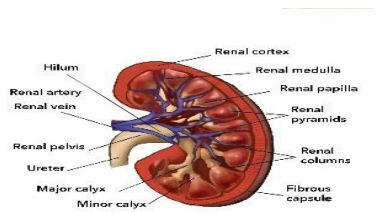
Experiment set up











Procedures and steps of the experiment

1. Soak a cotton in chloroform and put it in a bucket
2. Put the rabbit in the bucket containing soaked cotton and cover it until it anesthetized. Remove the rabbit and place it in the dissecting tray, ventral side up.
3. Tie the legs securely to the corners of the tray by passing a string or rubber Bands. Be sure that the specimen is held firmly before you begin dissecting.
4. Find the lower edge of the sternum (breastbone) and make an incision through the skin from that point to the pelvis. This will expose the layers of the abdominal muscles.
5. Strip the skin well back to the sides and examine the muscle layer.

Using the scissors or the scalpel, make another incision through the muscle layer. This will expose a thin membrane, the peritoneum, which lines the abdominal cavity

6. Cut through the peritoneum to expose the abdominal organs.
7. Open the abdominal cavity wide by making several lateral cuts and pulling the skin and muscle layer well to the side.
8. Use pins to pin back the cut sections of skin and muscle.
9. Discard the digestive organs and examine the kidneys.
10. Cut under each kidney and remove it along with the ureter tube.
11. Cut a kidney laterally and examine its internal structure.
12. You should find a spongy cortex on the other curved side and a hollow pelvis on the inner concave side. See if you can find the renal blood vessels which lead to and from the kidneys. Discard the kidneys.

Reflection questions

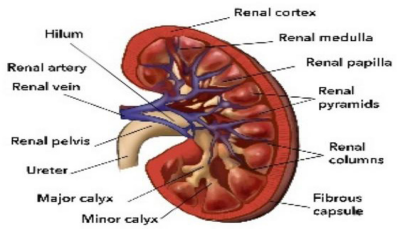
1. Based on your observation, describe the kidney location
2. Describe the kidney structure
3. Discuss the functions of each part of the urinary system

Data recording

During the rabbit dissection to indicate the kidney, the following kidney organs can be observed:

Kidney major structure	Diagram
Renal cortex Renal medulla Renal pelvis	

The kidneys are two bean-shaped organs, each about the size of a fist. They are located just below the rib cage, one on each side of your spine. During the rabbit dissection, the following structure are observed: The outermost layer is a tough connective tissue layer called the renal fascia. The second layer is called the perirenal fat capsule, which helps anchor the kidneys in place. The third and innermost layer is the renal capsule. Internally, the kidney has three regions—an outer cortex, a medulla in the middle, and the renal pelvis. The renal medulla contains the renal pyramids, where urine formation takes place. The renal cortex is granular due to the presence of nephrons—the functional unit of the kidney. Renal pelvis, the area at the center of the kidney. Urine collects here and is funneled into the ureter, the tube that connects the kidney to the bladder.



Longitudinal section of kidney showing internal structure.

Source of errors

Damaging internal organs during dissection will hinder the visibility of the kidney and its structures. Learners should be carefully and follow well the provided procedure. Teachers should guide learners.

Guidance on evaluation

Ask learners to observe carefully the major structures of a kidney during dissection and discuss on their functions.

UNIT: 8 GENERAL PRINCIPLES OF RECEPTION AND RESPONSE IN ANIMALS

Experiment 8.1 : Dissection of eye of mammals (cow, goat) to identify the three layers of the human eyeball

This experiment can be done when teaching the concept or topic related to structure of the human eye.

Rationale

The eye is a complex light sensitive organ that enables us to distinguish minute variations of shape, color, brightness, and distance. Exploring an actual mammalian eye allows students to learn how the parts of the eye function and how vision operates through a hands-on activity. In addition, they can learn about human vision by drawing similarities between the cow and human eye. Hence this experiment is imperative specially to help learners identify layers of the eyeball as well discuss their functions.

Objective

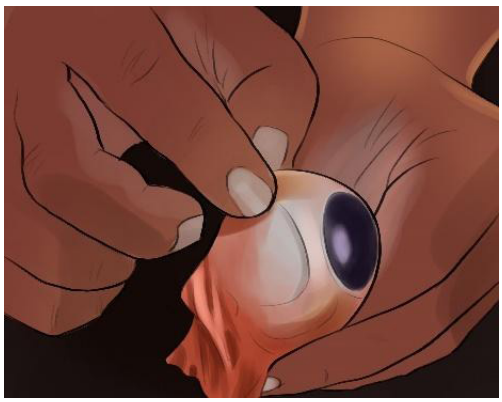
To identify three layers of the eyeball by dissecting the mammalian (cow) eye.

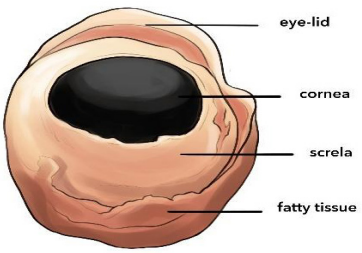
Materials

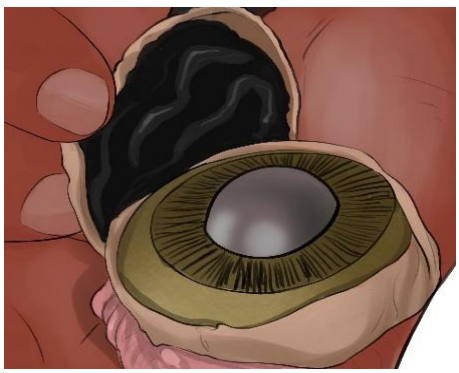
- One cow's eye for every 6 participants
- One single-edged razor blade or scalpel for every team of participants
- Scissors (optional)
- Wax paper and paper towels
- Plastic garbage bag
- A cutting board or other surface on which you can cut
- A sheet of newspaper

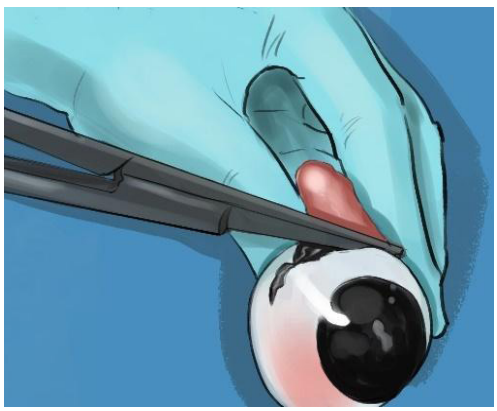
- Soap,
- Forceps
- water, and paper towels for cleaning up

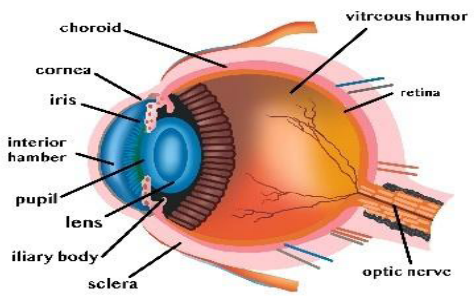
Experiment set up











Cow's eye dissection

Procedures and steps of the experiment

1. Examine the outside of the eye and see how many parts you can identify.
2. Cut away the fat and the muscle.
3. Use scalpel to make an incision in the cornea.
4. Cut until the clear liquid in the cornea is released. That clear liquid is the aqueous humour. It's made of mostly of water and keeps the shape of the cornea
5. Use the scalpel to make an incision through the sclera in the middle of the eye.
6. Cut around the middle of the eye until you get two halves. s. On the front half will be the cornea.
7. Remove the front part and place it on the board.
8. Cut the front part with scalpel or razor
9. During cutting of the front part, listen and explain what happens.
10. Pull out the iris between the cornea and the lens. It should come out in one piece. You can see that there's a hole in the center of the iris. That's the pupil, the hole that lets light into the eye.
11. Observe in the centre of the iris after pulling out the iris.
12. Remove the lens and mention its texture.
13. Hold the lens in front of you and observe. What do you observe?
14. Empty the vitreous humor out of the eyeball.
15. Remove the retina and mention whether the spot is attached to the back of the eye.
16. Find the optic nerve and pinch the nerve with your fingers or with a pair of scissors

Reflection questions

1. Draw and label the three main layers of the cow 'eyeball.
2. Write in your own words the functions of each part of a mammalian eye

Data recording

The following layers lie flat against each other and form the eyeball.

1. ***Outermost Layer: Sclera and Cornea***
   - **Sclera (white of the eye)**: The sclera is dense connective tissue made of mainly type 1 collagen fibers, oriented in different directions.
   - **Cornea**: The covering over the front of the eye that form transparent front layer of the eye
2. ***Middle Layer: Uvea (Iris, Ciliary Body, Choroid)***
   - **Iris:** Consists of stromal layer with pigmented, fibro vascular tissue and pigmented epithelial cells beneath the stroma.
   - **Ciliary Body:** The tissue that divides the posterior chamber and vitreous body consists of the ciliary muscle and the ciliary epithelium.
   - **Choroid:** Consists of a dense network of blood vessels supplying nourishment to structures of the eye, housed in loose connective tissue.
3. ***Innermost layer: Lens, Vitreous, Retina***
   1. **Lens:** Separates the aqueous and vitreous chambers. Consists of an outer capsule, a middle layer called cortex, and an inner layer called the nucleus
   2. **Vitreous:** a jelly-like space made of type II collagen separating the retina and the lens
   3. **Retina:** nervous tissue of the eye where photons of light convert to neurochemical energy via action potentials

Interpretation and conclusion

The cow's eyeball consists of three layers of tissue arranged concentrically: The sclera and cornea make up the exterior layer. The uvea or middle layer is the vascular layer in the middle, subdivided into the iris, ciliary body, and choroid. Innermost layer consists of the lens, vitreous and retina. The retina constitutes the innermost layer and is made up of nervous tissue.

Source of errors

Damaging the eyeball layers will not allow the correct visualization of their sutures. Allows students to participate in a dissection by providing guiding instructions.

Guidance on evaluation

Ask learners to describe the three layers of the cow's eye ball as per their observations during dissection.

Experiment 8.2 : Learners carry out activities on reverse color sense by cones

This activity will be done when teaching the concept or topic related to how cone cells produce color vision.

Rationale

The retina possesses the photoreceptor cells. These are of two types, cones and rods. Both converts light energy into the electrical energy or nerve impulses. Humans have 3 distinct color-sensing cones for red, green, and blue light. By combining these cells' signals, the brain can distinguish thousands of different colors. Cone cells, or cones, are one of the two types of photoreceptor cells that are in the retina of the eye which are responsible for color vision as well as eye color sensitivity; they function best in relatively bright light, as opposed to rod cells that work better in dim light. Students need to know clearly how color vision is produced and this activity will provide clarification.

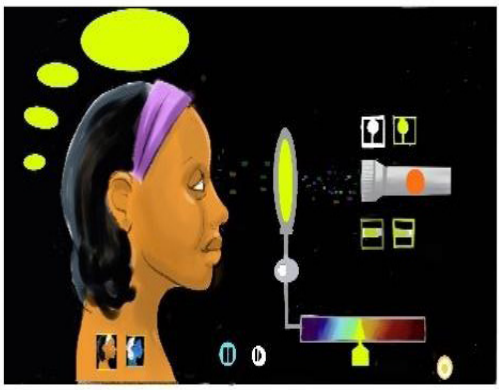
Objective

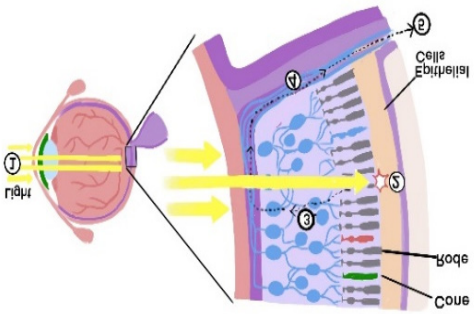
To carry out experiments on reverse color sense by cones

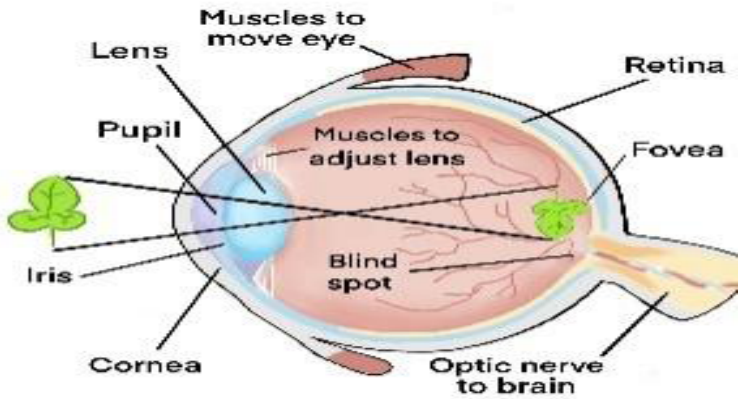
Materials

- Video(https://www.youtube.com/watch?v=VeDOpGRMZ7Y)
- Internet connectivity
- Computer
- Projector
- Simulation(https://phet.colorado.edu/sims/html/color-vision/latest/color-vision_en.html)

Experiment set up







Procedures & steps of the experiment

Connect a computer to project

1. Open the video or simulation and play it
2. Ask learners to carefully observe and record their observations.

Reflection questions

- What causes the appearance of an object's color?
- What is the difference between the cone and rod cells

Data recording

Experiment	Observation	Reason
Reverse color sense by cones	Colored image is formed upside down at retina.	When light enters the eye, it is refracted by the curved surface of the cornea, the lens, the aqueous and vitreous humor. The refraction of light causes the image to be formed upside down on fovea centralis. When cones and rods are stimulated by light, they send impulses through the optic nerves to the brain where the correct impression of the object is formed.

Interpretation and conclusion

Cones are stimulated by light and send signals to the brain. The brain is the actual we have three types of cones: blue, green, and red. The human eye only has about 6 million cones. Many of these are packed into the fovea, a small pit in the back of the eye that helps with the sharpness or detail of images interpreter of color. When light enters the eye, it is refracted by the curved surface of the cornea, the lens, the aqueous and vitreous humor. The refraction of light causes the image to be formed upside down on fovea centralis. When cones and rods are stimulated by light, they send impulses through the optic nerves to the brain where the correct impression of the object is formed.

Guidance on evaluation

Ask learner to describe the mechanism of color vision basing on their observation.

UNIT: 9 NERVOUS COORDINATION

Experiment 9.1: Demonstrate electrical activity in the nerve of a frog

This experiment can be conducted when teaching concepts or topics related to the transmission of nerve impulses, especially investigation of the nature of a nerve impulse in a nerve tissue of a frog.

Rationale

The neurons, like other cells, are positively charged outside and negatively charged inside. The transmission of a nerve impulse along a neuron from one end to the other occurs as a result of electrical changes across the membrane of the neuron. The membrane of an unstimulated neuron is polarized that is, there is a difference in electrical charge between the outside and inside of the membrane. Students need to know how nerve impulses are transmitted along an axon. This experiment will introduce learners to this concept and get to know how neurons are charged.

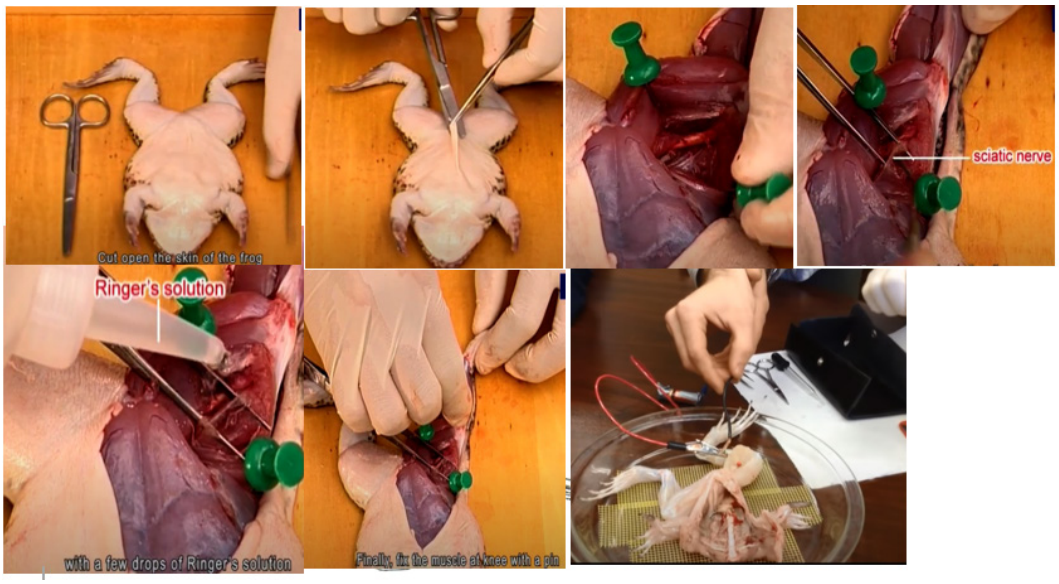
Objective

To demonstrate electrical activity in the nerve of a frog.

Materials

- Nerve chamber,
- cable and nerve chamber leads (red and black),
- glass hooks,
- Stimulator cable,
- grounding adapter or cable,
- forceps,

Experiment set up



The dissection of a frog's sciatic nerve to demonstrate electrical activity https://www.youtube.com/watch?v=sBzK-a0OhLU

Procedures and steps of the experiment

1. To begin dissection, retrieve a frog from your teacher and place it in a dissecting tray.
2. Remove the skin from the legs by making an incision through the skin and around the entire lower abdomen.
3. Cut the connections between the skin and the body especially around the base of the pelvic girdle.
4. Use forceps to pull the skin off the frog in one piece (like a pair of pants).
5. Place the frog with its dorsal side up.
6. Moisten the exposed tissue (legs) with Ringer's solution and place a wet paper towel (saturated with Ringer's solution) over one of the legs of the frog so that it is completely covered and wet.
7. Use forceps to separate the muscles of the thigh (the leg not covered with the Paper towel).

8. Pin the muscles apart so that more underlying muscle is visible.

This should also expose the cream-colored Sciatic nerve lying deeply between the muscles.

9. Use a glass hook to separate the nerve from the fascia and the vessels. If Possible, avoid cutting the blood vessels. If bleeding does occur, rinse away the blood with lots of Ringer's solution.
10. Free the nerve from the knee joint to the pelvis.
11. Use the glass hook to place a suture thread under the nerve. Move the thread as close to the knee joint as possible.
12. Ligate (tie off) the nerve; you may observe calf muscle fibrillation or foot movement as the knot is tied off.
13. Be sure the knot is tied tightly and
14. Cut the nerve between the knot and the knee joint.
15. Keep the exposed nerve moist at all times with Ringer's solution.
16. Carefully separate the muscles of the pelvis to expose the sciatic nerve.
17. Remember to rinse any blood away with Ringer's solution.
18. Fix the nerve by a pin and connect it to the 6V and 10 V
19. Record your observations.

Reflection question

What happens if a sciatic nerve is connected to electrical source (Voltage)?

Data recording

Activity done	Observations
Dissection of a frog	Exposed sciatic nerve
Locating sciatic nerve	The sciatic nerve is located in the leg of a frog between vertebrae at the caudal end of the vertebral column
Connecting sciatic nerve to voltage (6V and 10V)	– It is negatively charged inside and positively charged outside. – When connected to voltage by applying negative electrode outside and positive electrode inside there is contraction of a frog's leg.

Interpretation and conclusion

The results of this experiment have shown that the electrical stimulation of sciatic nerve accelerates biceps muscle force to a comparable level with control without effect on muscle sensitivity. Sciatic nerve electrical stimulation produced a significant increase in the electromyography (EMG) response of biceps femoris and this generated the frog's leg contraction. The frog's leg is negatively charged inside and positively charged outside. When connected to voltage by applying negative electrode outside and positive electrode inside there is contraction of a frog's leg. ……..

Guidance on evaluation

When evaluating this hands-on activity, focus on the concept of animal electricity. Ask learners to explain what happens when you electrically stimulate the sciatic nerve. Animal electricity is present in all living higher animals. Ask them to conduct this experiment on other animal types like rabbits etc.

UNIT: 10 PHORMONAL COORDINATION IN ANIMALS

Experiment 10.1 : Simulation/video on the mode of function of endocrine glands

This activity can be done when teaching the topic or concept related to the structure and function of the endocrine system.

Rationale

Endocrine system is made up of several organs called endocrine glands. These glands are located all over in the body and secrete (release) hormones. Hormones are chemicals that coordinate different functions in the body by carrying messages through blood to target organs, skin, muscles and other tissues. Endocrine glands are group of endocrine cells that are dedicated to perform specific function. It is important to help student to understand clearly how these glands function. This activity will provide a good explanation on how each produced hormone has a specific function by acting on its target cells in the body.

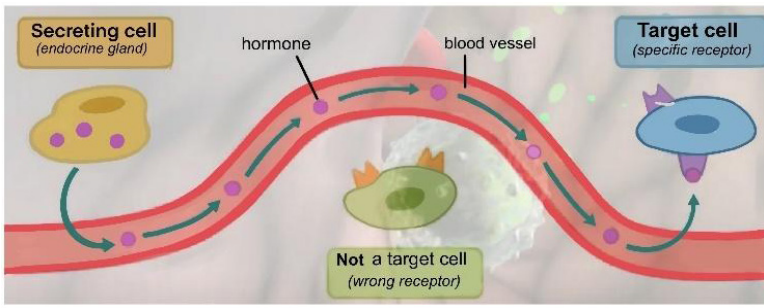
Objective

To demonstrate the mode of function of endocrine glands using simulation or videos.

Materials

1. Simulation or video (https://www.youtube.com/watch?v=Z804AVBP6Og) on mode of function of endocrine gland
2. Computers (or laptop)
3. Projectors
4. Internet connectivity

Experiment set up



Mode of function of endocrine glands (https://www.youtube.com/watch?v=Z804AVBP6Og)

Procedure and steps of the experiment

1. Find a video (https://www.youtube.com/watch?v=Z804AVBP6Og) or simulation on the endocrine gland
2. Connect your computer on projector
3. Open the simulation or video
4. Play it
5. Ask students to carefully observe the video.
6. When using the simulation and working in a computer lab, ask students to open the link and guide hem to manipulate by click on the indicated button.
7. Record observations.

Reflection questions

1. Based on the observations how do endocrine gland function?

Data Recording

Activity	Observation
Mode of function of endocrine glands	• Endocrine glands secrete hormones that diffuse to the bloodstream via capillaries and are transported to the target cells through the circulatory system. • Each hormone functions on its specific target cell/organ with the specific receptor.

Interpretation and conclusion

The glands of the endocrine system secrete hormones directly into the extracellular environment. The hormones then diffuse to the bloodstream via capillaries and are transported to the target cells through the circulatory system. This allows hormones to affect tissues and organs far from the site of production or to apply systemic effects to the whole body.

Source of error

Disappearance of video or simulation link.

Guidance on evaluation

Ask learners:

1. To explain the mechanism of action of hormones
2. To compare the mechanism of hormones and enzymes action

Experiment 10.2 : Simulation/video on hormonal disorders (gigantism and dwarfism)

This activity can be used when teaching the concept or topic related to hormonal disorders.

Rationale

Hormone is an organic substance which is produced in minute quantity by an endocrine gland, transported by blood to other parts or organs of the body where it exerts maximum effects. One of its effective functions of the hormones in the body is to regulate the growth and development of an organism. However, when the body produces too much growth hormone, the bone bones increase excessively in size. In childhood, this leads to increased height and is called gigantism (abnormal enlargement of the hands and feet). For adults, it is called acromegaly (an overproduction of growth hormone, even after puberty) that affects middle-aged adults. On the other hand, when the pituitary gland fails to produce an adequate amount of growth hormone, there is dwarfism. This activity aims to explain the necessity of hormonal balance in coordination of body activities.

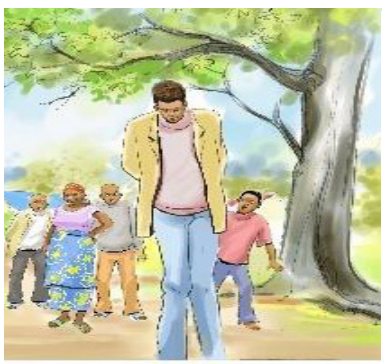
Objective

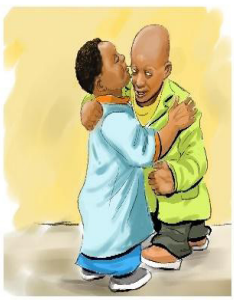
1. Learners will be able to explain why hormonal balance is necessary for coordinating the functions in the body.
2. Appreciate the role of hormones in the growth and development of organisms.

Materials

1. Projector
2. Computer
3. Video showing the hormonal disorders (gigantism and dwarfism)
4. Figures / images which can be used in the class by showing the gigantism and dwarfism disorders

Experiment set up





Procedures & steps of the experiment

1. Click on one of these links of videos Link: https://www.youtube.com/watch?v=Ze5ag7DdNpw ; https://www.youtube.com/watch?v=KEqrkcLVlH0
2. Connect your computer on projector
3. Open the simulation or video
4. Play it
5. Ask learners to carefully observe the video.
6. When using the simulation and working in a computer lab, ask students to open the link and guide them to manipulate by click on the indicated button.
7. Record observations.

Reflection questions

1. After watching the video, differentiate the dwarfism to gigantism?
2. How both of them differ with acromegaly?

Data recording

Growth hormonal disorders	Cause
Gigantism	Overproduction of growth hormone in child that leads to increased height (abnormal enlargement of the hands and feet).
Acromegaly	An overproduction of growth hormone for adult people, even after puberty.
Dwarfism	When the pituitary gland fails to produce an adequate supply of growth hormone.

Interpretation and conclusion

Several disorders of the anterior pituitary involve human growth hormone. Hyposecretion of human growth hormone during the growth years slows bone growth, and the epiphyseal plates close before normal height is reached.

This condition is called dwarfism. Other organs of the body also fail to grow, and the body proportions are childlike. Treatment requires administration of human growth hormone during childhood, before the epiphyseal plates close. Hypersecretion of human growth hormone during childhood causes gigantism, an abnormal increase in the length of long bones. For adults, it is called acromegaly (an overproduction of growth hormone, even after puberty) that affects middle-aged adults.

Guidance on evaluation

Teacher can play the videos or choosing other pictures / images, or simulation in the class and request learners to watch attentively and answer the questions that will be provided such as:

1. Discuss the effects of hypo and hyper secretion of anterior pituitary glands?
2. How acromegaly differs from gigantism?

Experiment 10.3 : Video / Simulations on negative feedback mechanism of hormonal action

This activity can be done when teaching the concept or topic related to negative feedback mechanism of hormonal action.

Rationale

Hormones alter conditions inside the cell, usually in response to a stimulus. That means they are activated at specific times. So they must be turned on and then turned back off. Most hormones are regulated by feedback mechanisms including the negative feedback loops. The negative feedback keeps the concentration of hormones within a narrow range. This activity aims to explain and demonstrate what controls the hormones themselves and what turns these hormones and their responses on or off.

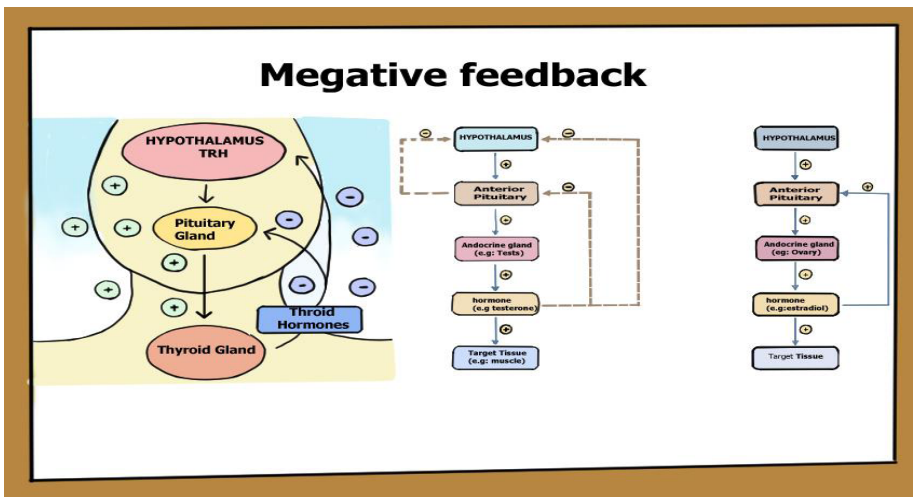
Objective

To describe the negative feedback mechanism of hormonal action by using video or simulations.

Materials

1. Projector
2. Computer
3. Video /or simulation showing the negative feedback mechanism of hormonal action
4. Figures / images which can be used in the class by the negative feedback mechanism of hormonal action
5. Internet connectivity

Experiment set up



Procedures & steps of the experiment

1. Click on one of these links of videos (Link: http://www.youtube.com/watch?v=Vae5CcaPN_8

   Link: https://www.youtube.com/watch?v=HrMi4GikWwQ
2. Connect your computer on projector
3. Open the simulation or video
4. Play it
5. Ask learners to carefully observe the video.

6. When using the simulation and working in a computer lab, ask students to open the link and guide them to manipulate by click on the indicated button.
7. Record observations

Reflection questions

After watching the videos above, reflect on the following questions:

1. How does our body control its release of hormones?
2. What is negative feedback? Give an example.
3. Draw and label a diagram depicting negative feedback.

Data recording

	Negative feedback	Positive feedback
Hypothalamus	• Inhibited by production of some hormones release such as Testosterone) & anterior pituitary gland	+
Anterior pituitary gland	• Inhibited by hormone released such as testosterone	+
Endocrine gland	• The inhibition of anterior pituitary gland also inhibit its function	+
Hormones released	• Inhibit the release of hypothalamus and anterior pituitary gland (eg. Testosterone)	• Stimulate the activity of endocrine gland

Interpretation and conclusion

Most hormones are regulated by feedback mechanisms. During regulation, the hypothalamus secretes thyrotropin-releasing hormone, or TRH, then the TRH stimulates the pituitary gland to produce thyroid-stimulating hormone, or TSH. TSH, in turn, stimulates the thyroid gland to secrete its hormones. When the level of thyroid hormones is high enough, the hormones feedback is to stop the hypothalamus from secreting TRH and the pituitary from secreting TSH. Without the stimulation of TSH, the thyroid gland stops secreting its hormones.

Guidance on evaluation

Teacher can play the videos discussing about the negative feedback loop or choosing other pictures / images, or simulation in the class and request learners to watch attentively and answer to the questions that he/she will prepare for them, such as:

1. What is negative feedback?
2. What might happen if an endocrine hormone such as thyroid hormone was controlled by positive instead of negative feedback?
3. Tasha had a thyroid test. Her doctor gave her an injection of TSH and 15 minutes later measured the level of thyroid hormone in her blood. What is TSH? Why do you think Tasha's doctor gave her an injection of TSH? How would this affect the level of thyroid hormones in her blood if her thyroid is normal**?**

Activity 10.4 : Research on the necessity of hormone balance and the effects of imbalance and write a report

This Activity can be done when teaching the c oncept or topic related to the necessity of hormone balance and the effects of imbalance.

Rationale

Hormones play an integral role in our overall health. As a result, there's a wide range of signs that could signal a hormonal imbalance. A hormonal imbalance happens when a person has too much or too little of one or more hormones. It's a broad term that can represent many different hormone-related conditions. Some hormonal imbalances can be temporary while others are chronic (long-term). In addition, some hormonal imbalances require treatment so a person can stay physically healthy, while others may not impact a person's health but can negatively affect your quality of life. This activity aims to understand the necessity of hormone balance and the effects of its imbalance.

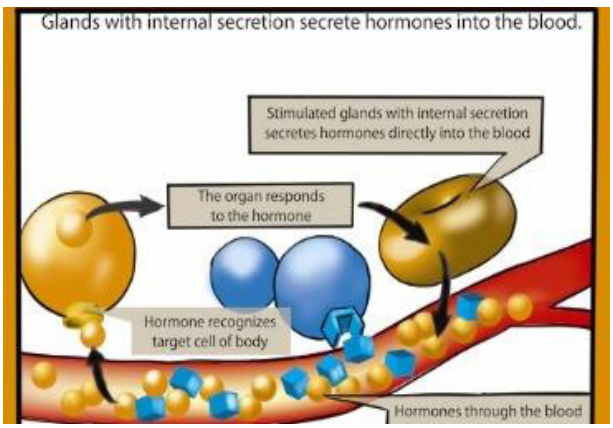
Objective

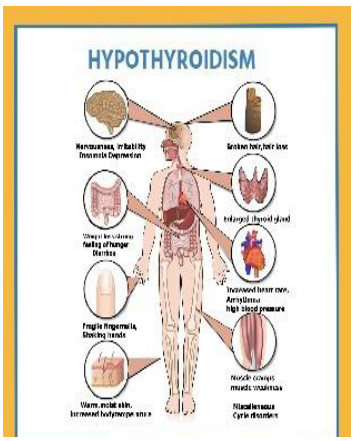
To study the necessity of hormone balance and the effects of imbalance

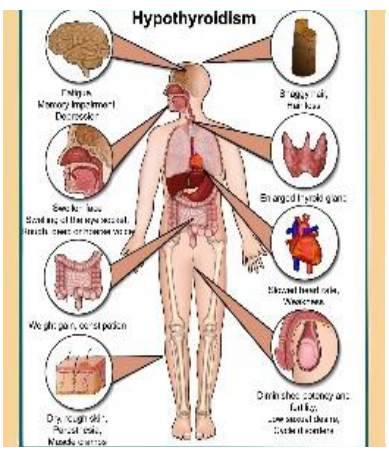
Materials

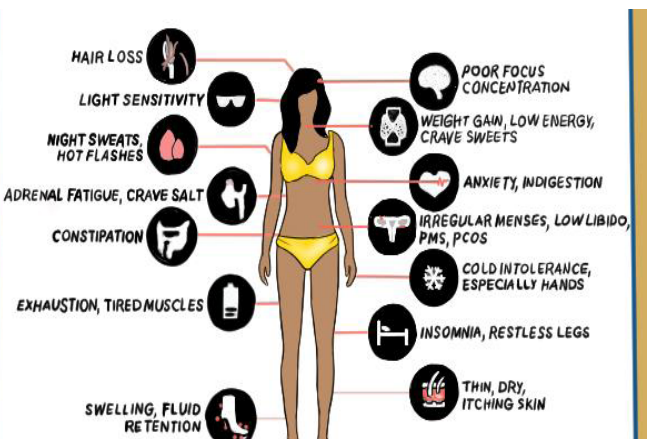
1. Projector
2. Computer & internet connection
3. Books
4. Video /or simulation showing the necessity of hormone balance and the effects of its imbalance.
5. Figures / images which can be used in the class showing or describing the necessity of hormone balance and the effects of its imbalance.

Experiment set up









Procedures & steps of the experiment

1. Click on one of these links of videos (Link: https://www.youtube.com/watch?v=4EFfByxXMRg&t=50s

Link: *https://www.youtube.com/watch?v=A7DiCTuGXI0*

2. Connect your computer on projector
3. Open the simulation or video
4. Play it
5. Ask learners to carefully watch the video.
6. When using the simulation and working in a computer lab, ask learners to open the link and guide them on how to use it by clicking on the indicated buttons
7. Record observations

Reflection questions

After watching the videos above, reflect on the following questions:

1. What issues can be caused by hormone imbalance?
2. How can you control your hormonal imbalance?

Data recording

Hormone balance	Hormone Imbalance
• Help regulate many of our bodily functions (eg. help us sleep through the night, have babies, grow hair, grow our body, metabolize food, and keep us warm, etc…)	• It can be associated with many bodily problems (eg. period problems, unwanted hair growth, fertility struggles, weight gain, difficulty sleeping,etc…

Interpretation and conclusion

The disorders of the endocrine system often involve either the hypo-secretion (too little or under) or the hyper-secretion (too much or above). Hormonal balance is having the appropriate amount of hormones at a specific time. For example women have to keep their estrogen and progesterone levels in balance, and men also have to keep their testosterone in balance. In other cases, the problem is faulty hormone receptors, an inadequate number of receptors, or defects in second-messenger systems. If there is too much or too little hormone, overall health is under risk of various diseases.

Guidance on evaluation

1. Teacher can play the videos showing the necessity of hormone balance and the effects of its imbalance or he/she can choose other images, or simulation to use in the class and request learners to follow attentively and answer the following questions: You may know people suffering from ovarian cancer, or diabetes mellitus or you may have heard about these diseases from the radio or from a newspaper.
   - Collect information about the cause of these diseases?
   - How do you think these diseases can be treated?
2. Observe carefully the figures below and suggest the type of disorders the following people may be suffering from.

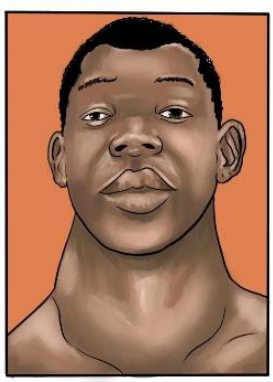


Fig. A

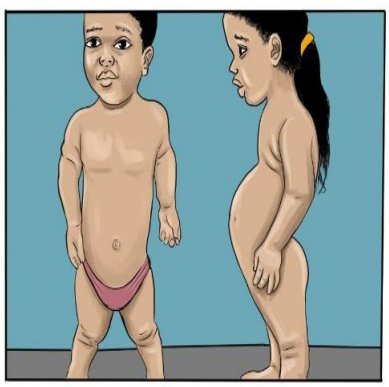


Fig. B

Source:https://www.tellitnurse.com/2021/02/goitre-causes-signs-and-symptoms.html

UNIT: 11 SKELETONS, MUSCLES AND MOVEMENT

Experiment 11.1 : Observe earthworms and insects to compare a hydrostatic skeleton and exoskeleton respectively

This experiment can be done when teaching the concept or topic related to types of animal skeletons: hydrostatic, exoskeleton and endoskeleton. Specifically comparing earthworms and insects' hydrostatic skeleton and exoskeleton.

Rationale

A support system is made up of those materials that bear the weight of the body, strengthen its parts and endure all stresses that the body or its parts may be subjected to during movement. Consequently, the strength of the supporting materials in an organism is directly related to its size and weight. An endoskeleton is a hardened internal skeleton, and an exoskeleton is a hard external framework, while a hydrostatic skeleton, or hydroskeleton, is a kind of skeleton that is composed of soft tissue filled with an incompressible fluid or gel-like substance. It is of importance to conduct this experiment to help learners to clearly observe earthworm and insect skeleton types so as to be able to differentiate them.

Objective

To compare a hydrostatic skeleton and exoskeleton by observing earthworms and insects.

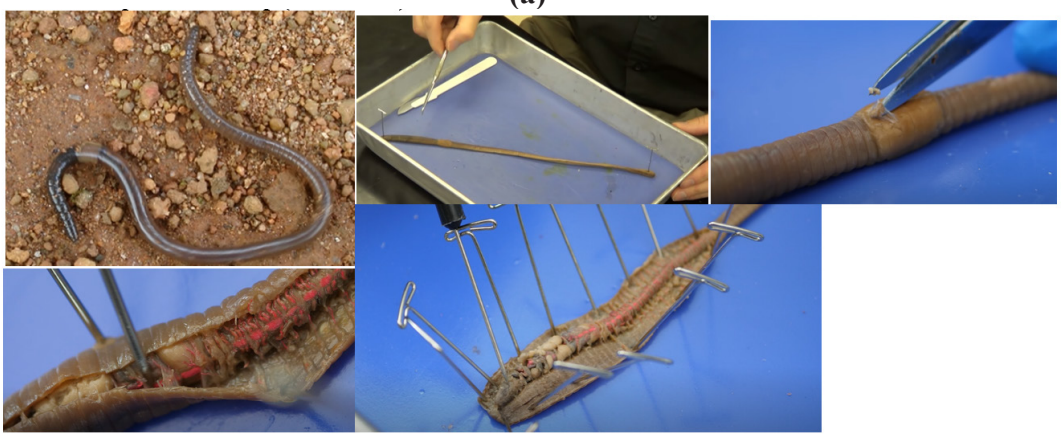
Materials (for both earthworm and Grasshopper)

- Preserved earthworm,
- Preserved insect (Grasshopper for example)
- Dropper.
- Dissecting scissors.

- Forceps.
- Pins.
- Scalpel Handle
- Teaser Needles Straight
- Styrofoam dissecting tray.
- Dissection guide.
- 70% to 80% alcohol (ethanol or ethyl alcohol)

Experiment set up

(a)



(b)

Procedures and steps of the experiment

For earthworm:

- Put the worm on the dissecting tray, keeping the dorsal surface upwards and fix it in a straight line
- Starting from the initial incision cut the skin along the mid-dorsal line, proceeding anteriorly or posteriorly or both as required for dissection.
- Hold the skin with a pair of fine forceps and free it from septa with a fine needle.
- Pin down the loose flaps of the skin and proceed for dissection of organ systems.
- Then you can start observing the type of skeleton you want.

For grasshopper:

Find the grasshopper from the school environment

Preserve it in 70% to 80% alcohol (ethanol or ethyl alcohol)

Ask learners to observe carefully the external parts of grasshopper

Ask them to record their observations

Below are videos for both sides earthworm and grasshopper dissection that can help you to perform well the mentioned dissection.

- Link: https://www.youtube.com/watch?v=aCnwF6vtE2g
- Link: https://www.youtube.com/watch?v=8p-GAX4Xb2A
- https://www.youtube.com/watch?v=Nv0TrVh6Jos

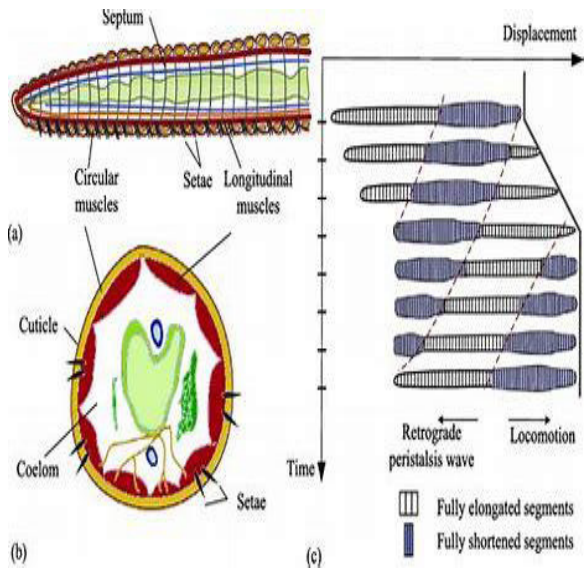
Reflection questions

In your groups, after observing earthworms and grasshopper compare their hydrostatic skeleton and their exoskeleton?

Data recording

Type of skeleton	Observations
Hydrostatic skeleton	• Inside the body • Made of fluid • Muscles around the fluid can press against it
Exoskeleton	• Outside the body • Made of non-living material • Muscles are attached to the inside of the skeleton • Does not grow, so it needs to be shed to enable the animal to grow.

Interpretation and conclusion



Earthworm structure

Earthworm skeleton belongs to a group of soft-bodied and cold-blooded animals having a coelom. This coelom is a fluid-filled cavity surrounded by muscles and the rigidity caused by the fluid. The muscles serve as a supporting structure for organisms. It is basically composed of a fluid filled body cavity surrounded by sets of antagonistic muscles and operates on the principle that water is incompressible and therefore can provide a rigid medium against which muscles can contact.

Eg. Invertebrates like earthworm, some fish such as jelly fish, starfish, and sea anemones.

The **exoskeletons** are found in all arthropods it is found outside the body and forms a protective covering for the animals. All crustaceans have exoskeleton. Crabs, spiders, lobsters, insects are all arthropods. Animals with exoskeleton are usually small. This is because large animals could not be supported by exoskeleton and need bones to support them. Animals with exoskeleton have a head and abdomen and, in some cases, a thorax

Eg. Crustaceans, insects, arachnids, mollusks, centipedes, and millipedes

Source of errors

- Damaging the specimen during collection. Teacher and learners should be careful during collection so as not to destroy the earth worm hydroskeleton and insect exoskeleton because they have to be observed in full.

Guidance on evaluation

Assess learners on the types of animal skeleton by asking them to write a short note on the difference between hydrostatic skeleton, exoskeleton and endoskeleton.

Experiment 11.2 : Use prepared slides of the three types of muscles and compare their characteristics.

This experiment can be done when teaching the concept or topic related to main types of mammalian muscles. Specifically, when comparing the structure of cardiac, smooth and skeletal muscle.

Rationale, purpose

There are three types of mammalian muscle: skeletal, smooth, and cardiac. The functions of muscle tissue are: movement, stability, control of body openings and passages and heat production. Muscles work by either contracting or relaxing to cause movement. This movement may be voluntary or done without our conscious awareness (involuntary). Therefore, to carry out those functions, all muscle tissue has the different characteristics. This experiment aims to compare the characteristics of the three types of muscles by using prepared slides.

Objective

To compare the characteristics of three types of muscles by observation of prepared slide under microscope.

Materials

Permanent slide of skeletal muscle

- Permanent slide of smooth muscle
- Permanent slide of cardiac muscle
- Light microscope
- Pencils
- Rubber
- notebook

Experiment set up

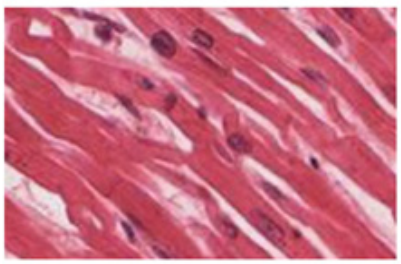


Fig. Cardiac muscle

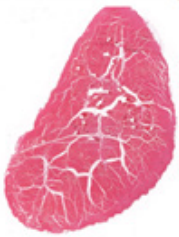


Fig. Skeletal muscle

Fig. Smooth muscle

Procedures & steps of the experiment

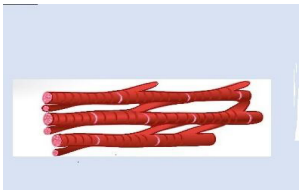
- Set the microscope on the appropriate table in classroom or laboratory
- Fix the permanent slide one by one of each of the 3 types of muscles on the microscope
- Start by low power objective to scan a large area of the specimen and observe the mounted slide under light microscope.
- Draw and label the observed characteristics
- Repeat the process with the permanent slide of each of the 3 types of muscles
- Compare the structures of the muscle observed under the microscope
- Record the main characteristics of 3 types of muscles.

Reflection questions

Are structures different for 3 types of muscles?

Data recording

Type of muscle	Structure	Characteristics
Skeletal muscle		• Attached to the skeleton • Their contraction is under voluntary control • They are mainly responsible for movement of the body
Smooth muscle		• They are found in the walls of all the hollow organs of the body (except the heart) • They regulates the flow of blood in the arteries, expels of urine, etc... • They are involuntary muscle

Cardiac muscle		• It is the only type of muscle that exists in the heart • It works automatically and constantly without ever pausing to rest (squeeze blood out of the heart, and relaxes to fill it with blood).

Interpretation and conclusion

Muscles are made up of hundreds of thousands of muscle cells (also called muscle fibres). These muscle cells act together to perform the functions of the specific muscle they are part of. There are 3 types of muscle: skeletal, smooth, and cardiac. To carry out their functions, all muscle tissues have the various characteristics respectively. In skeletal muscle, the fibres are packed into regular parallel bundles, attached to the skeleton, responsible for movement and their contraction is under voluntary control. In cardiac muscle tissue, the bundles are branched, like a tree, but connected at both ends, its contraction is usually not under conscious control (involuntary). Last but not least, smooth muscle cells are small, and spindle shaped that have no striations, with bundles of thin and thick filaments, contracting involuntary, and are found in the walls of all the hollow organs of the body (except the heart).

Guidance on evaluation

1. Teacher may bring in the class annotated figure, containing the structure of 3 types of muscle labelled using letters A, B, C, and ask learners to differentiate them.
2. The teacher can also ask the questions: How does the structure of a muscle cell type relate to its function?

Experiment 11.3 : Dissect a frog/toad heart to observe myogenic contraction

Rationale

This experiment can be done when teaching the concept or topic related to observation of myogenic contraction

Toads have a special heart feature of being myogenic. This is the ability of the heartbeat to function without the control of the nervous system. The contractions in the heart result from the excitement created by the cardiac muscle membranes which are subjected to depolarization until a particular threshold is reached when the action potential begins. The functioning of the heart of a toad is facilitated by the availability of oxygen and nutrients which enable it to function correctly. As a result of this function, it has been used as the best specimen for conducting scientific experiments aimed at understanding the functions of the heart and factors affecting the functions of the heart of poikilotherms.

Objective

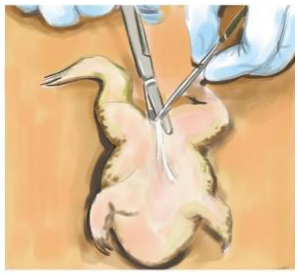
To observe myogenic contraction by dissecting a heart of a frog or toad.

Materials

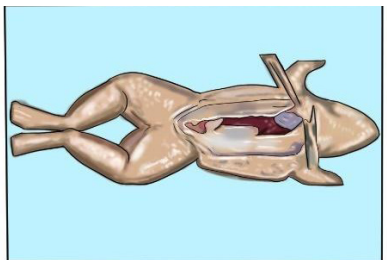
- Dissecting tray pan
- Needles
- Ringer's solution (20 ml of physiological liquid)
- Droppers
- Suture needle with thread attached
- Razor blade
- Bell jar
- Frog or toad
- Water
- Pair of scissor
- Magnifying hand lens
- Pins
- Chloroform
- Cotton wool
- Forceps
- Glass beaker
- Gloves

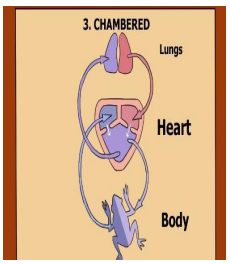
Experiment set up

Unit9/a



Unit 9/b





Procedure and steps of the experiment

- Collect a living frog or toad from environment mainly the nearest swamp
- Prepare 20ml of Ringer's liquid in a glass beaker
- Put the cotton wool imbibed of 10 ml of chloroform in the bell jar
- Put your frog in the bell jar for 5 minutes, then remove it
- Place the frog on its dorsal surface
- Fix its four limbs with pins on the dissection dish
- Carry out the longitudinal section from the abdomen to the chest using surgical blade (razor blade) or scissor.
- Using the sharp end of a pair of sharp scissors make a small penetration into the abdominal cavity of the frog.
- Carefully cut abdominal wall with a pair of scissors and cut towards the sternum. Lift the scissor as you cut to prevent cutting of the heart bloods vessels or other internal organs.
- Cut through the pectoral girdle to expose the heart in the pericardial sac.
- Carefully remove the pericardial sac.

- Cut any connective tissue attachments (not the vessels around the atria) so that the heart beats freely
- Using forceps to grasp the apex of the ventricle
- Cut any connective tissue attachments (not the vessels around the atria) so that the heart beats freely
- Using forceps to grasp the apex of the ventricle
- Connect the thread from the frog heart to the force transducer S-hook
- Position the frog so the thread from the heart is vertical. If it is pulling at an angle much of the contraction of the frog heart will not be observed.
- Don't worry about the stand height or thread tension at this point.
- Remember to bathe the heart in Ringer's periodically
- Observe the heart beats and contractions.

https://www.youtube.com/watch?v=6TvmMrHwlpo (the video on this link show clearly the procedures)

Reflection questions

Based on your observations, discuss the toad/frog heart myogenic functions.

Data recording

Dissected specimen	Observations
Toad heart	– The heart beats on its own. – Cardiac muscle contract at the same time. – When the ventricle or the left atrium is cut away, it quickly ceases to beat, while the right atrium keeps contracting. – The heart of the frog has three chambers, one ventricle and two atria.

Interpretation and conclusion

The heart is made of only cardiac muscle. Unlike other types of muscle, cardiac muscle never gets tired. It works automatically and constantly without ever pausing to rest. Cardiac muscle contracts to squeeze blood out of the heart, and relaxes to fill the heart with blood.

The heart of a frog is myogenic in nature as it can contract without getting stimuli from the nerve cells. The contractions are initiated within the heart by specialized cardiac muscles known as nodal tissue. During this experiment, you can see the frog heart is beating on its own. This is possible because the heart keeps its own rhythm using a group of specialized cells, known as the pacemaker cells. In the frog, they are located near the junction of the vena cava and the right atrium, a region called the sinus venosus. These cells have an intrinsic heart rate, which can be increased by the sympathetic nervous system and decreased by the parasympathetic nervous system. The cells fire signals called action potentials, which move throughout the nerves on the heart, causing parts of the cardiac muscle to contract at the same time. When the ventricle or the left atrium is cut away, it quickly ceases to beat, while the right atrium keeps contracting as it holds the pacemaker cells. It will continue to contract until it runs out of either ATP (a type of chemical energy) or extracellular sodium.

Guidance on evaluation

Ask learners some questions to check what they captured during the experiment.

1. How was it easy to dissect the frog?
2. What have you observed related to frog heart contraction?

Experiment 11.4 : Use prepared slides and micrographs to compare structures of cardiac, smooth and skeletal muscles

Rationale

The muscular system consists of all the muscles of the body. Muscles are composed mainly of muscle cells, which are also called muscle fibers. Each muscle fiber is a very long, thin cell that can do something no other cell can do. It can contract, or shorten. Muscle contractions are responsible for all the movements of the body, both inside and out. For example, muscular movements help the body to move, to maintain posture and help the passage of materials such as blood, **lymph**, and food in the digestive system. It's a good thing to investigate and know their structures as they work on their own without any conscious effort on your part and movement of these muscles is essential for survival.

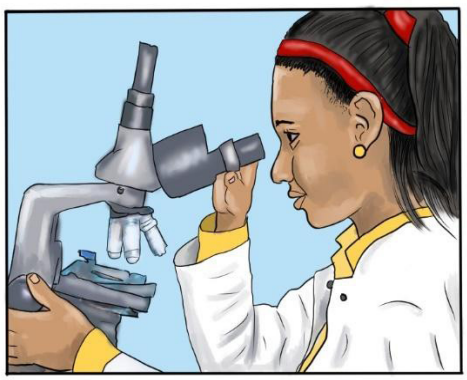
Objective

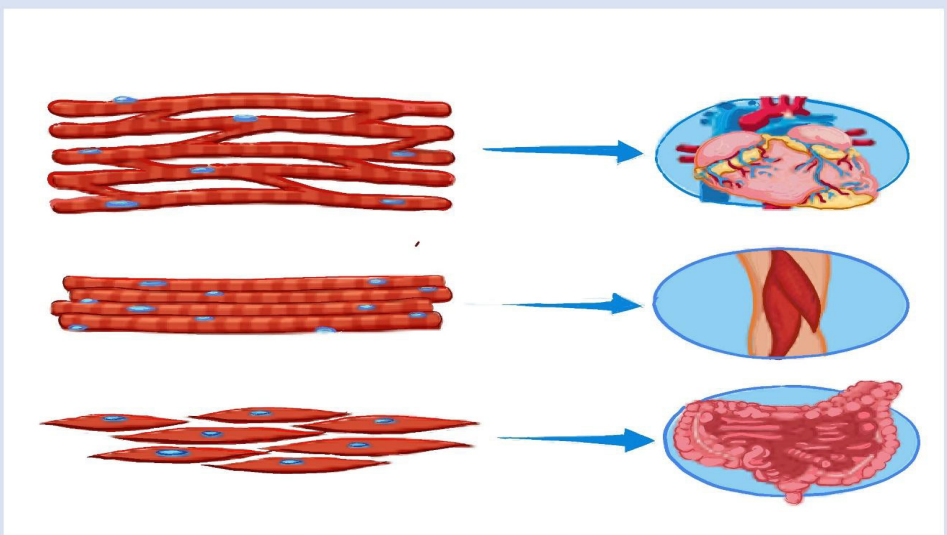
Observe and compare structures of cardiac, smooth and skeletal muscles using prepared slides

Materials

- Permanent slides of cardiac, smooth and skeletal muscles
- Microscope

Experiment set up





Procedures

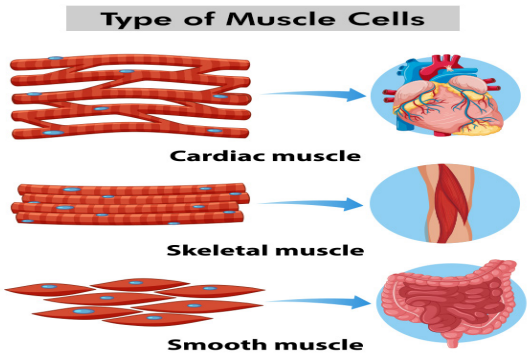
1. Have separate prepared slides cardiac, smooth and skeletal muscles
2. Mount on the microscope prepared slide of cardiac muscles
3. Draw and label your observation under the high magnification of microscope
4. Repeat the steps 2 and 3 above using prepared slides of smooth and skeletal muscles
5. Draw your observations showing specific structure of each muscle.

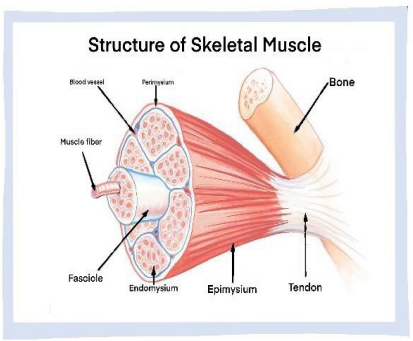
Data recording

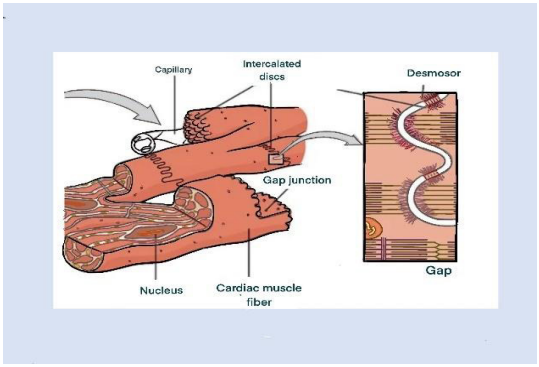
Cardiac muscles	Skeletal muscle	Smooth muscle
– Found only in the walls of the heart	– Found attached to bones and skin	– Line walls of the internal organs such as urinary bladder, stomach, intestine, uterus, and the walls of blood capillaries.
– Cardiac muscle bundles are branched but connected.	– Skeletal muscle fibres are packed into regular parallel bundles.	– Smooth muscle has bundles of thin and thick filaments.
– Comprise branching chains of cells, connected by porous intercalated discs with a single nucleus	– Comprise very long cylindrical, multinucleated cells	– Comprise single, tapering, single nucleated cells
– Striated with many myofibrils in orderly arrangements	– Striated with orderly arranged myofibrils	– Not striated, fewer myofibrils are found in varying length.

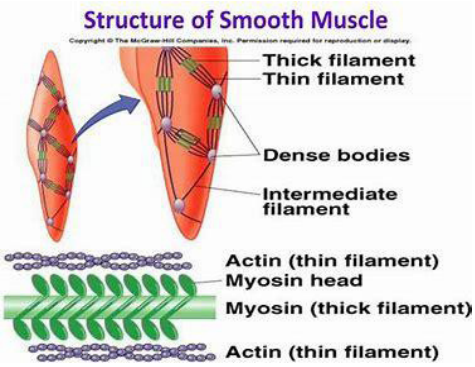
Interpretation and conclusion

There are three types of human muscles: Cardiac muscle (only in the heart), skeletal muscle and smooth muscle (in internal organs).









The cardiac muscle cells are Y-shaped cells, and they are shorter and wider than skeletal muscles. Each cardiac muscle cell is mononucleotide. Since it is a high energy requiring muscle, the cardiac muscle cells comprise many **mitochondria** and **myoglobin**. Cardiac muscle tissue, like skeletal muscle tissue, looks striated or striped because their cells are arranged in bundles. The bundles are branched, like a tree, but connected at both ends. Unlike skeletal muscle tissue, the contraction of cardiac muscle tissue is usually not under conscious control, so it is called involuntary.

The skeletal muscles are the striated muscles (the fibres contain alternating light and dark bands (striations), which are typically attached to the skeleton and under the voluntary control. The fibres are packed into regular parallel bundles. The skeletal muscles are composed of thousands of cylindrical cells. The size, shape, and the arrangement of fibers vary depending on the position of the body.

- Smooth muscles are a type of muscle fibers which are not highly ordered; The smooth muscles are involuntary muscles, which are not striated. The shape of the muscle cell is spindle-like with a single, centrally located nucleus. The smooth muscle cells are not striated. Compared to skeletal muscle, smooth muscle cells are small and not striated because their cells are arranged in sheets instead of bundles. They are spindle shaped and have no striations. Instead, they have bundles of thin and thick filaments.

Source of errors

- Dirty slides
- Wrong manipulation of microscope
- Inattention to details

Guidance on evaluation

Ask learners some questions to check what they captured during the experiment.

- Compare the three types of muscles.
- Why are skeletal and cardiac muscles striated?
- Where is smooth muscle tissue found?
- What is the function of skeletal muscle? Give an example.

Experiment 11.5 : Simulations/videos to demonstrate the structure and functioning of the sarcomere during muscle contraction

This activity can be done when teaching the concept or topic related to muscle contraction. This topic is in the unit of skeletons, muscles and movement.

Rationale

The sarcomere is the main contractile unit of muscle fiber in the skeletal muscle. Each sarcomere is composed of protein filaments called myofilaments that include mainly the thick filaments called myosin, and thin filaments called **actin**, and the two are the active structures responsible for muscular contraction. The bundles of myofilaments are called **myofibrils** that produce a muscular **contraction** in which the filaments slide over each other. This activity aims to demonstrate the molecular mechanisms of contraction.

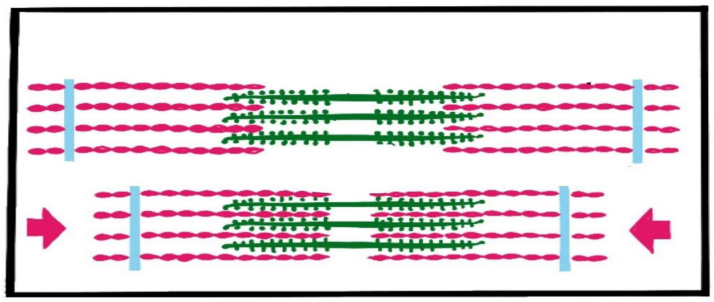
Objective

To describe the structure and functioning of the sarcomere during muscle contraction

Materials

- Computer
- Projector
- Video /or simulation showing the muscle contraction mechanism

Experiment set up



Procedures

- Avail and set the needed materials for playing a video in classroom
- Request learners to follow attentively the video and answer the reflection questions related to the video
- Play the video on the following link: https://www.youtube.com/watch?v=NfEJUPnqxk0

Reflection questions

After watching the videos above, reflect on the following questions:

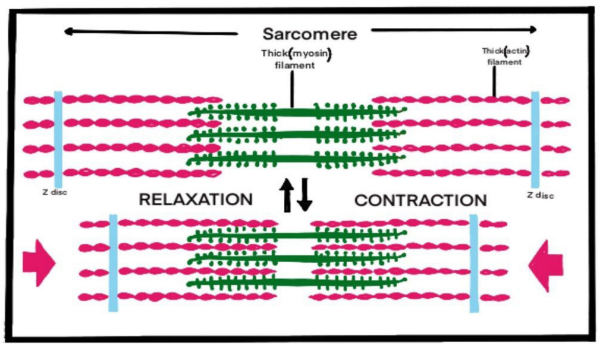
1. What are the main parts of a sarcomere involved in muscle contraction?
2. How does muscle contraction work?
3. Draw and label a diagram depicting sarcomere actions during contraction.

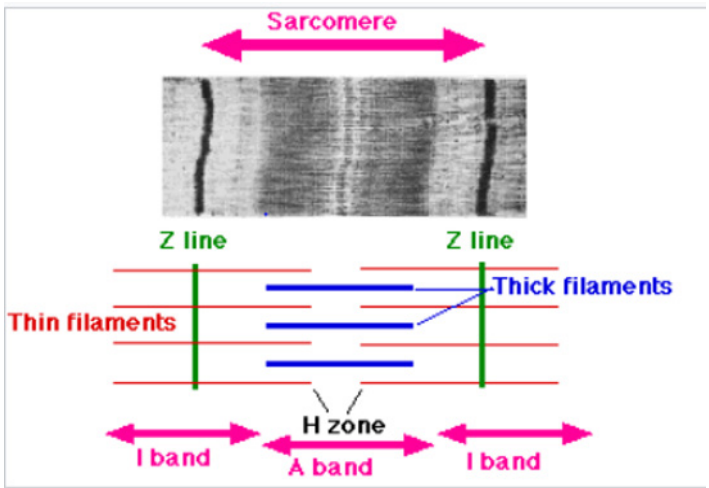
Data recording

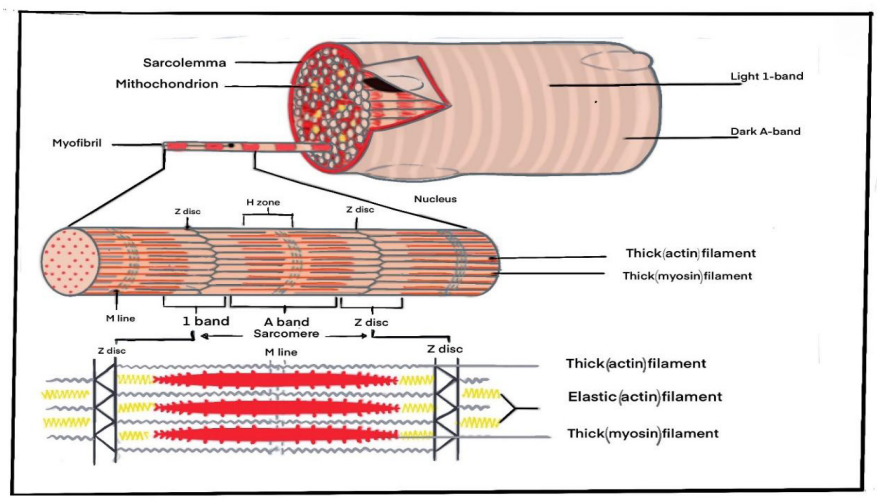
- **A band (or anisotropic bands)** - dark bands that contain whole thick filaments (myosin).
- **I bands** (or *isotropic bands*) - light bands that contain only the thin filaments (actin) and are located between the two thick filaments.
- **Z disc** - is an area that traverses the I bands and marks the point of the connection between the two neighboring actin filaments. That said, the sarcomere can also be described as the structure between the two Z discs.
- **M line -** marks the middle of the sarcomere and contains the protein called myomesin.

– **H zone -** is the area between the M line and Z disc. The H zone contains only myosin.
– Presence of Ca2+ ions and ATP.

Interpretation and conclusion







A sarcomere consists of more than just contractile and regulatory proteins. The M line and the Z disc hold the thick and the thin filaments in place, respectively. The elastic filament helps keep the thick filament in the middle between the two Z discs during contraction.

Because the lengths of the thick and thin filaments do not change, the change in length of the I band could occur only if the thin filaments were to slide past the thick filaments. Therefore, the reversed polarity of the thick and thin filaments relative to the center line of the sarcomere (M line) cause a shortening of the sarcomere during contraction by the sliding of thin actin filaments, which are attached to the Z disk, past the thick myosin filaments toward the center of the sarcomere. The concentration of Ca2+ ions and breakdown of ATP are involved in activation of the contraction process.

During contraction, a sarcomere shortens as the actin filaments at each end of a central myosin filament slide toward the myosin's centre. The movements of myosin appears like a molecular dance, with the myosin reaching forward to binds to the actin, contracting, then releasing actin, before it reaches forward again to bind actin in a new cycle.

Guidance on evaluation

1. What are the parts of sarcomere observed in the video?
2. Explain the sliding filament model of muscle contraction.

UNIT: 12 HUMAN REPRODUCTION

Experiment 12.1 : Simulations/Video of the stages that bring about the fertilization and development of an embryo

This activity can be done when teaching the concept or topic related to copulation, fertilization and embryo development.

Rationale

Human development begins after the union of the male and female gametes. Fertilization is a complex process that enables the reproduction and continuation of the species.

Egg and sperm union occurs **in the fallopian tube**. The result of this union leads to the production of a fertilized egg called a **zygote**, initiating **embryonic development**. As a baby goes through several stages of development, beginning as a fertilized, egg that develops into a blastocyst, an embryo, then a fetus, this activity will allow learners to explore such stages for better understanding and application in their life.

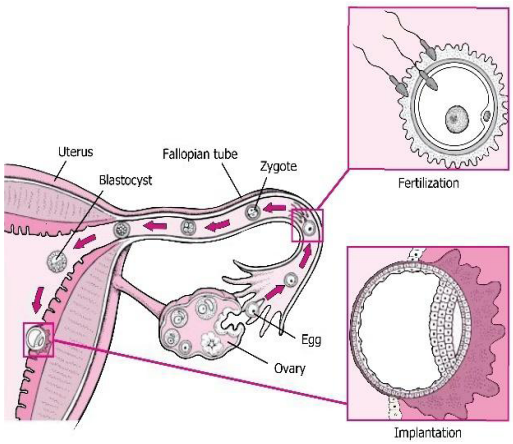
Objective

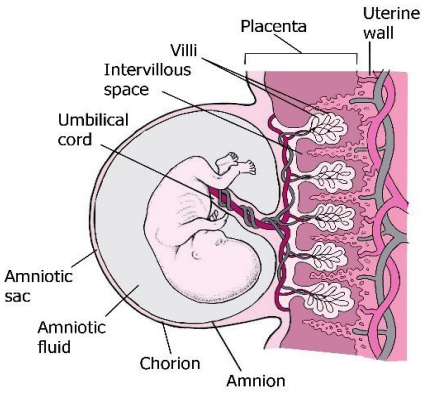
To observe and describe the stages that bring about the fertilization and development of an embryo**.**

Materials

- Computer
- Projector
- Video /or simulation showing tCopulation, fertilization and embryo development.

Experiment set up





Procedures

- Avail and set the needed materials for playing a video in classroom
- Request learners to follow attentively the video and answer the reflection questions related to the video
- Play the video on the following link: https://www.youtube.com/watch?v=s-Xpa5UZAZs

Reflection questions

While watching the videos above, reflect on the following questions:

1. What do you understand by the term fertilization?
2. What are the necessary conditions for fertilization to take place?
3. Does the fetus keep the same size and position during pregnancy?

Data recording

From the video, we recorded the following:

- 14 days after the last menstrual period, there is ovulation
- The egg is released in fallopian tube
- The sperms move in the vagina to the uterus and to fallopian tube
- One sperm enters the egg: Fertilization
- The zygote enters the uterus in 3 to 5 days: Implantation

- Zygote cells continue to divide, becoming blastocyst.
- The blastocyst implants in the wall of the uterus by 9 to 10 days after fertilization.
- About day 10 to 12, the blastocyst becomes an embryo.
- By about 10 weeks after fertilization, almost all organs are completely formed
- By 12 weeks of pregnancy: The fetus fills the entire uterus.
- By about 14 weeks: The sex can be identified.
- By about 16 to 20 weeks: The fetus is felt moving.
- By about 24 weeks: The fetus has all organs

Interpretation and conclusion

In the reproductive process, fertilization occurs when a male sperm and a female egg cell join to make fertilized egg. Pregnancy begins once the fertilized egg implants in the uterus.

Normally once a month, an egg is released from an ovary into a fallopian tube. After sexual intercourse, sperms move from the vagina through the cervix and uterus to the fallopian tubes, where one sperm fertilizes the egg. The fertilized egg (zygote) divides repeatedly as it moves down the fallopian tube to the uterus for implantation. First, the zygote becomes a solid ball of cells, then it becomes a hollow ball of cells called a blastocyst. Inside the uterus, the blastocyst implants in the wall of the uterus, where it develops into an embryo attached to a placenta and surrounded by fluid-filled membranes that provide support and nourishment. The embryo goes through three developmental stages including cleavage (division of zygote into daughter cells), gastrulation (development of ectoderm, mesoderm, and endoderm layers) and organogenesis and differentiation in which there is formation of specific organs and tissues.

Guidance on evaluation

Ask learners some questions about what they captured in the video.

- Where does the fertilization take place?
- Where does the implantation take place?
- What are the main stages of embryo development observed in the video?

Activity 12.2 : Simulations/Video showing the stages of birth

This activity can be conducted when teaching the concept related to the main stages of delivery process.

Rationale

Birth is the most physiological process during which the fetus, membranes, umbilical cord and placenta are expelled from uterus. Birth study help to explore childbirth experiences and their meaning among postnatal mothers. Improving the experience of women throughout labour and childbirth is essential to help increase women and men's trust in facility-based care as well as ensuring access to quality postnatal care following birth.

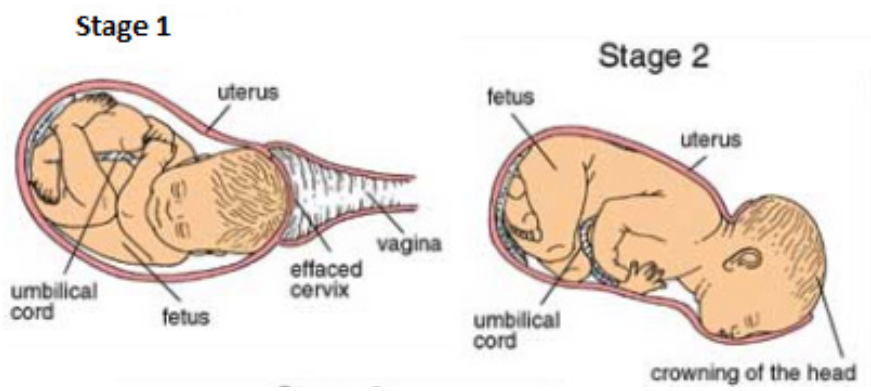
Objective

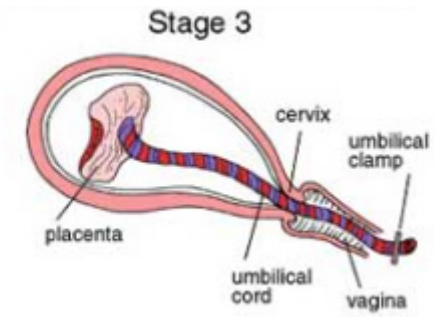
Study the steps of human birth process.

Materials

- Computer
- Projector
- Video /or simulation showing Copulation, fertilization and embryo development.

Experiment set up





Procedure

- Avail and set the needed materials for playing a video in classroom
- Request learners to attentively watch the video and answer the reflection question related to the video.
- Play the video on the following link: *https://www.youtube.com/watch?v=s-Xpa5UZAZs*

Reflection question

What are the main stages of the human birth process?

Data recording

The process of giving birth is composed of three main stages: dilation stage, the expulsion stage and placenta stage.

Interpretation and conclusion

Dilation stage: During this stage, a water sac filled with amniotic fluid forms and precedes the head, widening soft tissue of the birth canal, cervix, and vagina for a canal of constant diameter. The amnion ruptures and amniotic fluid drains through vagina.

The expulsion stage: During this stage, the cervix is fully dilated while abdominal muscle bear down in supporting rhythmic contraction of the uterus shortening the uterine wall and baby is pushed into and through the birth canal. The head and shoulder align themselves first.

Placenta stage: This stage begins with complete expulsion of the baby and ends with expulsion of the fetal membrane. The cord is clamped and cut when the delivery of the baby is complete. This leads carbon dioxide enrichment into the baby's blood which activates the respiratory center and the baby begins to breathe with the first cry at the same time foetal circulation changes to the baby's own systemic.

Guidance on evaluation

Assess the learners by giving questions related to the human birth process.

Example:

Briefly explain the distinction between the stages of the human birth process.

UNIT: 13 PRINCIPLES OF GENE TECHNOLOGY.

Activity 13.1 : Visit local university, health center or forensic lab to observe the gel electrophoresis used to analyze proteins and nucleic acids.

This activity can be done when teaching the concept or topic related to the principles and techniques of gene technology.

Rationale

Gel electrophoresis is a technique commonly used in laboratories to separate charged molecules like DNA, RNA and proteins according to their size. It is used in separation of DNA fragments for DNA fingerprinting to investigate crime scenes, and analyze the genes associated with a particular illness. This activity will give an opportunity to students to observe the gel electrophoresis and record its steps.

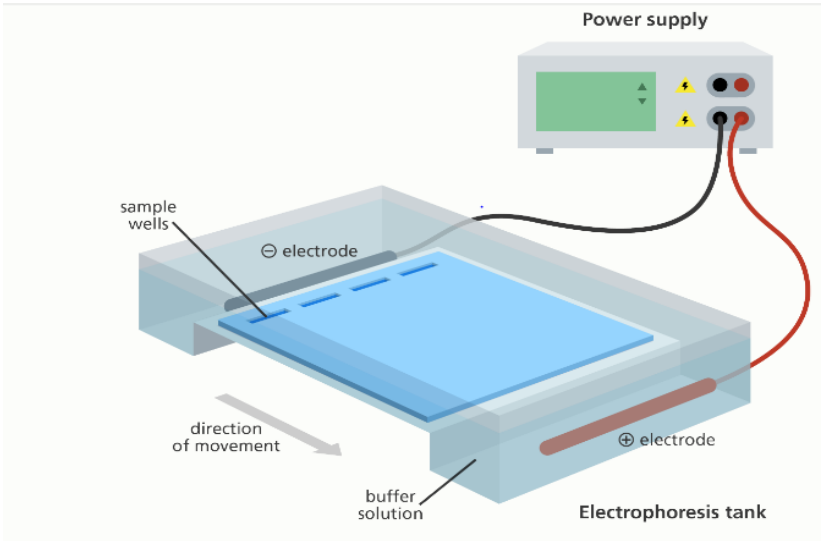
Objective

To observe the use of gel electrophoresis and record its steps.

Materials

- Reporting format
- Notebook
- Electrophoresis tank

Experiment set up



Procedures and steps of the experiment

- Visit a nearby university, health centre, or forensic laboratory, or search for a video describing functioning of a gel electrophoresis.
- Use the field visit or video to observe the steps of gel electrophoresis
- Record the steps of gel electrophoresis

Reflection question

What do you see when a gel electrophoresis is running and after it runs?

Data recording

Steps	Observations
Preparing the gel	Agarose powder is mixed with an electrophoresis buffer and heated to a high temperature until all of the agarose powder is dissolved.

Preparing the DNA samples	A dye is added to the sample of DNA prior to electrophoresis to increase the visibility of the sample.
Separating the DNA fragments	The electrical current is then turned on so that the negatively charged DNA moves through the gel towards the positive side of the gel.
Staining the gel and visualizing the results	The electrical current is switched off and the gel is removed from the electrophoresis tank. The gel is stained with a fluorescent dye that binds to the DNA, and is placed on an ultraviolet transilluminator which will show up the stained DNA as bright bands.

Interpretation and conclusion

The gel electrophoresis apparatus consists of gel, which is often made from agar or polyacrylamide, and an electrophoretic chamber (typically a hard plastic box or tank) with a cathode (negative terminal) at one end and an anode (positive terminal) at the opposite end.

The key to separating DNA molecules is that larger molecules are more strongly impeded by the gel than smaller molecules. As a result, smaller molecules of DNA (those composed of fewer nucleotides) migrate through the gel at a faster rate. After a period of time, the shorter fragments are further from the origin than are the longer molecules. In this manner, DNA fragments in a solution are separated on the basis of size.

Guidance on evaluation

Provide enough time to learners to observe all the steps of gel electrophoresis and the results. Give them also enough time to interpret the results (DNA bands).You may ask some questions, such as: What are steps of agarose gel electrophoresis?

UNIT: 14 APPLICATIONS OF GENE TECHNOLOGY

Activity 14.1 : Find out how gene technology is applied in the modernization of agriculture.

(Focus on the following crop varieties: maize, cassava, Irish potatoes, beans, tomatoes, oranges, mangoes, and avocado. Focus also on the following animals: chickens, cows, goats, sheep, and pigs). This activity can be done when teaching the concept or topic related to applications of gene technology.

Rationale

Genetic engineering (also called genetic modification) is a process that uses laboratory-based technologies to modify the DNA makeup of an organism. One of the most significant benefits of genetic engineering is to increase crop production. Scientists can use genetic engineering to increase crop yields, lower food costs, improve food quality, food security, and medicinal value. Thus this activity aims to evaluate how gene technology is applied in modernization of agriculture.

Objective

To evaluate how gene technology is applied in modernization of maize plantation and poultry farming.

Materials

- Camera
- Prepared questionnaire
- Reporting format

Experiment set up

Procedures and steps of the experiment

- Visit a nearby modern maize plantation and poultry farm;
- Using a camera, take picture of modern maize plantation and poultry farm;
- Use prepared questionnaire to collect data about modernized maize plantation and poultry farming;
- Ask some questions about the maize plantation and poultry farming
- Elaborate a report of the field visit

Field guiding questions

1. What kind of species are you growing/rearing in your farm?
2. Are the species hybrid or not hybrid?
3. Why do farmers grow/rear hybrid crops/chickens?
4. What has been the impact of hybrid crops/chickens on pesticide use?

Data recording

Type	Yield production
Crop plants	Gene technology is used in agriculture to modify characteristics such as growth rate, resistance to the cold and to disease, and nutritional quantity and quality.
Livestock	Production of animals with large quality and quantities, resistant to diseases and pests, high growth rate and adaptation to weather conditions.

Interpretation and conclusion

Today, scientists have developed crops and animals with needed characteristics that can withstand any disease, virus, or natural disaster. Genetic engineering is one of the most significant innovations in production of GMOs/hybrids that are used in many industries, particularly agriculture.

However, GMOs have a negative impact on the environment and human health, such as long-term unforeseen genetic issues and pollen interfering with natural crops.

Despite these disadvantages, genetic engineering is widely used because the benefits outweigh the disadvantages. Many scientists have already acknowledged the problems associated with gene engineering, but nothing on the planet has no side effects.

Guidance on evaluation

Assess learners by providing questions on the importance of gene technology.

Example: Explain the significance of genetic engineering in improving the quality and yield of crop plants and livestock in solving the demand for food in the world.

UNIT: 15 VARIATION

Activity 15.1 : Test for the significant differences between 2 populations by using t-test

This activity can be done when teaching the concept or topic related to the variation of two different populations.

Rationale

A population is a subset of individuals of one species that occupies a geographic area. Geographic boundaries of a population are easy to establish for some species but more difficult for others. For example, plants and animals on a given island have a geographic range defined by the perimeter of the island. In contrast, some species are dispersed across vast expanses, and the boundaries of local populations are more difficult to determine. Considering two ecosystems, it is necessary to assess if populations in these ecosystems are the same or different. T-test is one of statistical data analysis tool used to assess the significant difference between two distinct populations.

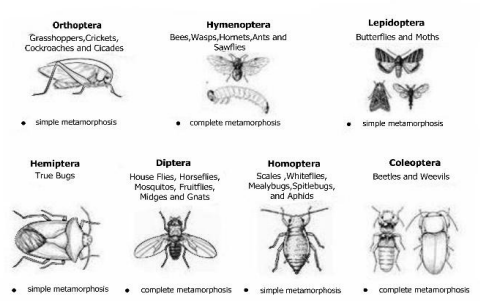
Objective

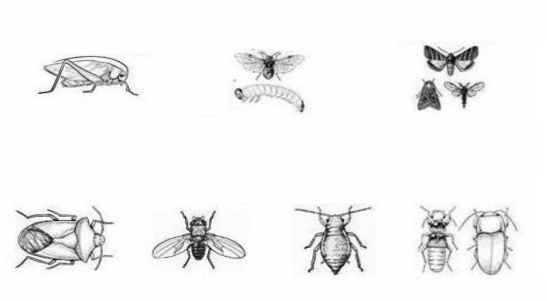
To assess the differences between two populations from two different sites.

Materials

- Sweep net
- Collecting jars
- Ethanol 75%
- Meter tape
- Calculator

Experimental set up





Procedure

- Select two different sites around the school
- Make a transect of 30 meters in each site
- Set 5 sampling points across the transect, each sampling point being separated by 5m from another
- Use the sweep net to collect insects in each sampling site across the transect
- Keep the collected insects in a container containing 20 ml of 75% ethanol
- In the laboratory, classify the collected insects in the same order by sampling point from each site
- Count the number of individuals making each order per each sampling point and note down its total
- Calculate the mean of insects for each sampling site
- Calculate the standard deviation of the first and second sampling site
- Use the formula: t = to test whether the two populations are significantly different at 95% confidence level

Data recording

Order	Site 2						Site 1					
	SP1	SP2	SP3	SP4	SP5	Total	SP1	SP2	SP3	SP4	SP5	Total
Orthoptera	2	5	3	1	0	11	4	5	3	2	2	16
Hymenoptera	3	2	2	1	1	9	5	4	3	6	7	25
Lepidoptera	1	4	3	2	1	11	3	3	5	6	4	21
Hemiptera	4	5	3	2	5	19	6	3	3	4	5	21
Diptera	3	3	1	0	3	10	3	3	5	4	1	16
Homoptera	5	3	4	6	3	21	3	4	5	6		18
Coleoptera	4	4	3	2	4	17	5	5	3	3	5	21
n_2						116	n_1					138
						6.6						19.7
$S_2 = \sqrt{\frac{\sum(x-\bar{x}_2)^2}{n-1}}$						2.7	$S_1 = \sqrt{\frac{\sum(x-\bar{x}_1)^2}{n-1}}$					3.25
	S_2^2					7.3	S_1^2					10.57

$$t=\frac{X_1-X_2}{\sqrt{\frac{S_1^2}{n_1}-\frac{S_2^2}{n_2}}}=\frac{19.7-16.6}{\sqrt{\frac{10.57}{13.8}-\frac{7.3}{11.6}}}=\frac{3.1}{\sqrt{\frac{10.57}{13.8}-\frac{7.3}{11.6}}}=\frac{3.1}{\sqrt{0.076-0.063}}=\frac{3.1}{\frac{3.1}{\sqrt{0.013}}}=\frac{3.1}{0.1140}=27.2$$

Interpretation and conclusion

Since the confidence level is 95%, the significance level is 5% (0.05). Statistically, significance level is the probability value (p value) that forms the boundary between rejecting or not rejecting the null hypothesis: There is no significant difference between the two populations.

The decision rule:

1. If the probability value (p-value) is smaller than or equal to 0.05: reject the null hypothesis: Conclude that there is a statistically significant difference, there is evidence to conclude effect.
2. If the p-value is greater than 0.05, do not reject the null hypothesis. No evidence against null hypothesis, there is no effect.

Since the t value is greater than the p value (27.2 > 0.05), the formulated null hypothesis is maintained: There is no significant difference between the two populations. Therefore, there is no statistically significant difference between the two populations.

Guidance on evaluation

Assess the students by providing them data obtained after sampling from the field and ask them to apply t-test and use the decision rule to decide whether there are significant differences between two populations.

Example: Two samples have means of 10 and 12, standard deviations of 1.2 and 1.4, and sample sizes of 17 and 15. Determine if the sample's statistics are different at a 99.5% confidence interval. Use a summative table and the formula to determine the t-value, formulate the null hypothesis, determine the p-value (0.005 in this case) and decide whether there are significant differences between two populations.

Activity 15.2 : Use continuous and discontinuous variations among organisms to analyze graphs

This activity can be done when teaching the concept or topic related to continuous and discontinuous variation.

Rationale

In many species, variations allow animals to adapt to different environmental conditions. Some variations are continuous and can be measured quantitatively while discontinuous variations are qualitative. However, each variation is explained by genetic or environmental factors. There is a need to understand how both continuous (for instance height, weight) and discontinuous (sex, blood group, eye color) can be interpreted by using graphs.

Objective

To interpret graphs based on continuous and discontinuous variations among organisms

Materials

- Data from a survey on the number of people having different height category
- Data from a survey on the number of people having different blood groups
- Pencil
- Rubber
- Ruler
- Graph paper

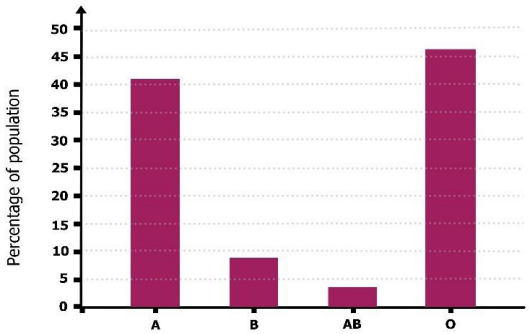
Procedure

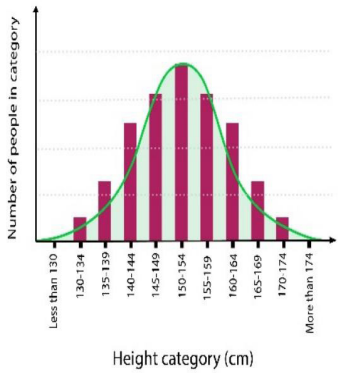
- Analyze data on blood groups and height given in terms of numbers of people having a blood group /height (cm),
- Plot a graph using given data (X-axis: blood group, Y-axis: number of people in each category
- Interpret graphs and conclude

Data recording

≠	Blood group	Number of people having the blood group
1	A	41
2	B	9
3	AB	4
4	O	46
	Height category (cm)	**Number of people having the height included on the interval**
1	Less than 130	1
2	130-134	8
3	135-139	15
4	140-144	21
5	145-149	25
6	150-154	21
7	155-164	15
8	165-174	8

Interpretation and conclusion





Blood group

Height ranges from that of the shortest person to that of the tallest person. Any height is possible between these two extremes. So, it is continuous variation. The above shape of graph is typical of a feature with **continuous variation**. The curved graph is the result of a normal distributed variable. It is called **bell shaped** and shows **normal distribution**.

The **blood group** is an example of discontinuous variation. In the ABO, blood group system, only four blood groups are possible (A, B, AB, or O). There are no intermediate values, it is considered as a discontinuous variation. The drawing of curved graphs is not possible due to the lack of normal distribution.

Therefore, Continuous variation is the difference between individuals of a specie where the differences are quantitative (measurable). Discontinuous variation refers to the differences between **individuals** of a species where the differences are qualitative (categoric). Each type of variation can be affected by genetic or environmental factors.

Guidance on evaluation

Assess learners by giving an application exercise like the activity done.

The table below displays data on plant height.

Plant no.	Height (cm)	Plant no.	Height (cm)	Plant no.	Height (cm)
1	6	8	10	15	10
2	8	9	12	16	9
3	11	10	13	17	11
4	12	11	11	18	10
5	6	12	8	19	14
6	15	13	7	20	9
7	11	14	7	21	9

a. Use the table below to record the data before drawing your graph.

Height (cm)	Number of plants

b. Plot the graph.

c. State whether plant height is continuous or discontinuous variation and explain why?

UNIT: 16 ARTIFICIAL AND NATURAL SELECTION

Activity 16.1: Advantages of selective breeding in comparison with natural selection

This activity can be done when teaching the concept or topic related to crop improvement by selective breeding.

Rationale

Selective breeding commonly known as artificial selection is the process by which humans use animal and plant breeding to selectively develop phenotypic traits through choosing typically animal or plant species that may reproduce sexually and give improved yield offspring with appropriate genetic needed characters. Natural selection is the process by which populations of living organisms evolve naturally by developing changes and adaptations to their environments.

Objective

To compare the advantages of selective breeding and natural selection

Procedure

- Conduct two field visits (1 and 2) for the crops with selective breeds other with non-selective breeds
- Observe and compare the advantages of the crops with selective breeds and others with non-selective breeds
- Draw a comparative table of the observations
- Report your observations

Reflection questions

Why are crop characteristics different in the two field visits?

Data recording

Type of field	Advantages of the observed crops
Field 1 with selective breeds	Green quality leaves, early maturity, big white grain colour, production of a lot of grains, highly productive.
Field 2 without selective breeds	Poor green quality leaves at the base, take long time to reach maturity, production of few grains, less productive.

Results interpretation and conclusion

Natural selection explains how evolution occurs while different varieties of plants with desired characteristics can be developed by selective breeding. Selective breeding is the traditional method for improving and developing crops and livestock with a selected set of desirable characteristics, such as increased disease resistance, increased quality and quantity of milk produced by cows, or drought resistance and increased yield. Natural selection and selective breeding can both cause changes in plants. However, selective breeding differs from natural selection in the following ways:

Considered point	Selective breeds	Natural selection
Advantages	– Causes artificial changes in plants – Results from human activities – Desired characteristics such as production of a lot of grains from plants can be developed – Selection is in response to satisfying human needs.	– Causes natural changes in plants – Occurs naturally – Less exposed to diseases
Disadvantages	– There is an increased risk of genetic diseases caused by recessive alleles – The gene pool can lead to the loss of alleles from the gene pool making it more difficult to produce new varieties	– Impossible to produce desired characteristics – Low production economically

Generally, natural selection happens under the existing conditions of nature whereas selective breeding only occurs through human intervention. For this reason, selective breeding is sometimes called artificial selection and is used for economic importance by providing more or better-quality food to feed people.

Guidance on evaluation

Assess students by providing images of modern breeds of cattle and natural cattle and ask them to compare the cattle based on the observed characteristics.

Activity 16.2 : Similarities of closely related organisms using mitochondrial DNA and protein sequences

This activity can be done when teaching the concept or topic related to molecular evidence of evolution.

Rationale

Mitochondrial DNA is the DNA located in mitochondria in a small portion. The human mitochondrial DNA was the first significant part of the human genome to be sequenced. This sequencing revealed that the human mitochondrial DNA includes 16 569 base pairs and encodes 13 proteins. Since animal mitochondrial DNA evolves faster than nuclear DNA, it represents a mainstay of phylogenetic and evolutionary biology. It also permits an examination of the relatedness of populations, and so has become important in anthropology and biogeography. This activity is therefore equipping the students with ability to align sequences of mitochondrial DNA from different organisms and/or the gene products (proteins) with a purpose of determining their similarities.

Objective

To use mitochondrial DNA and protein sequences to identify similarities between organisms.

Experimental set up

Organism	DNA Sequence
Organism A	TCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAGTCAGTCA GTCAGTCAG

Organism B	AGCCCTAAGTGGGTGGTAAACTCCATCTAAGGCTAAATATGACCACGAGA CCGATAGCGA
Organism C	GTGCTTGCTTCGGCAACACATATACTAAAATTGGAACGATAGAAGATTAG CATGGCCCCT

Procedure

- Observe carefully and compare the DNA sequences of organisms A, B, and C
- Search all amino acids that are coded by the provided DNA sequences (A, B, and C). Use the genetic code in the table below:
- Identify the similarities among the organisms A, B, and C.

Second letter

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

- Which ones are closely related animals? Explain

Data recording

	Organism A	Organism B	Organism C
Mitochondrial DNA sequences	TCA-GTC-AGT-CAG-TCA-GTC-AGT-CAG-TCA-GTC-AGT-CAG-TCA-GTC-AGT-CAG-TCA-GTC-AGT-CAG	AGC-CCT-AAG-TGG-GTG-GTA-AAC-TCC-ATG-TAA-GGC-TAA-ATA-TGA-CCA-CGA-GAC-CGA-TAG-CGA	GTG-CTT-GCT-TCG-GCA-ACA-CAT-ATA-CTA-AAA-TTG-GAA-CGA-TAG-AAG-ATG-AGC-ATG-GCC-CCT
mRNA sequences	AGU-CAG-UCA-GUC-AGU-CAG-UCA-GUC-AGU-CAG-UCA-GUC-AGU-CAG-UCA-GUC-AGU-CAG-UCA-GUC	UCG-GGA-UUC-ACC-CAC-CAU-UUG-AGG-UAC-AUU-CCG-AUU-UAU-CCG-AUU-GCU-CUG-GCU-AUC-GCU	CAC-GAA-CGA-AGC-CGU-UGU-GUA-UAU-GAU-UUU-AAC-CUU-GCU-AUC-UUC-UAC-UCG-UAC-CGG-GGA
Amino acids sequences	Ser- Gln-Ser-Val-Ser- Gln-Ser-Val-Ser- Gln-Ser-Val-Ser- Gln-Ser-Val-Ser-Gln-Ser- Val	Ser-Gly-Phe-Thr-Hist-His-Leu-Arg-Tyr-Ile-Pro-Ile-Tyr-Pro-Ile-Ala-Leu- Ala- Ile- Ala	His-Glu-Arg -Ser- Arg-Cys-Val-Tyr-Asp-Phe-Asn-Leu- Ala- Ile-Phe-Tyr-Ser- Tyr-Arg- Gly

Interpretation and conclusion

The comparison analysis of amino acids sequences for these animal samples are presented as follows:

- **Organism** A: **Ser**- Gln-Ser-Val-Ser- Gln-Ser-Val-Ser- Gln-Ser-Val-Ser- Gln-Ser-Val-Ser-Gln-Ser- Val
- **Organism** B: **Ser**-Gly-Phe-Thr- Hist-His-Leu-Arg-Tyr-Ile-Pro-Ile- Tyr-Pro-**Ile**-Ala-Leu- Ala- Ile- Ala
- **Organism** C: His-Glu-Arg -Ser- Arg-Cys-Val-Tyr-Asp-Phe-Asn-Leu- Ala- **Ile**-Phe-Tyr-Ser- Tyr- Arg- Gly

Organism A and organism B are sharing the same amino acid at the first place: serine (ser).

Organism B and organism C are sharing the same amino acid at the 15th place: isoleucine (ile)

Organism A and C do not have any amino acid in common.

Guidance on evaluation

Assess learners by providing a sequence of Mitochondrial DNA of two or more organisms, ask them to compare those sequences, to identify the derived amino acids by using the table of genetic code, and identify the similarities among these organisms.

You may give the students the question such as:

The following are samples of DNA sequence of two different species:

- *Human:* GTGAATATTGTCTTCTTTGTTATG
- *Chimpanzee*: GTGAATATTGCTTTTTTGTTTATG

a. Use genetic code to search all amino acids that are coded by the provided DNA sequences of human and chimpanzee.

b. Make a comparison between generated sequences of amino acids.

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