

BOTÁNICA Y BIOLOGÍA VEGETAL



Explorando la diversidad vegetal
desde la estructura, función y evolución



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Guayaquil - Ecuador

<https://colloquiumbiblioteca.com/index.php/web>

First edition, 2026

ISBN: 978-9942-600-90-5

Online distribution

 Open access

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Acknowledgements

To the authorities of the Agricultural University of Ecuador, the faculty members of the Faculty of Agricultural Sciences, and all those who contributed photographs, images, and other materials, making the review and publication process possible.

Preface

Books, manuals, and laboratory guides represent a fundamental tool in academic training, as they condense years of study, experience, and applied knowledge within a specific field. Their development is not a simple process: it involves organizing complex theoretical information and translating it into clear, precise, and replicable procedures within a practical environment.

This *Plant Biology Laboratory Manual*, aimed at students in the Agronomy program at the Agricultural University of Ecuador, has been designed with the purpose of facilitating active and meaningful learning, integrating theory and practice into each of its sections.

Throughout this book, students will find a sequence of structured laboratory sessions that begin with essential theoretical foundations, allowing them to comprehend key concepts before their application in the laboratory. Each session includes clear objectives, a list of materials, and detailed procedures oriented toward developing technical skills and scientific judgment.

A distinguishing feature of this manual is its pedagogical approach: it is not limited to describing procedures, but rather guides the student step-by-step, as if they had the direct accompaniment of a faculty member. Through exercises, illustrations, and explanations, it promotes autonomous yet guided learning, strengthening the capacity for analysis and observation.

The content begins with basic laboratory safety rules, which are indispensable for ensuring a responsible working environment. Subsequently, it addresses fundamental topics such as plant morphology, cellular organization, plant tissues, and plant development and functions. Additionally, laboratory sessions related to plant propagation techniques and concepts of agro-industrial processing are included, broadening the student's perspective toward real-world applications in the agronomic field.

In a context where information is easily accessible, the true value lies in the ability to interpret, analyze, and apply it correctly. For this reason, this manual seeks not only to inform but to educate: fostering scientific discipline, critical thinking, and an investigative attitude in future agricultural professionals.

Finally, this document is presented as an academic contribution open to continuous improvement. Students and faculty members are invited to enrich it with new experiences, observations, and knowledge, thereby strengthening its utility and relevance over time.

Introduction

Training in Plant Biology within the Agronomy program demands more than just theory: it requires seeing, touching, comparing, and understanding plant life from the microscopic level to the structural. This laboratory manual has been designed so that students do not just stop at the basics, but rather develop real scientific judgment, with solid foundations that are applicable in the field.

The journey begins with the correct handling of the microscope, a key tool in any laboratory. Mastering its use is not optional; it is the foundation for interpreting cellular structures with precision. From there, students advance toward the observation and identification of plant and animal cells, understanding their differences and functions, which allows them to build a clear vision of biological organization.

Subsequently, the focus broadens toward organisms that are fundamental in agricultural systems, such as algae and fungi. Macroalgae and microalgae are studied not only for their structure but also for their ecological importance and productive potential. In parallel, higher fungi, molds, and yeasts are analyzed organisms that are key both in beneficial processes and in phytosanitary problems that every agronomist must know how to recognize.

The book continues with the study of vascular tissues in monocotyledonous and dicotyledonous plants, enabling an understanding of how water and nutrients are transported, which is essential to comprehend plant development and its response to environmental conditions. Then, through flower dissection, students identify reproductive structures, strengthening their morphological analysis capacity, which is essential for crop classification and management.

Finally, less complex plant groups that are equally important in plant evolution are addressed, such as mosses, liverworts, and hornworts, along with pteridophytes. This block allows for an understanding of the origin and transition of plants toward more complex forms, giving the student a complete and well-connected view of plant biology.

This book does not seek to have you memorize meaningless data. It seeks to make you understand how the plant functions, how it relates to its environment, and how that knowledge translates into smarter agronomic decisions. Each laboratory session is designed for you to develop observation, analysis, and precision, because in the real field, there is no room for improvisation.

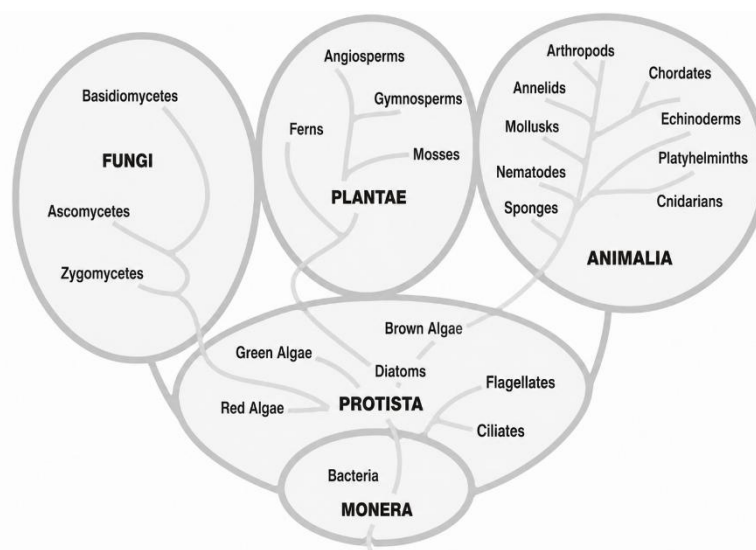
Classification of Living Things

In their quest to understand the complexity and diversity of life, scientists have always sought to classify living organisms. In 1758, the Swedish naturalist Carl von Linné proposed a rule-based classification system called *Systema Naturae* (System of Nature). The highest level of Linnaean classification consisted of the mineral, vegetable, and animal kingdoms. If minerals are excluded, two kingdoms remain: plants and animals. In this two-kingdom classification, bacteria and certain (photosynthetic) protists were considered part of the plant kingdom, while non-photosynthetic protozoa were categorized as part of the animal kingdom.

In the 19th century, the scientist Ernst Haeckel was the first to establish a phylogenetic classification, dividing organisms into three kingdoms: animal, plant, and protist. The Protist kingdom included unicellular organisms of both animal lineage and photosynthetic nature. In 1925, the microbiologist Édouard Chatton noticed that there were protists with and without a nucleus and proposed distinguishing them from the rest of living things. He coined the terms **eukaryote**, grouping all nucleated organisms (*eu* = true; *karyon* = nucleus), including animals and plants, and **prokaryote**, for bacteria and cyanobacteria (blue-green algae). Somewhat later, in 1938, a botanist named Copeland proposed a new kingdom to include prokaryotes, which he called Monera or Bacteria.

In 1959, Robert Whittaker, an ecologist from Cornell University, proposed separating fungi from the plant kingdom, thereby adding a new kingdom called Fungi. This established the five kingdoms: Monera, Protista, Fungi, Plantae, and Animalia (Gagneten, 2020).

Image 1. Kingdoms established by the ecologist Robert Whittaker, 1959.



Source:: (Gagneten, 2020)

Kingdom Monera

Characteristics: prokaryotic cells, unicellular or colonial, nutrition by absorption, photosynthesis or chemosynthesis, asexual reproduction, motile or non-motile.

Kingdom Protista

Characteristics: eukaryotic cells, unicellular or colonial (multinucleate forms may occur), diverse modes of nutrition (photosynthesis, ingestion or a combination of these), reproduction by asexual and sexual cycles, with meiosis, motile or non-motile.

Kingdom Fungi

Characteristics: eukaryotic cells, predominantly multinucleate with a mycelial syncytium, without plastids or photosynthetic pigments, nutrition by absorption, primarily non-motile, sexual and asexual cycles.

Kingdom Plantae

Characteristics: eukaryotic cells, multicellular, with cells possessing a cellulose wall, with pigments in plastids, nutrition by photosynthesis, primarily non-motile.

Kingdom Animalia

Characteristics: eukaryotic cells, multicellular, without cell walls or photosynthetic pigments, nutrition by ingestion, in some cases by absorption, with evolution of the sensory-neuromotor systems, fundamentally sexual reproduction.

Laboratory Safety Regulations

Work in a laboratory involves the use of equipment, chemical reagents, and other elements, which can generate direct or indirect physical, chemical, and biological risks to those present and, in general, to the community surrounding the facilities where these activities take place; therefore, it is necessary to be aware of these risks to prevent any type of accident. Knowing and always applying biosafety regulations in the laboratory is essential to make it a safe place and, thus, avoid accidents.

General Regulations

Punctuality is important to start the laboratory session at the defined time, along with respect for those in the laboratory and a high sense of responsibility for people and facilities. The maximum waiting time for students to enter the laboratory is defined as 10 minutes after the assigned time; after this time, the student will not be admitted to the session.

The laboratory session cannot be performed without the presence of the professor.

Each student or work group is responsible for their work area, as well as the materials and equipment used.

Laboratory attendees must wash their hands before, during the development of scheduled practical activities, and after finishing the laboratory session.

The laboratory must remain clean and orderly.

The correct handling and disposal of chemical and biological waste must be guaranteed.

The monitor is a fundamental support for conducting the session, but the professor is responsible for its development and must define in advance the requirements regarding materials, reagents, and equipment needed for this activity.

Broken material or contaminated reagent will be the responsibility of the student or work group involved in the event. Its replacement will be essential for the issuance of the respective clearance certificate at the end of the semester.

The following equipment must always be operated in the presence of the responsible professor in charge of the laboratory: microscope with camera, viscometer, colorimeter, water activity meter, moisture balance, and spectrophotometer.

It is defined by consensus that cell phones are to be used solely as a work tool, and in this case, the professor will assign a student in charge of its use for this purpose.

Students are not authorized to work alone in the laboratory.

The execution of the laboratory sessions for the semester is scheduled in advance; therefore, any change or modification to one of them must be agreed upon beforehand.

Basic Code of Conduct

Access to the laboratory will be limited to personnel authorized for the assigned practice; unauthorized personnel must not enter.

To enter the laboratory, students must always be accompanied by the professor or monitor.

Eating, drinking, smoking, and applying cosmetics are formally prohibited in the laboratory work area, as is the storage of food or beverages. Exceptionally, there will be sensory evaluation practices where substances that may represent a chemical or biological risk to personnel cannot be present.

The student must use only the materials and equipment assigned for their practice.

Before entering the laboratory, the student must know exactly the practice to be performed; in this way, accidents due to ignorance or improvisation will be avoided. The best safety rule is the good planning of the laboratory practice.

The discipline of identifying and marking samples, works, and/or elements used during the laboratory practice must be developed.

It is the responsibility of the laboratory personnel and the respective professor to always enforce the established safety regulations for laboratory use.

Biosafety Regulations

Always wear a laboratory coat, which must be long-sleeved, with cuffs, cover down to the beginning of the knee, and be worn closed.

The use of shorts or ripped pants, skirts, high heels, open shoes, sandals, or shoes made of fabric is prohibited.

Always use protective goggles when working with chemical substances that carry a risk of splashing and sharp equipment. Remember that the minimum protective equipment consists of gloves, face masks, and protective goggles.

Contact lenses must not be worn without the protection of goggles. • Tie back long hair and very loose clothing.

Jewelry must not be worn in the laboratory.

Mouth pipetting is strictly prohibited; always use the pipette with the suction bulb.

All persons attending the practice must take special care to avoid skin contact with potentially infectious or corrosive material; for this purpose, gloves must be worn. These gloves must always be discarded in the container for that purpose before leaving the laboratory; you must never leave the laboratory with gloves on, nor should you use them to pick up the telephone, touch reference or exam sheets, or door handles.

Walk calmly through the laboratory, try to anticipate the movement of your peers, do not play, shout, or make jokes in this place; this will avoid accidents.

Spills, accidents, and/or incidents must be reported immediately to the professor of the practice or to the person in charge of the laboratory, to make the respective record, care, and solution of the situation.

Know in advance the hazards of the compounds to be worked with; the label and safety data sheet must be read before using a chemical product.

It is very important to make students aware of the importance of reporting mistakes made in order to correct them and avoid a possible accident or damage to health, as well as compliance with biosafety regulations.

If you disinfect yourself with alcohol, please stand at a safe distance from fire or, in certain cases, the burner.

It is the responsibility of all attendees of the laboratory practices to know the location and handling of safety elements, such as alarms, emergency exits, showers, fire-fighting equipment, as well as the established procedures to act in the event of an emergency.

Sharp objects (needles, scalpel blades, broken glass, etc.) must be deposited in appropriate containers.

All work surfaces must be cleaned and disinfected before starting the practice and whenever a spill occurs.

Desktop materials, books, and cell phones must not be placed in the work area, as they can become contaminated.

Whenever dangerous gases, substances, or vapors are released in high concentrations or quantities during a laboratory practice, general safety regulations for these establish the mandatory use of fume hoods.

Equipment Handling

Equipment must be operated under the supervision of the professor responsible for the practice to avoid personal risks or damage to the equipment.

If there is a lack of knowledge at the time of using the equipment, assistance in handling it must be requested from the laboratory personnel.

Each time a piece of equipment is used, the equipment usage form must be filled out by the monitor in charge.

There are pieces of equipment that can only be handled by professors, given the purpose of the equipment, such as: the viscometer, colorimeter, microscope with digital camera, and the spectrophotometer.

What to do in case of accidents?

In the event of accidents in the laboratory, it must be communicated immediately to your professor.

What could be the common accidents in the laboratory?

The common accidents that can occur in laboratories are the following:

Cuts, burns by fire, burns by acids and/or bases, burns by hot objects, liquids, or vapors, and there may also be risks of poisoning.

Accident prevention

Cuts

Do not use chipped material or material in imperfect conditions. Never force or apply excessive pressure with your hands on joints or valves, etc. Never try to loosen glass joints by hitting them with hammers or similar tools. Never subject glassware to sudden changes in temperature. Always fire-polish the ends of glass tubes or rods. Protect your hands when attempting to insert or remove glass tubes or thermometers into or out of cork or rubber stoppers (it is always recommended to lubricate the stopper hole beforehand with soapy water or glycerin). The transport of glassware is always dangerous. Use a box or other means, never carry it with the help of your body or arms. Failure to comply with these regulations results in wounds, which must be attended to immediately in the following manner: Wash the wound with abundant water. Then treat it with a cotton pad soaked in an antiseptic liquid (hydrogen peroxide, povidone, or betadine) and then cover the wound with a sterile bandage. Take special care to remove broken glass from the sink or basin. Use a separate container to collect all broken material and leave it in plain sight for its subsequent collection by the person who does the general cleaning of the laboratory. In case of suffering an accident, any piece of glass must be eliminated immediately. A piece of modeling clay could be used to pick up very small pieces of glass.

Burns

Burns with hot appliances or splashes with hot liquids

Do not try to grab a hot utensil without using appropriate gloves or tongs. Never place or leave a clamp of hot material or apparatus on the counter without placing a note indicating it.

Liquids or liquid-solid mixtures can be heated in a water bath or by direct, gentle, and uniform heating with the burner. Before heating, make sure that the container is not closed (excess pressure from heat can cause it to explode). Do not apply heat with the burner to a single area of the container (it can cause splashing). When heating viscous liquids, ensure that the container is completely dry (water causes violent splashing). When heating viscous liquid, use a safety mask. In case of small burns, let abundant water run over the affected area and then apply an appropriate medication. In case of major burns, the injured person must be sent quickly to the nearest medical center.

Burns by acids and/or bases.

When mixing acids, perform this operation in a place where spills are easily eliminated. When working with acids that generate irritating or unpleasant vapors (hydrochloric, sulfuric, nitric acid, etc.), do so under a fume hood or in a ventilated place. Whenever you are going to dilute acids, always add acid to water. When transporting bottles with acids, do it one by one and with care. Place perfectly closed concentrated acid bottles away from fire and from the edges of the counter. In case of spills, wash the area with abundant water and then neutralize it with a saturated solution of Sodium Bicarbonate. If the burn is in the eyes, after washing, go to the medical service. If the splash is extensive, take the injured person to the shower stream immediately and then go to the medical service.

Burns by hot objects, liquids, or vapors

Apply burn ointment to the affected part. If necessary, protect the skin with gauze and go to the medical service.

Poisoning

Very few chemical reagents can be considered completely harmless. Hence, they should not be ingested or inhaled. Direct contact should also be avoided as many of them can be absorbed through the skin. (Arrizabalaga & Baeza, 2016)

What are the characteristics of plants?

Plants are multicellular living organisms and use photosynthesis to transform water and carbon dioxide into sugars. Neither multicellularity nor the capacity to photosynthesize are exclusive to plants, but the simultaneous presence of these traits is very rare outside the plant kingdom. However, the most distinctive characteristic of plants is their reproductive cycle.

Plants have a sporophytic generation and a gametophytic generation.

The life cycle of plants is characterized by the alternation of generations, in which individual diploid and haploid generations alternate. It is important to remember that in a diploid organism there are two sets of chromosomes; a haploid organism, one set. In the diploid generation, the plant body is composed of diploid cells and is known as the sporophyte. Certain cells of the sporophytes undergo meiosis to produce haploid spores. These spores divide by mitosis and develop into multicellular haploid plants called gametophytes. Finally, gametophytes produce male and female haploid gametes by mitosis. The gametes fuse to form diploid zygotes, which develop to constitute a diploid sporophyte and the cycle starts again.

Green algae gave rise to land plants

Of the different groups of current algae, green algae are probably those that most closely resemble ancestral plants. This assumption is based on the close

phylogenetic relationship between the two groups. DNA comparisons have shown that green algae are the closest living relatives of plants. Likewise, evidence of other types supports the hypothesis that land plants evolved from ancestral green algae.

Green algae use the same type of chlorophyll and auxiliary pigments in photosynthesis as land plants. In contrast, the photosynthetic pigments of the other groups of red algae and brown algae differ from those of plants.

LABORATORY PRACTICE 1

THE MICROSCOPE, ITS PARTS AND ITS HANDLING

INTRODUCTION

According to (Loaiza, 2024) The study of cells, tissues, and their parts, due to their size, requires the use of instruments where it is possible to magnify images of the structures that constitute them; such an instrument was used by the first scientists and biologists for the study of structures that are not possible to observe with the human eye, through the use of the microscope.

The optical microscope consists of three systems: mechanical system, optical system, and illumination system. The mechanical system consists of the following elements: base, arm, microscope tube, nosepiece, stage, coarse focus screw, and fine focus screw. The optical system consists of eyepieces and objectives. The illumination system consists of the following parts: light source, diaphragm, and condenser. (Burbano, 2017)

According to (Silvia, 1987) the students of the agronomy career perform their studies through experimental designs, that is, in the field and laboratory, where hypotheses are subjected to testing, for which the use of the laboratory is necessary, where professionals in training familiarize themselves with the biological, physiological, and physical phenomena that are implicit in the development of plants. In the laboratory, there are rules to comply with, such as order and cleanliness, as well as the correct use of the microscope and other instruments and equipment.

GENERAL OBJECTIVE

Recognize the parts of the optical microscope and correctly apply the basic techniques for its handling and utilization in biological observations.

SPECIFIC OBJECTIVES

1. Identify the main mechanical, optical, and illumination parts of the compound microscope.
2. Adequately apply focusing and handling techniques during the microscopic observation of biological samples.

LEARNING OUTCOMES

- Recognizes the parts and functions of the compound optical microscope.
- Correctly manipulates the microscope to perform basic biological observations.

METHODOLOGY AND TECHNIQUES

The practice is developed under an experimental-descriptive approach through direct observation and practical handling of the compound optical microscope.

The technique used consists of:

- Visual recognition of the parts of the microscope.
- Basic manipulation and calibration of the equipment.
- Microscopic observation of simple samples using different magnifications.

PROCEDURE

PART A: RECOGNITION OF THE MICROSCOPE

1. Place the microscope on a stable and clean table.
2. Identify the mechanical parts:
 - Arm
 - Base
 - Stage
 - Nosepiece
 - Coarse focus screw
 - Fine focus screw
3. Identify the optical parts:
 - Eyepiece
 - Objectives
4. Illumination system:
 - Light source
 - Diaphragm
 - Condensador

PART B: MICROSCOPE HANDLING

1. Turn on the light source or correctly direct the mirror toward the illumination.
2. Place a microscopic preparation on the stage.
3. Secure the sample using the stage clips.
4. Start the observation with the lowest magnification objective (4X or 10X).
5. Use the coarse focus screw to achieve an initial focus.
6. Adjust sharpness using the fine focus screw.

7. Change progressively to higher magnification objectives if necessary.
8. Regulate the entry of light using the diaphragm.
9. Once the observation is finished, remove the sample carefully.
10. Clean the microscope using special lens paper.
11. Store the equipment correctly covered.

MATERIALS AND REAGENTS

Materials

- Compound optical microscope
- Microscope slides
- Coverslips
- Lens cleaning paper
- Simple biological samples
- Dropper
- Tweezers

Reagents

- Distilled water
- Methylene blue (optional for staining)

RESULTS AND OBSERVATIONS

During the practice, it was possible to recognize the main parts of the compound optical microscope and their specific functions. In addition, the focusing of biological samples using different magnifications was performed correctly.

It was observed that:

- The lowest magnification objective facilitates the initial localization of the sample.
- The coarse focus screw allows for quick focusing, while the fine focus screw provides precision.
- Adequate illumination considerably improves the quality of microscopic observation.

DRAWINGS, SCHEMATICS AND DESCRIPTIONS

MAIN PARTS OF THE MICROSCOPE

- Eyepiece: lens through which the image is observed.
- Objectives: lenses of different magnifications.
- Stage: surface where the sample is placed.
- Nosepiece: rotating structure that holds the objectives.
- Coarse focus screw: allows for quick focusing.

- Fine focus screw: allows for precise focusing.
- Diaphragm: regulates the amount of light.
- Condenser: concentrates the light onto the sample.
- Arm: structural support of the microscope.
- Base: provides stability.

MICROSCOPIC OBSERVATIONS

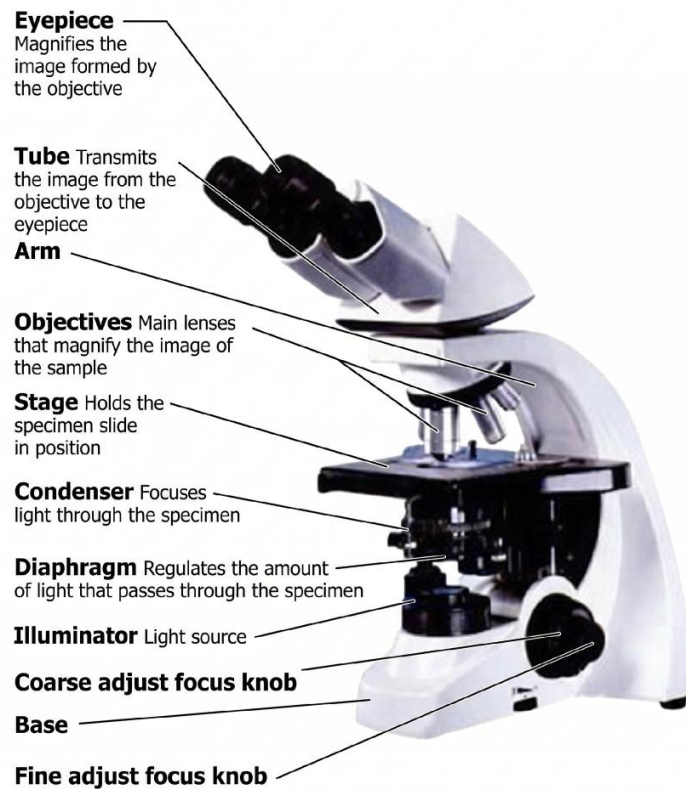
The observed samples presented better definition under magnifications of 4X; 10X and 40X. The importance of correctly regulating the illumination and keeping the equipment lenses clean to avoid visual distortions was demonstrated.

CONCLUSIONS

1. The optical microscope constitutes a fundamental tool for the study of microscopic biological structures.
2. The recognition of the mechanical and optical parts allows for the proper use of the equipment and avoids damage during its handling.
3. The correct management of focusing and illumination significantly improves the quality of microscopic observations.
4. The use of the microscope is of great importance in agronomy for the study of plant cells, microorganisms, and phytopathological diagnosis.

Reference image

Image 2.- The microscope: its parts and functions



(Perguez, 2026)

QUESTIONNAIRE

Multiple-Choice Questions (Single Best Answer)

1. Which structure regulates the amount of light entering the microscope?

- a) Revolving nosepiece
- b) Diaphragm
- c) Eyepiece (Ocular lens)
- d) Stage

Answer: b

2. What is the primary function of a compound optical microscope?

- a) To measure chemical substances
- b) To observe microscopic structures invisible to the human eye
- c) To calculate molecular weight
- d) To sterilize biological samples

Answer: b

3. Which part of the microscope is used to achieve precise focusing of the specimen?

- a) Revolving nosepiece
- b) Stage
- c) Fine adjustment knob
- d) Condenser

Answer: c

4. Which objective lens should be used to begin microscopic observation?

- a) 100X objective lens
- b) 40X objective lens
- c) Lowest power objective lens
- d) Oil immersion objective lens

Answer: c

5. Which part of the microscope holds and allows for changing the objective lenses?

- a) Diaphragm
- b) Revolving nosepiece
- c) Eyepiece (Ocular lens)
- d) Condenser

Answer: c

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LABORATORY SESSION 2

OBSERVATION AND IDENTIFICATION OF PLANT CELLS

Introduction

The plant cell constitutes the basic structural and functional unit of plant organisms. Its microscopic observation allows for the identification of fundamental components such as the cell wall, nucleus, cytoplasm, vacuole, and plastids—structures that directly participate in essential physiological processes such as photosynthesis, storage, and transport of substances (Flores-Vindas, 2024)

The use of simple plant tissues such as onion epidermis, tomato pulp, and aloe vera tissue facilitates practical learning of plant cell morphology due to the ease of specimen preparation and visualization of cellular structures. This laboratory session strengthens core competencies in microscope handling and laboratory techniques applied to Plant Biology (Alonso Peña, 2011)

General Objective

To observe and identify plant cells using an optical microscope in onion, tomato, and aloe vera tissues to recognize their main structures and morphological characteristics.

Specific Objectives

1. To prepare fresh plant specimens of onion, tomato, and aloe vera for microscopic observation.
2. To identify plant cell structures such as the cell wall, nucleus, cytoplasm, and vacuoles through microscopic observation.

Learning Outcomes

- Recognizes the main structures present in a plant cell using an optical microscope.
- Develops basic skills in plant specimen preparation and proper handling of laboratory equipment.

Methodology

Type of Session

Experimental and descriptive laboratory session conducted in the Plant Biology laboratory.

Method

The direct observation method via optical microscopy was employed to analyze fresh plant specimens.

Technique

The technique used consisted of preparing temporary wet mounts on microscope slides with stained plant tissues to facilitate cellular identification.

Methodological Development

- Collection of fresh plant specimens of onion, tomato, and aloe vera.
- Preparation of thin sections of plant epidermis using a scalpel and forceps.
- Preparation of wet mounts on slides using distilled water and biological stain.
- Microscopic observation starting with low-power objectives and progressing toward higher magnifications.
- Identification and comparison of cellular structures observed in each plant tissue.
- Recording of observations through drawings or cellular diagrams.

Materials

- Compound optical microscope
- Microscope slides
- Coverslips
- Forceps
- Scalpel or razor blade
- Dropper
- Distilled water
- Methylene blue or Lugol's iodine solution
- Absorbent paper
- Onion (*Allium cepa*)
- Ripe tomato (*Solanum lycopersicum*)
- Aloe vera leaf (*Aloe vera*)

Detailed Procedure

A. Observation of Onion Cells

Specimen Preparation:

1. Carefully peel a thin, transparent layer of the inner epidermis of the onion using forceps.

2. Place the specimen on a clean microscope slide.
3. Add a drop of distilled water to prevent tissue dehydration.
4. Apply a drop of methylene blue or Lugol's iodine to highlight cellular structures.
5. Carefully place the coverslip, avoiding the formation of air bubbles.

Microscopic Observation:

6. Place the slide preparation on the microscope stage.
7. Begin observation with the lowest power objective lens (4X or 10X).
8. Adjust focus and illumination until the cells are clearly visualized.
9. Progressively switch to higher magnifications (40X).
10. Identify the cell wall, nucleus, cytoplasm, and vacuole.

Expected Results:

Onion cells exhibit a rectangular shape and an orderly, brick-like arrangement, with the cell wall being clearly observable.

B. Observation of Tomato Cells

Specimen Preparation:

1. Cut a small portion of the pulp from a ripe tomato.
2. Place the specimen on a microscope slide.
3. Add a drop of distilled water.
4. Cover with the coverslip, applying gentle pressure to disperse the tissue.

Microscopic Observation:

5. Observe initially under low power magnification.
6. Adjust the focus to identify cellular structures.
7. Observe the presence of chromoplasts, which are responsible for the red coloration of the tomato.

Expected Results:

Tomato cells display irregular shapes and abundant reddish or orange pigments due to the presence of chromoplasts.

C. Observation of Aloe Vera Cells

Specimen Preparation:

1. Cut a small section of the gelatinous pulp from the aloe vera leaf.

2. Place a thin portion on the microscope slide.
3. Add a drop of distilled water.
4. Carefully place the coverslip.

Microscopic Observation:

5. Observe initially under low power magnification.
6. Adjust the focus until cells and mucilage are visualized.
7. Identify the presence of vacuoles and parenchymal tissue.

Expected Results:

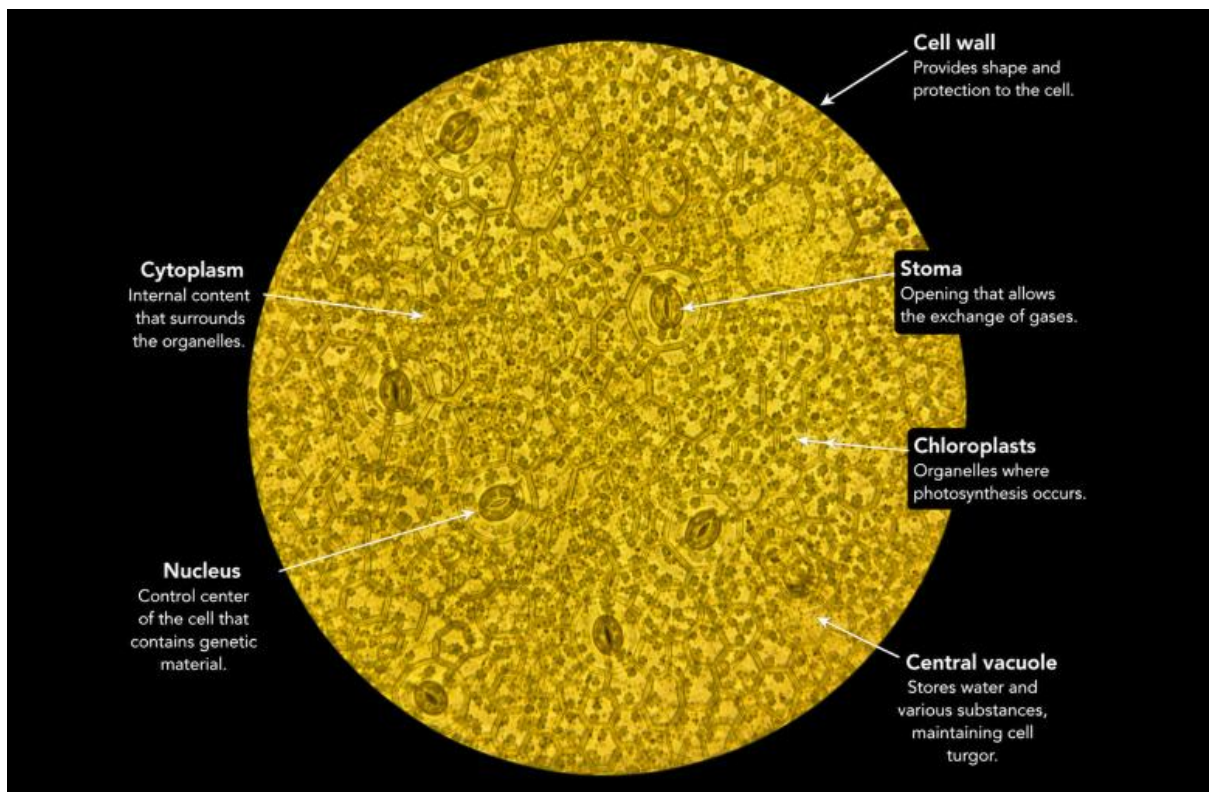
Aloe vera cells display abundant water content and large vacuoles associated with water storage.

Conclusions

- Plant cells possess characteristic structures such as a cell wall and vacuoles, which were clearly observable in the analyzed specimens.
- The onion allowed for easier identification of cellular organization due to the transparency of its epidermis.
- The tomato demonstrated the presence of chromoplasts related to plant pigmentation.
- The aloe vera showed cells adapted for water storage, standing out for their large vacuoles and mucilaginous content.
- Correct microscope handling and proper specimen preparation are fundamental for the successful observation of plant tissues.

Reference Images

Image 3. Tomato cells observed under the microscope

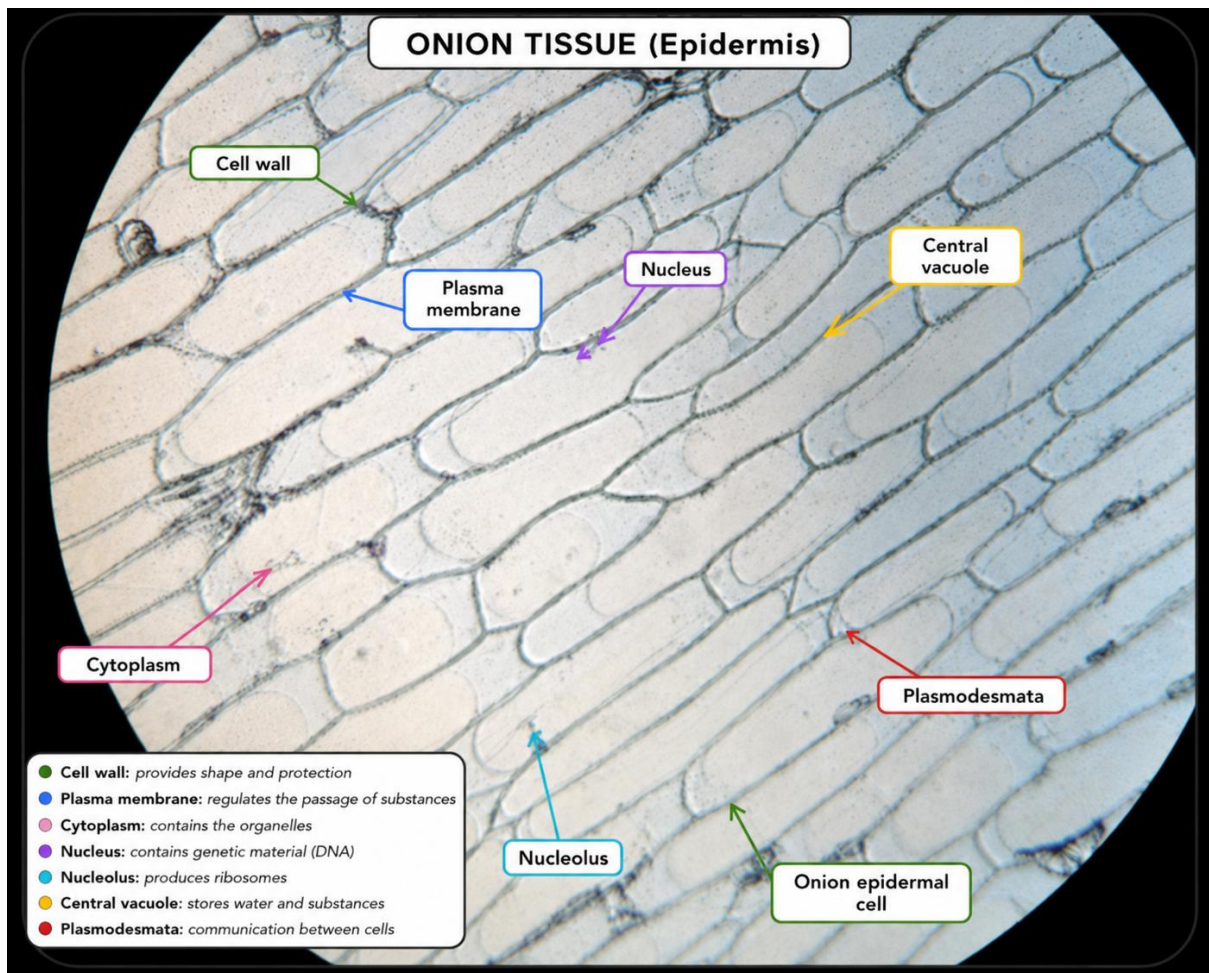


Source: Authors, 2026

Appendix Description:

Plant cells of a tomato (*Solanum lycopersicum*) observed under an optical microscope, highlighting the presence of the cell wall, cytoplasm, nucleus, a large vacuole, and chromoplasts (responsible for the red pigmentation).

Image 4. Onion epidermis observed under the microscope

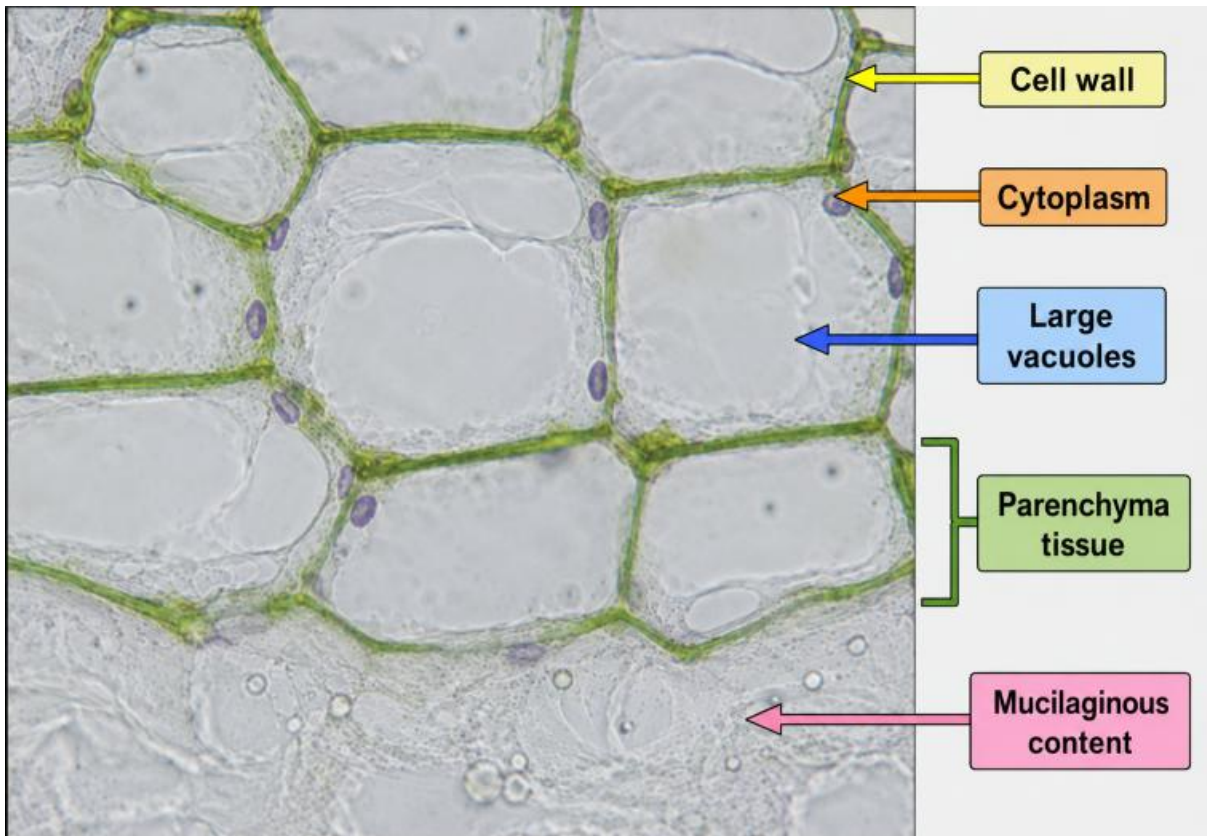


Source: Authors, 2026

Appendix Description:

Microscopic observation of onion (*Allium cepa*) epidermal cells, showing the cell wall and the rectangular arrangement of the plant cells.

Image 5. Microscopic observation and identification of aloe vera (*Aloe vera*) tissue



Source: Authors, 2026

Appendix Description:

Microscopic observation of aloe vera (*Aloe vera*) tissue, identifying the cell wall, cytoplasm, large vacuoles, parenchymal tissue, and mucilaginous content.

Questionnaire: Multiple-Choice Questions

1. What was the main objective of the plant cell observation laboratory session?

- a) To analyze animal tissues
- b) To observe and identify plant cellular structures using an optical microscope
- c) To identify bacteria present in plants
- d) To evaluate fungal growth

Correct answer: b)

2. Which cellular structure was observed with the greatest ease in the onion epidermis?

- a) Chloroplasts
- b) Mitochondria
- c) Cell wall
- d) Ribosomes

Correct answer: c)

3. Which biological stain was used to highlight the plant cellular structures?

- a) Crystal violet
- b) Methylene blue or Lugol's iodine
- c) Basic fuchsin
- d) Malachite green

Correct answer: b)

4. Which organelles were primarily observed in the ripe tomato cells?

- a) Leucoplasts
- b) Vacuoles
- c) Chromoplasts
- d) Ribosomes

Correct answer: c)

5. What is the primary function of the vacuoles observed in the aloe vera cells?

- a) Protein production
- b) DNA transport
- c) Storage of water and substances
- d) Energy formation

Correct answer: c)

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LABORATORY SESSION 3

OBSERVATION AND IDENTIFICATION OF ANIMAL CELLS

Introduction

Animal cells possess unique structural characteristics that enable them to perform specific functions within the organism. A simple and safe way to observe animal cells is by using the buccal epithelium (cells from the inner cheek mucosa). These cells are squamous, irregular, and have a well-defined nucleus surrounded by cytoplasm and delimited by the plasma membrane. Microscopic observation of this type of cell provides an understanding of its organization and allows for the recognition of its main components (Alberts, 2006).

General Objective

To observe and identify animal cells present in the buccal epithelium, recognizing their main structures.

Specific Objectives

1. To properly prepare a buccal epithelium specimen for microscopic observation.
2. To identify and describe the main parts of the animal cell in the observed specimen.

Learning Outcomes

- Recognizes animal cells and their main structures through microscopic observation.
- Relates cellular structure to the basic functions that animal cells perform in epithelial tissues.

Methodology and Techniques

The laboratory session is developed under an experimental-descriptive approach.

The technique used is the microscopic observation of a stained biological specimen using the wet mount preparation method.

Procedure

1. Rinse the mouth with water to remove food residues.
2. Using a sterile cotton swab, gently scrape the inside of the cheek.

3. Place the swab onto the microscope slide and smear the material to form a thin layer.
4. Add a drop of 1% methylene blue onto the specimen.
5. Allow the stain to sit for 1 to 2 minutes.
6. Carefully place the coverslip to avoid the formation of air bubbles.
7. Observe first under the 4X objective lens to locate the specimen, and then with the 10X and 40X objective lenses to observe details.
8. Identify the cellular structures and draw a diagram of the observations.
9. Wash and sanitize all equipment used and properly dispose of waste material.

Materials

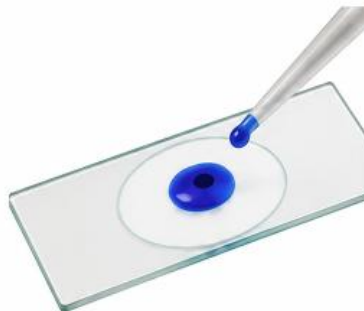
- Compound optical microscope
- Microscope slides
- Coverslips
- Dropper
- Distilled water
- 1% Methylene blue
- Absorbent paper
- Dropper

Note: The materials used must be clean and in good condition. The specimen must be safely disposed of after the laboratory session.

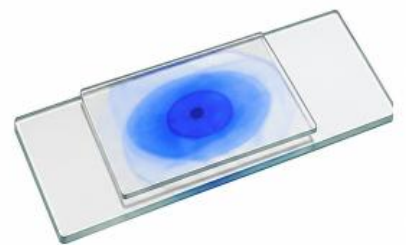
Image 6. Procedure for buccal tissue extraction.



1. Collection of buccal epithelial sample.



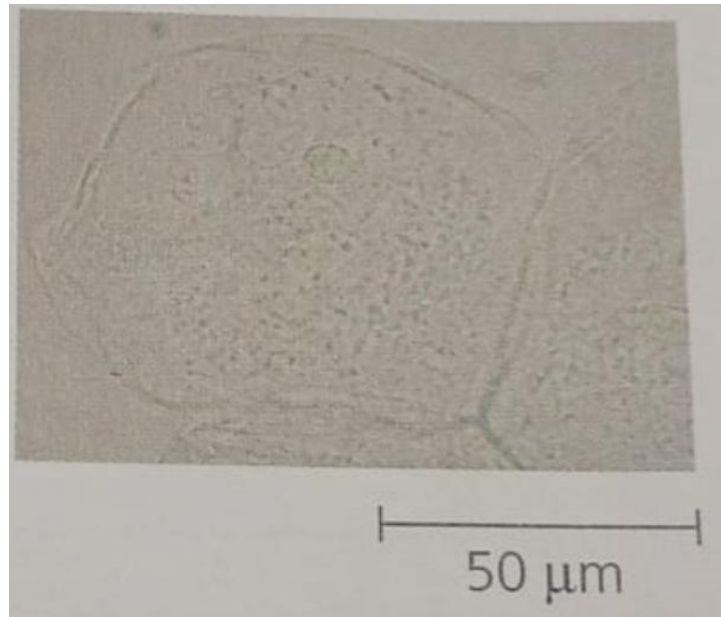
2. Extension of the sample and application of the stain.



3. Placement of the coverslip.

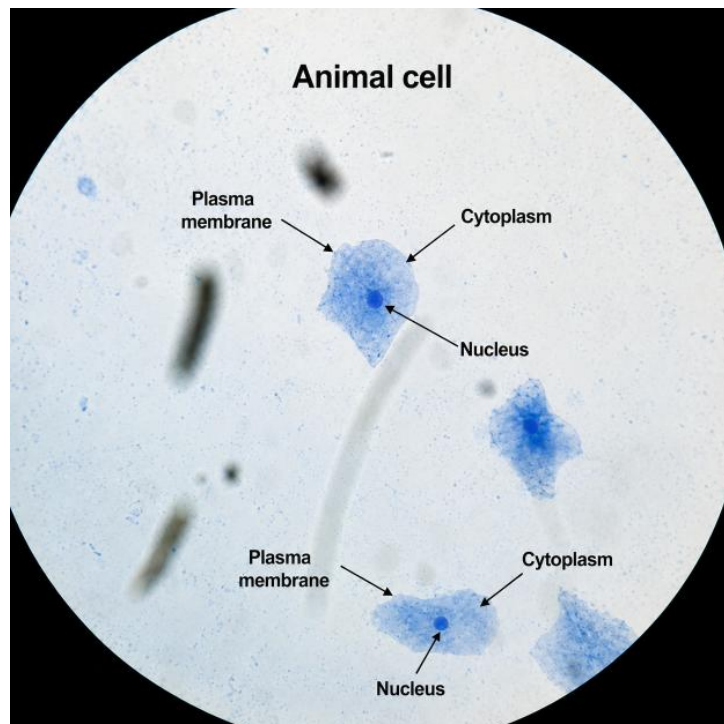
Source: Authors, 2026

Image 7. In an unstained specimen, a low-contrast image of a human cheek epithelial cell is observed.



Source: (Campbell, 2007)

Image 8. Microscopic observation of buccal epithelial cells stained with methylene blue.



Source: Authors, 2026

Conclusions

- Plant cells possess characteristic structures such as a cell wall and vacuoles, which were clearly observable in the analyzed specimens.
- The onion allowed for easier identification of cellular organization due to the transparency of its epidermis.
- The tomato demonstrated the presence of chromoplasts related to plant pigmentation.
- The aloe vera showed cells adapted for water storage, standing out for their large vacuoles and mucilaginous content.
- Correct microscope handling and proper specimen preparation are fundamental for the successful observation of plant tissues.

Questionnaire: Multiple-Choice Questions

1. What type of specimen was used to observe animal cells in the laboratory session?

- a) Onion epidermis
- b) Human blood
- c) Buccal epithelium
- d) Tomato pulp

Correct answer: c)

2. Which stain was used to dye the animal cells observed under the microscope?

- a) Lugol's iodine
- b) 1% Methylene blue
- c) Malachite green
- d) Safranin

Correct answer: b)

3. What is the primary function of methylene blue in this laboratory session?

- a) To eliminate bacteria
- b) To facilitate the observation of cellular structures
- c) To dehydrate the specimen
- d) To increase cellular size

Correct answer: b)

4. Which instrument was used to obtain the buccal epithelium specimen?

- a) Scalpel
- b) Dissecting needle
- c) Cotton swab
- d) Forceps

Correct answer: c)

5. Which cellular structure can be clearly observed in the stained animal cells?

- a) Cell wall
- b) Chloroplasts
- c) Nucleus
- d) Chromoplasts

Correct answer: c)

6. With which magnification should the microscopic observation of the specimen begin?

- a) 100X
- b) 40X
- c) 4X
- d) 60X

Correct answer: c)

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LABORATORY SESSION 4

CHARACTERIZATION AND IDENTIFICATION OF MACROALGAE

Introduction

According to Ramirez, Quan, & Carrera (2025), macroalgae are multicellular photosynthetic organisms that primarily inhabit marine and estuarine environments. These organisms hold great ecological importance due to their participation in primary production, oxygen release, and the formation of aquatic habitats.

Macroalgae are classified mainly into green algae (Chlorophyta), brown algae (Phaeophyceae), and red algae (Rhodophyta), differing in their pigmentation, structure, and biochemical composition. Green algae contain chlorophyll a and b ; brown algae present fucoxanthin; while red algae possess phycobilins as their predominant pigments. From a morphological standpoint, macroalgae present structures such as the thallus, holdfast, stipe, and frond, which perform functions of support, attachment, and photosynthesis. Unlike higher plants, they lack true roots, stems, and leaves (Arreola, 2025).

According to Vega, Ceballos, Urriola, & Lopez (2018), photosynthesis is the process that occurs in terrestrial plants, aquatic and marine algae, among other autotrophic organisms that have the capacity to produce organic matter from inorganic matter, which constitutes the base of the food chain.

The study of macroalgae holds great importance in agronomy and environmental sciences due to their applications in biofertilizers, animal feed, biotechnology, and agricultural sustainability.

GENERAL OBJECTIVE

To characterize and identify different types of macroalgae through morphological and microscopic observation, recognizing their main structures and biological classification.

SPECIFIC OBJECTIVES

1. To identify the main morphological characteristics of green, brown, and red macroalgae.
2. To differentiate the external structures of macroalgae through direct and microscopic observation.

LEARNING OUTCOMES

- Recognizes the main morphological and taxonomic characteristics of macroalgae.
- Differentiates macroalgae groups according to coloration, pigmentation, and thallus structure.

METHODOLOGY AND TECHNIQUES

The laboratory session is developed under an experimental-descriptive approach through direct observation and morphological analysis of fresh macroalgae specimens.

The techniques used include macroscopic observation, microscopic observation, taxonomic identification, and structural description of the analyzed specimens (Pereira, 2021).

PROCEDURE

PART A: COLLECTION OF SPECIMENS

1. Collect fresh macroalgae specimens in coastal areas or bodies of water.
2. Place the specimens in containers filled with water from the same environment to prevent dehydration.
3. Label the specimens indicating the date and place of collection.

PART B: MACROSCOPIC OBSERVATION

1. Place the specimens on trays or Petri dishes.
2. Observe characteristics such as:
 - Coloration
 - Size
 - Thallus shape
 - Type of branching
 - Attachment structures
3. Identify main structures:
 - Holdfast
 - Stipe
 - Frond
 - Air bladders (pneumatocysts), if present.

Morphological characteristics allow for the differentiation of taxonomic groups of macroalgae and the recognition of important ecological adaptations (Ferreira et al., 2023).

PART C: MICROSCOPIC OBSERVATION

1. Cut a small section of the thallus.
2. Place the specimen on a microscope slide with a drop of water.
3. Carefully place the coverslip.
4. Observe initially under the 10X objective lens and subsequently under 40X.
5. Identify cellular structures and pigmentation.

Microscopic observation allows for the recognition of photosynthetic cells and the structural organization of the algal thallus (Raven et al., 2021).

PART D: IDENTIFICATION

1. Compare the observed characteristics with taxonomic keys and reference images.
2. Classify the macroalgae according to:
 - *Chlorophyta*
 - *Rhodophyta*
 - *Phaeophyceae*

The classification of macroalgae is mainly based on pigmentation, thallus structure, and reproductive characteristics (Pereira, 2021).

MATERIALS AND REAGENTS

Materials

- Optical microscope
- Microscope slides
- Coverslips
- Petri dish
- Forceps
- Dropper
- Scalpel
- Observation trays
- Taxonomic guide

Reagents

- Distilled water
- Marine saline solution
- Lugol's iodine or methylene blue (optional)

RESULTS AND OBSERVATIONS

During the laboratory session, macroalgae belonging to different taxonomic groups were observed. Green algae presented an intense green coloration associated with chlorophyll; brown algae showed brown shades due to the presence of fucoxanthin; while red algae presented reddish colorations related to phycobilins (Pereira, 2021).

The observed structures included:

- Holdfast
- Stipe
- Frond
- Branching
- Air bladders

Microscopically, photosynthetic cells and the internal organization of the algal thallus were identified.

DRAWINGS, DIAGRAMS AND DESCRIPTIONS

HOLDFAST

Attachment structure that allows adherence to rocky or marine substrates.

STIPE

A stem-like structure that provides support to the fronds.

FROND

Laminar photosynthetic zone responsible for capturing light energy.

THALLUS

The general vegetative body of the macroalgae.

Macroalgae present structural diversity related to environmental adaptation and photosynthetic efficiency (Gupta & Abu-Ghannam, 2022).

DESCRIPTION OF THE MAIN GROUPS

Group	Predominant color	Main pigments	Example
<i>Chlorophyta</i>	Green	Chlorophyll A and B	<i>Ulva sp.</i>
<i>Rhodophyta</i>	Red	Phycobilins	<i>Gelidium sp.</i>
<i>Phaeophyceae</i>	Brown	Fucoxanthin	<i>Sargassum sp.</i>

GENERAL OBSERVATIONS

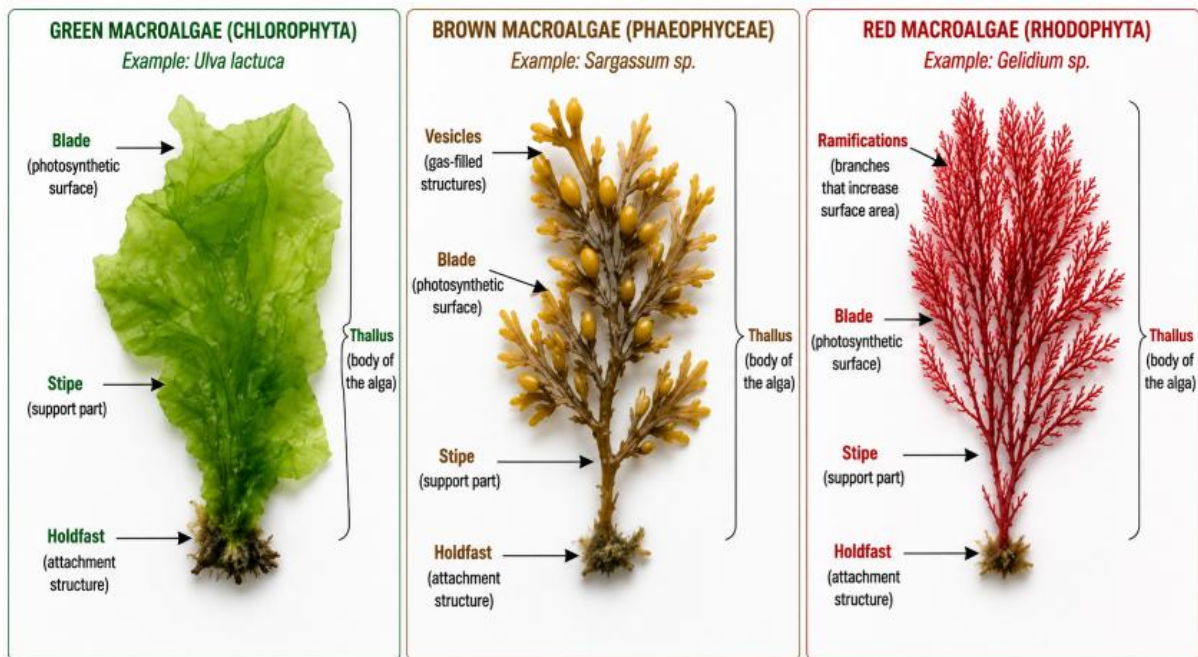
Macroalgae presented different shapes, sizes, and branching types. Some species showed simple laminar structures, while others exhibited complex branching and air bladders related to flotation (Ferreira et al., 2023).

CONCLUSIONS

1. Macroalgae are multicellular photosynthetic organisms of great ecological and biotechnological importance.
2. Coloration and morphology allow for the differentiation of the main taxonomic groups of macroalgae.
3. Thallus structures perform support, attachment, and photosynthesis functions.
4. Microscopic observation facilitates the identification of cellular structures and pigments present in macroalgae.
5. The study of macroalgae has important applications in sustainable agriculture, biotechnology, and environmental conservation.

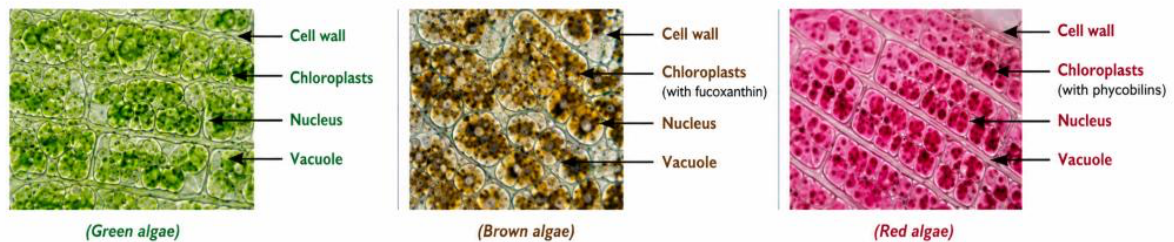
Reference Images

Image 9. Main parts of macroalgae.



Source: (Chocas, 2020)

Image 10. Microscopic view of macroalgae cells



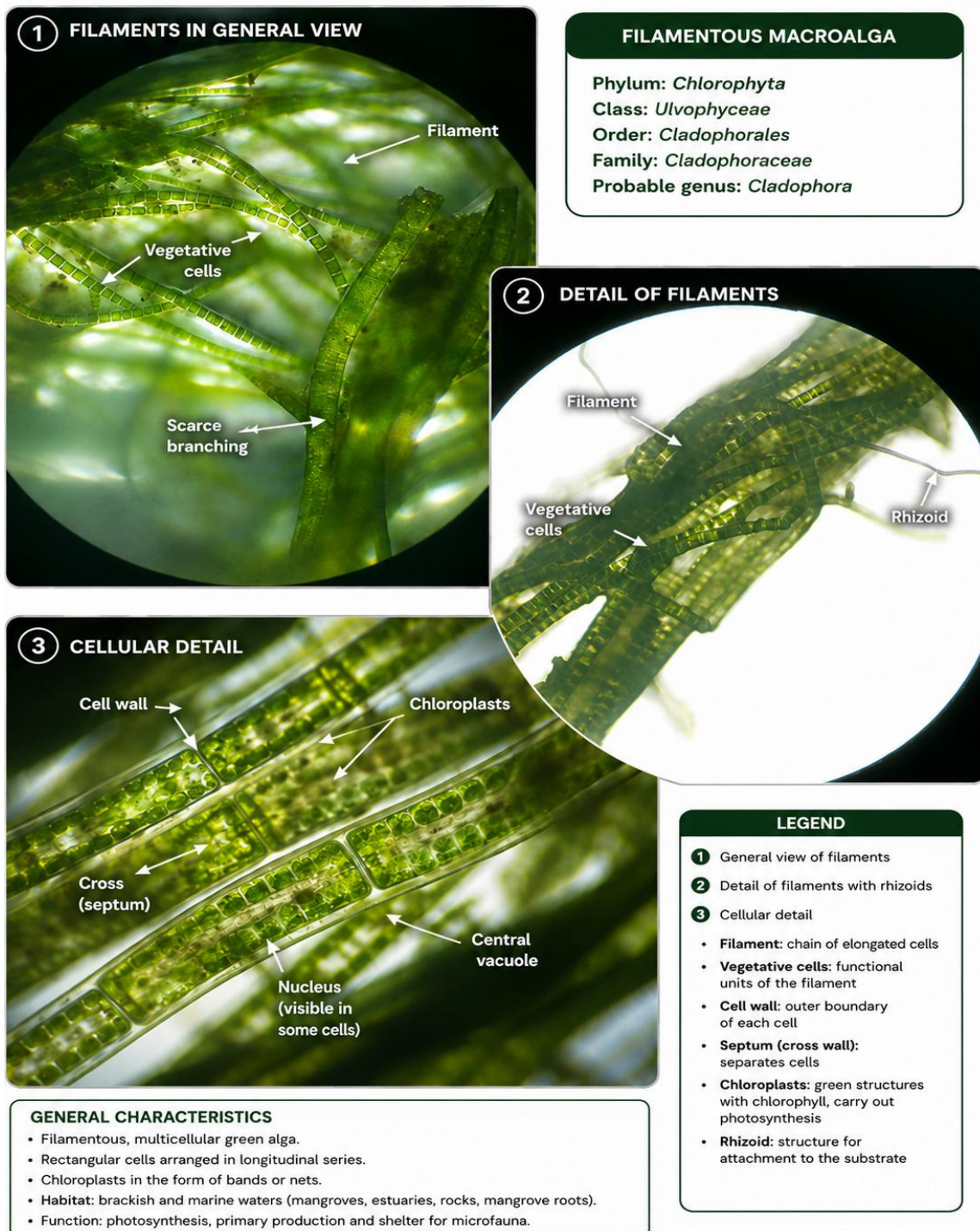
Source: (Chocas, 2020)

Image 11. Macroalgae specimens (phylum Chlorophyta), collected from the Salado mangrove in the Cristo del Consuelo sector of the Guayaquil canton.



Source: Authors, 2026

Image 12.- The observed specimen corresponds to a filamentous green macroalga belonging to the phylum Chlorophyta. Multicellular filaments formed by rectangular cells arranged in series, separated by well-defined transverse septa, were observed. The cellular interior presented abundant green chloroplasts, responsible for photosynthetic activity. Based on the observed morphological characteristics and the estuarine environment of origin, the specimen shows affinity with the family Cladophoraceae, possibly of the genus *Cladophora*.



Source: Authors, 2026

Questionnaire: Multiple-Choice Questions

1. What is the primary ecological function of macroalgae in aquatic ecosystems?

- a) Antibiotic production
- b) Primary production and oxygen release
- c) Seed formation
- d) Flower production

Correct answer: b)

2. Which pigment primarily characterizes brown algae (Phaeophyceae)?

- a) Phycobilin
- b) Chlorophyll b
- c) Fucoxanthin
- d) Carotene

Correct answer: c)

3. Which macroalgae structure allows for attachment to the substrate?

- a) Frond
- b) Stipe
- c) Holdfast
- d) Air bladder

Correct answer: c)

4. Which group of macroalgae presents chlorophyll a and b as its main pigments?

- a) Rhodophyta
- b) Phaeophyceae
- c) Chlorophyta
- d) Diatoms

Correct answer: c)

5. Which part of the macroalgae primarily performs the photosynthetic function?

- a) Holdfast
- b) Frond
- c) Stipe
- d) Rhizoid

Correct answer: b)

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LABORATORY SESSION 5

OBSERVATION AND IDENTIFICATION OF MICROALGAE

INTRODUCTION

Microalgae are unicellular, microscopic photosynthetic organisms that inhabit both freshwater and marine environments. These microorganisms hold great ecological importance due to their participation in primary production, oxygen generation, and atmospheric carbon dioxide capture. From an agronomic and biotechnological standpoint, microalgae have important applications in the production of biofertilizers, animal feed, bioremediation, biofuel production, and the sourcing of bioactive compounds of industrial and pharmaceutical interest (Gomez, 2007).

According to Rodriguez (2025), microalgae present great morphological and taxonomic diversity, encompassing groups such as Chlorophyta, Cyanobacteria, Bacillariophyta, and Euglenophyta. These organisms contain photosynthetic pigments that allow them to transform light energy into chemical energy through photosynthesis.

According to García-Romeral (2017), the observation and identification of microalgae allows for the recognition of cellular shapes, sizes, and structural and pigmentary characteristics used in their taxonomic identification. Furthermore, it sharpens the understanding of physiological processes related to biological productivity and environmental sustainability.

GENERAL OBJECTIVE

To observe and identify microalgae using optical microscopy techniques, recognizing their main morphological and structural characteristics.

SPECIFIC OBJECTIVES

1. To identify different groups of microalgae through microscopic observation.
2. To recognize the main cellular structures and morphological characteristics present in microalgae.

LEARNING OUTCOMES

- Recognizes different groups of microalgae through microscopic observation.
- Relates the morphological characteristics of microalgae to their biological classification and ecological function.

METHODOLOGY AND TECHNIQUES

The laboratory session is developed under an experimental-descriptive approach through microscopic observation of aquatic specimens containing microalgae.

The techniques used include:

- Collection of aquatic specimens.
- Preparation of wet mounts.
- Microscopic observation at different magnifications.
- Taxonomic identification through morphological characteristics.

PROCEDURE

PART A: COLLECTION OF SPECIMENS

1. Collect water specimens from ponds, lagoons, reservoirs, or freshwater bodies.
2. Place the specimens in clean, labeled bottles.
3. Keep the specimens protected from direct sunlight until observation.

Microalgae are typically found suspended in water as part of the aquatic phytoplankton.

PART B: SPECIMEN PREPARATION

1. Gently shake the specimen to homogenize it.
2. Place a drop of water onto a clean microscope slide.
3. Carefully add a coverslip, avoiding the formation of air bubbles.
4. If necessary, add a drop of Lugol's iodine solution to improve cellular visualization.

The wet mount preparation allows for the observation of motility, coloration, and the natural cellular organization of microalgae (Raven et al., 2021).

PART C: MICROSCOPIC OBSERVATION

1. Place the slide preparation onto the microscope stage.
2. Observe initially under the 4X objective lens and then under the 10X objective lens.
3. Switch progressively to 40X to observe cellular details.
4. Identify:
 - Cellular shape
 - Coloration
 - Colonial organization
 - Presence of chloroplasts
 - Cellular movement

Microalgae exhibit spherical, filamentous, spiral, and colonial shapes depending on the taxonomic group observed.

PART D: IDENTIFICATION

1. Compare the observed structures with taxonomic keys and reference images.
2. Classify the observed microalgae according to their morphological characteristics.

The main groups identified may include:

- Chlorophyta
- Diatoms
- Euglenophyta
- Cyanobacteria

Taxonomic identification is primarily based on cellular shape, pigmentation, and structural organization (Pereira & Costa, 2022).

MATERIALS AND REAGENTS

Materials

- Optical microscope
- Microscope slides
- Coverslips
- Dropper
- Collection bottles
- Absorbent paper

Reagents

- Distilled water
- Lugol's iodine solution
- Methylene blue (optional)

RESULTS AND OBSERVATIONS

During the laboratory session, different types of microalgae were observed, showing variations in size, shape, and pigmentation. Some species presented a unicellular organization, while others formed microscopic colonies and filaments.

Structures identified included:

- Chloroplasts

- Cell wall
- Nucleus
- Vacuoles
- Flagella (in some species)

Green microalgae presented an intense green coloration associated with chlorophylls, while diatoms showed siliceous cell walls with characteristic geometric shapes (Raven et al., 2021).

Microscopic observations allowed for the recognition of motility in some flagellated species and colonial groupings in other microalgae.

DRAWINGS, DIAGRAMS, AND DESCRIPTIONS

CHLOROPHYTA

Green microalgae with visible chloroplasts and spherical or colonial shapes.

DIATOMS

Microalgae with silica cell walls and symmetrical geometric shapes.

EUGLENOPHYTA

Flagellated microalgae with the capacity for movement.

CYANOBACTERIA

Photosynthetic prokaryotic organisms with filamentous or colonial shapes.

Cellular structures observed allow for the differentiation of the main groups of microalgae and the understanding of their ecological adaptation (Ferreira et al., 2023).

GENERAL OBSERVATIONS

Microalgae presented great morphological and pigmentary diversity. It was observed that some species possess active motility by means of flagella, while others remain forming microscopic colonies.

Proper illumination and focusing of the microscope were fundamental to achieving a correct identification of the observed cellular structures.

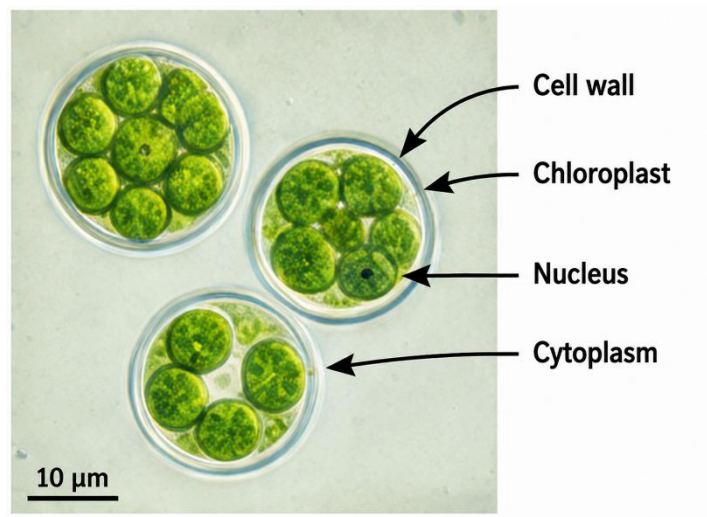
CONCLUSIONS

1. Microalgae are microscopic photosynthetic organisms of great ecological and biotechnological importance.
2. Microscopic observation allows for the identification of different groups of microalgae through their morphological characteristics.

3. Observed cellular structures facilitate the taxonomic classification of microalgae.
4. Microalgae have important applications in sustainable agriculture, biofertilizer production, and biotechnology.
5. Proper use of the microscope is fundamental for the identification and characterization of aquatic microorganisms.

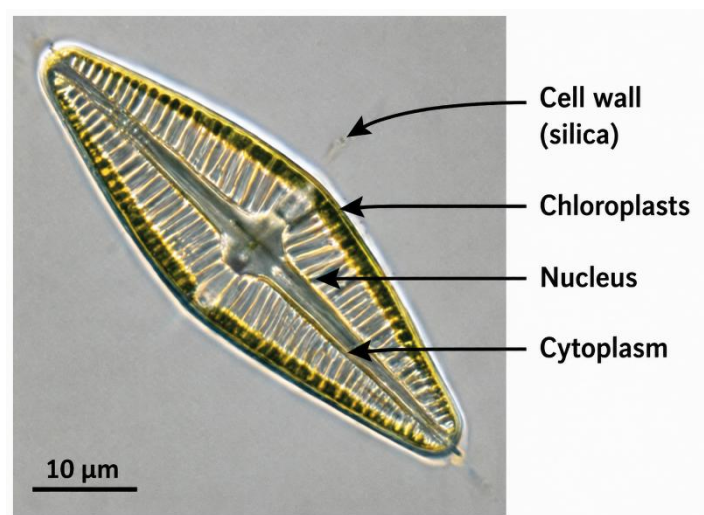
Reference Images

Image 13. A. Chlorophyta (e.g., *Chlorella* sp.)



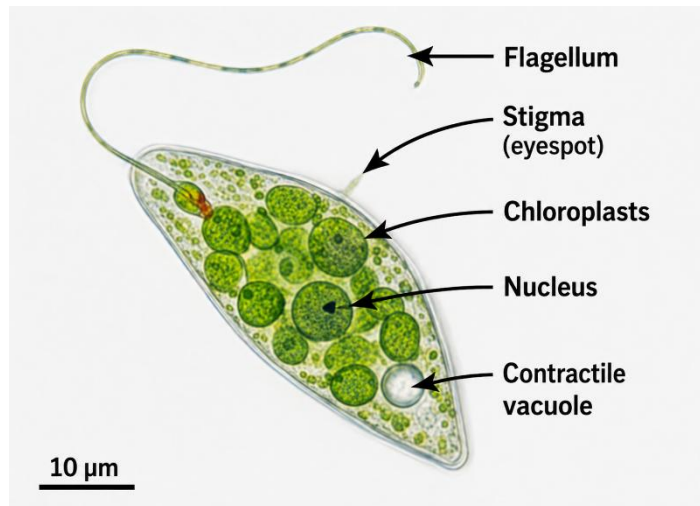
Source: (skincare, 2020)

Imagen 14.- B. Diatomeas (ej. *Navicula* sp.)



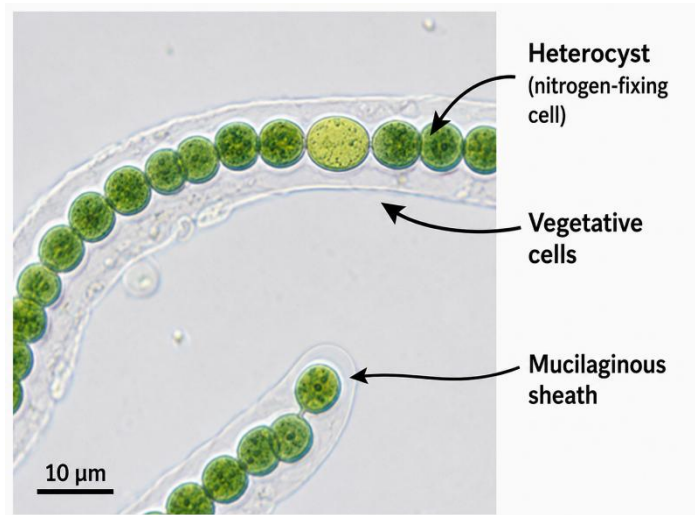
Source: (Flickr, 2017)

Image 15. C. Euglenophyta (e.g., *Euglena* sp.)



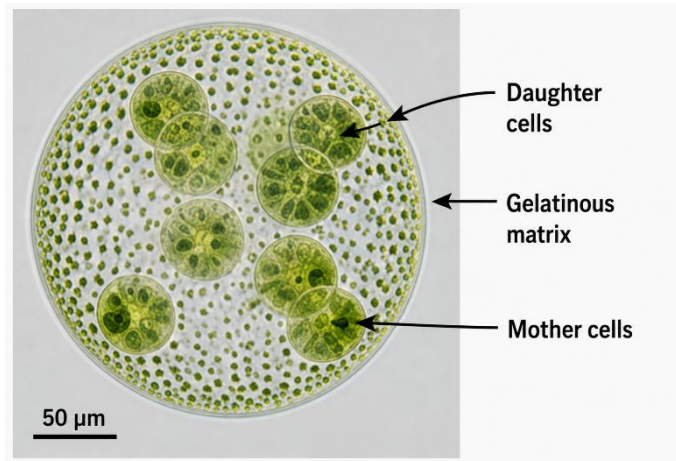
Source: (Znanje, 2026)

Image 16. D. Cyanobacteria (e.g., *Anabaena* sp.)



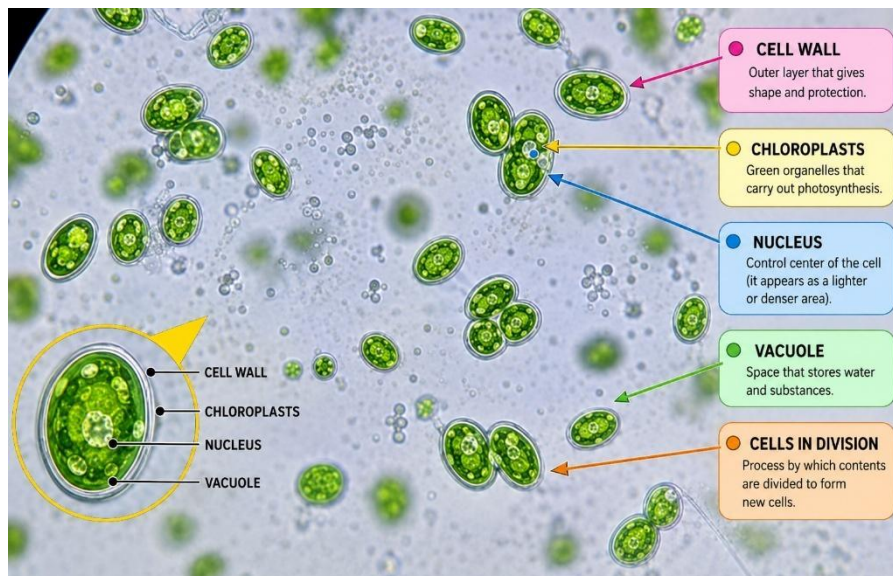
Source: (Timmer, 2020)

Image 17. E. Colonial (e.g., *Volvox* sp.)



Source: (Umimefakta, 2026)

Image 18.- Algae from the Chlorophyta group observed under the microscope in the Phytopathology laboratory of the Agricultural University of Ecuador



Source: Authors, 2026

Questionnaire: Multiple-Choice Questions

1. What is the primary ecological importance of microalgae?

- a) Seed production
- b) Primary production and oxygen generation
- c) Root formation
- d) Flower production

Correct answer: b)

2. Which group of microalgae possesses silica cell walls with geometric shapes?

- a) Chlorophyta
- b) Euglenophyta
- c) Diatoms
- d) Cyanobacteria

Correct answer: c)

3. Which structure allows for movement in some microalgae?

- a) Chloroplast
- b) Nucleus
- c) Vacuole
- d) Flagellum

Correct answer: d)

4. Which reagent can be used to improve the cellular visualization of microalgae?

- a) Ethyl alcohol
- b) Lugol's iodine solution
- c) Hydrogen peroxide
- d) Safranin

Correct answer: b)

5. Which of the following was one of the cellular structures identified during the laboratory session?

- a) Giant chromosome
- b) Chloroplast
- c) Chitin wall
- d) Sporangium

Correct answer: b)

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LABORATORY SESSION 6

CHARACTERIZATION AND IDENTIFICATION OF HIGHER FUNGI

INTRODUCTION

According to Vianney (2014), higher fungi are multicellular eukaryotic organisms that lack motile cells. They are divided into three groups depending on whether they form sexual spores or not: Ascomycetes, Basidiomycetes, and Deuteromycetes. Fungi perform fundamental ecological functions due to their participation in organic matter decomposition processes, plant and animal symbiosis, and nutrient recycling, which is vital for maintaining ecosystem balance. Furthermore, the study of fungi is crucial in agricultural production and biological sciences due to their involvement in soil fertility, mycorrhiza formation, organic waste degradation, biological control, and carbon recycling. Additionally, some fungi possess economic importance in food, medicine, and biotechnology, while others can cause diseases in agricultural crops. Without the presence of fungi, many natural processes could not take place, which would drastically affect biodiversity and ecosystems (Rodrigo, 2024).

According to Monaco, Sisterna, & A. (2026), higher fungi present visible reproductive structures known as fruiting bodies or carpophores, mycelia, cell walls, and hyphae. Fruiting bodies produce spores. These structures possess a wide diversity of shapes, sizes, colors, and textures—characteristics utilized in taxonomic identification processes.

According to Cepero, Restrepo, Franco, Cardenas, & Vargas (2012), saprophytic fungi are the best decomposers of insoluble plant material, mainly lignin. As wood degraders, this type of fungi produces three types of rot: white rot, which degrades cellulose, hemicellulose, and lignin; and fungi causing brown rot, which are those that degrade cellulose and hemicellulose but little to no lignin.

Macroscopic and microscopic observation of higher fungi allows for the recognition of morphological and reproductive structures used in their characterization and taxonomic identification, making it possible to understand their ecological, environmental, and agronomic importance.

GENERAL OBJECTIVE

To characterize and identify higher fungi through macroscopic and microscopic observation, recognizing their main morphological and reproductive structures.

SPECIFIC OBJECTIVES

1. To identify the main morphological structures present in higher fungi.
2. To differentiate groups of higher fungi by observing macroscopic and microscopic characteristics.

LEARNING OUTCOMES

- Recognizes the main vegetative and reproductive structures of higher fungi.
- Relates the morphological characteristics of fungi to their classification and ecological and agronomic importance.

METHODOLOGY AND TECHNIQUES

The laboratory session is developed under an experimental-descriptive approach through direct observation of fruiting bodies and microscopic analysis of fungal structures.

The techniques used include:

- Macroscopic observation of carpophores.
- Microscopic preparation of spores and hyphae.
- Taxonomic identification using morphological keys.
- Descriptive and schematic recording of observed structures (Pérez-Moreno et al., 2023).

PROCEDURE

PART A: COLLECTION OF SPECIMENS

1. Collect specimens of higher fungi in forested areas, humid soils, or organic debris.
2. Carefully place the specimens in clean containers to avoid damaging them.
3. Label the specimens indicating the date and place of collection.

Higher fungi usually develop in humid environments rich in organic matter (Kumar et al., 2024).

PART B: MACROSCOPIC OBSERVATION

1. Place the specimens on observation trays.
2. Observe and record:
 - Color
 - Size
 - Cap shape
 - Hymenical type
 - Presence of a ring
 - Presence of a volva

- Type of stem or stipe
3. Identify main structures:
- Cap or pileus
 - Gills or pores
 - Stipe
 - Ring
 - Volva

External morphological characteristics constitute fundamental criteria for the taxonomic identification of higher fungi (Alexopoulos et al., 2022).

PART C: MICROSCOPIC OBSERVATION

1. Cut a small section of the hymenium or gills.
2. Place the specimen on a microscope slide.
3. Add a drop of lactophenol cotton blue or distilled water.
4. Carefully place the coverslip.
5. Observe under the 10X objective lens and subsequently under 40X.
6. Identify:
 - Hyphae
 - Spores
 - Basidia
 - Septa

Microscopic observation allows for the differentiation of reproductive structures and cellular characteristics used in fungal classification (Raven et al., 2021).

PART D: IDENTIFICATION

1. Compare the observed structures with taxonomic keys and reference images.
2. Classify the specimens according to morphological and reproductive characteristics.

Higher fungi belong mainly to:

- Basidiomycota
- Ascomycota

Identification is based on carpophore morphology, spore type, and hymenium organization (Pérez-Moreno et al., 2023).

MATERIALS AND REAGENTS

Materials

- Optical microscope
- Microscope slides
- Coverslips
- Forceps
- Scalpel
- Petri dish
- Observation trays
- Taxonomic guides

Reagents

- Distilled water
- Lactophenol cotton blue
- 70% Alcohol

RESULTS AND OBSERVATIONS

During the laboratory session, different types of higher fungi were observed with variations in shape, size, and coloration. Some specimens presented laminar caps, while others showed porous surfaces or branched structures.

The main structures observed were:

- Pileus or cap
- Gills
- Stipe
- Ring
- Volva
- Hyphae
- Spores

Microscopically, septate hyphae and spores of different shapes and sizes were identified. Some species presented visible basidia associated with the production of basidiospores (Alexopoulos et al., 2022).

The observations allowed for the differentiation of fungi belonging to Basidiomycota and Ascomycota through reproductive and morphological characteristics.

DRAWINGS, DIAGRAMS, AND DESCRIPTIONS

PILEUS OR CAP

The upper structure of the fungus responsible for protecting the hymenium.

GILLS

Structures located beneath the cap where spores are produced.

STIPE

The supporting structure that elevates the cap.

RING

The remnant of the partial veil present in some species.

VOLVA

A basal structure derived from the universal veil.

HYPHAE

Microscopic filaments that make up the mycelium of the fungus.

SPORES

Reproductive structures responsible for dispersal and propagation.

Reproductive structures allow for the differentiation of taxonomic groups and the recognition of species of ecological and agricultural importance (Kumar et al., 2024).

GENERAL OBSERVATIONS

Higher fungi presented great morphological diversity related to ecological adaptation and reproductive strategies. It was observed that moisture and the presence of organic matter favor the development of fruiting bodies.

The proper use of the microscope allowed for the visualization of microscopic structures essential for taxonomic identification.

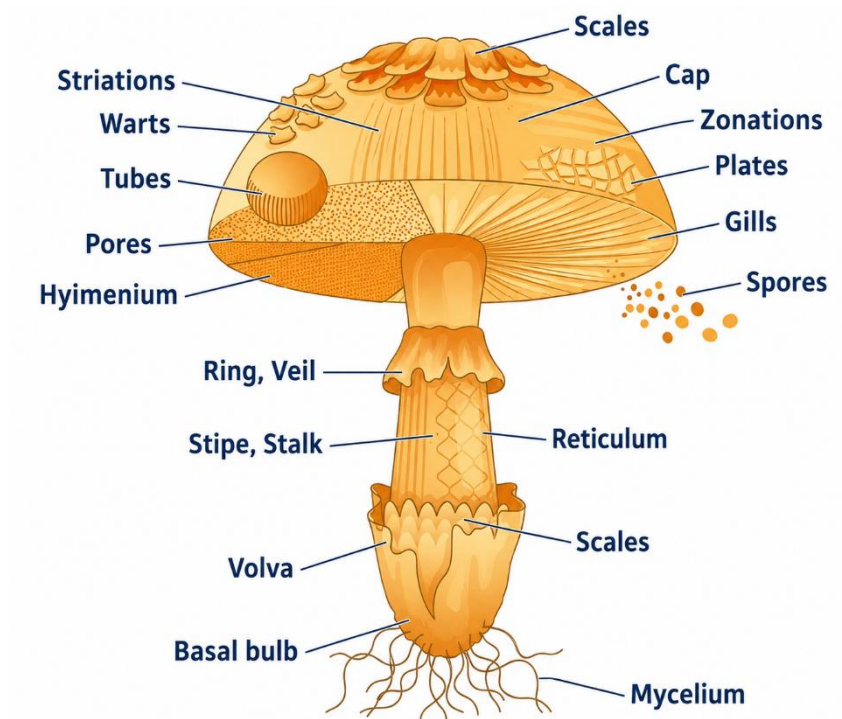
CONCLUSIONS

1. Higher fungi are multicellular eukaryotic organisms of great ecological and agronomic importance.
2. Macroscopic and microscopic characteristics allow for the differentiation of taxonomic groups of higher fungi.
3. Reproductive structures constitute fundamental criteria for fungal identification.
4. Fungi participate in important ecological processes such as decomposition and nutrient recycling.

5. The study of higher fungi has important applications in agriculture, biotechnology, and the sustainable management of ecosystems.

Reference Images

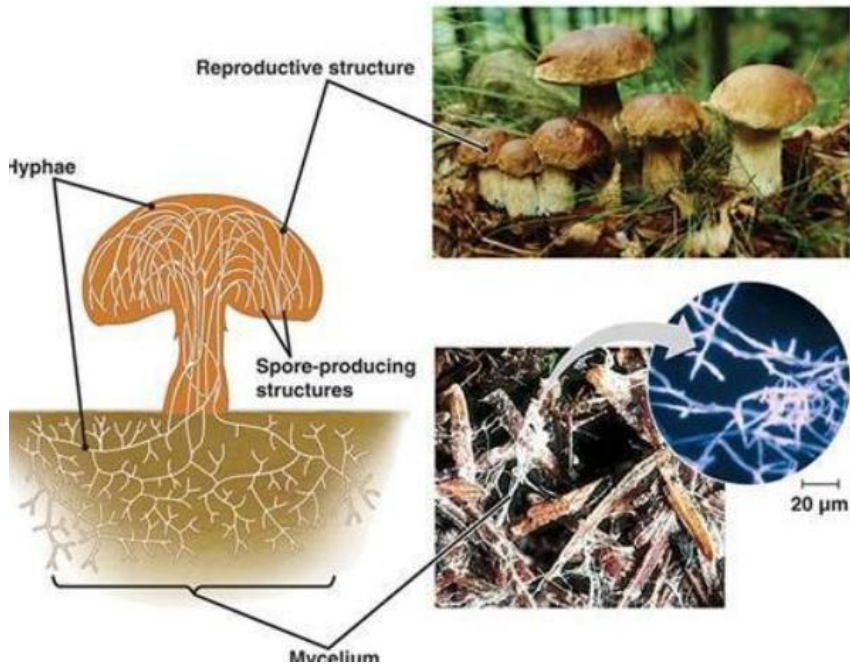
Image 19. Anatomy of macroscopic fungi.



Source: (Lidefer, 2020)

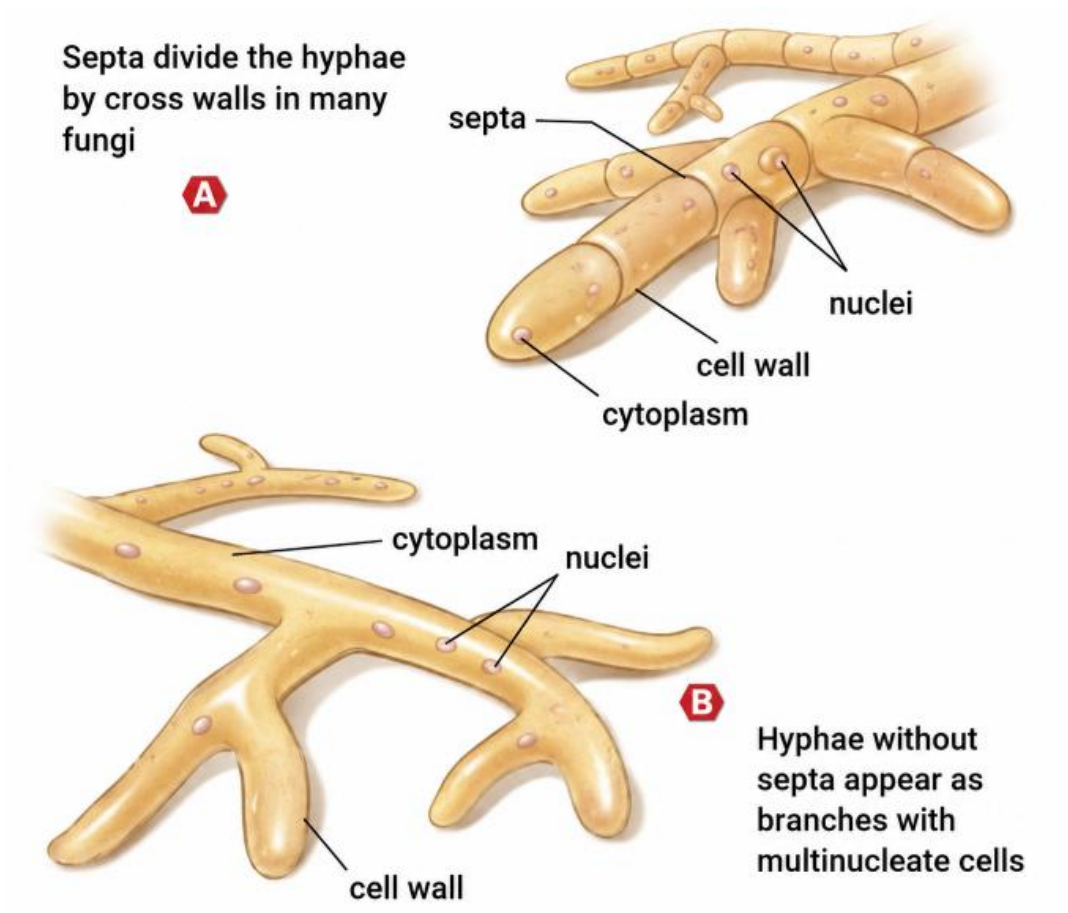
Part of the fungus	Function
Scales	Protect the cap and other fungal structures; they are remnants of the universal veil.
Cap (Pileus)	Protects the hymenium and the reproductive structures where spores are produced.
Striations	Facilitate cap expansion and aid in taxonomic identification.
Warts	Remnants of the universal veil that provide protection to the young fungus.
Tubes	Structures where spores are formed and released in some fungi.
Pores	Openings of the tubes that allow spore release and dispersal.
Hymenium	Fertile tissue responsible for producing spores.
Gills (Lamellae)	Increase the reproductive surface area for spore production.
Spores	Reproductive structures that enable fungal propagation and reproduction.
Ring or veil	Remnant of the partial veil that protected the gills during development.
Stipe or stem	Supporting structure that elevates the cap and facilitates spore dispersal.
Reticulum	Network-like ornamentation on the stipe used in taxonomic identification.
Volva	EBasal structure that completely protects the fungus when it is immature.
Basal bulb	Enlarged base that provides stability and support to the fungus.
Mycelium	Vegetative part composed of hyphae that absorb nutrients from the substrate.
Zonation patterns	Bands or growth patterns that aid in species identification.
Plates	Hymenial structures where spores develop in some fungi.

Image 20.- Reproductive structures of the fungus



Source: (Lidefer, 2020)

Image 21. Hyphae of higher fungi



Source: (Cummings, 2018)

QUESTIONNAIRE

True or False

- _____ Higher fungi belong mainly to the phyla Ascomycota and Basidiomycota.
- _____ The pileus or cap is the structure responsible for producing chlorophyll in fungi.
- _____ The lamellae or gills are structures where spores are produced.
- _____ Hyphae are microscopic filaments that make up the mycelium of the fungus.
- _____ Higher fungi have no ecological or agronomic importance.
- _____ Microscopic observation allows the identification of structures such as spores, basidia, and septa.
- _____ Moisture and organic matter favor the development of higher fungi.

ANSWERS

True

False

True

True

False

True

True

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LABORATORY PRACTICE 7

OBSERVATION AND IDENTIFICATION OF MOLDS

INTRODUCTION

(Monaco, Sisterna, & A., 2026) The term fungus comes from the Latin fungus and this from the Greek sphongos “sponge”. Fungi are eukaryotic organisms that feed through the absorption and degradation of organic compounds; they lack chlorophyll. Around 70% of plant diseases are caused by fungi, which affects agricultural production.

According to (Romero, 2017) Molds are grouped within the kingdom Fungi; they are heterotrophic and osmotrophic organisms whose cell wall is composed of chitin or chitosan.

(Chura, 2024) Crop loss due to pests and diseases is a highly significant challenge for global food security and sovereignty; yield losses caused by pests and diseases are estimated at 21.5% in wheat, 30% in rice, 22.6% in corn, 17.2% in potato, and 21.4% in soybean.

(Piepenbring, Lopez, & Caceres, 2016) All fungi found in nature perform important ecological functions related to the degradation of organic matter and nutrient recycling. However, some species possess phytopathological importance because they cause diseases in agricultural crops and deterioration of stored products.

According to (Hernandez & Mendez, 2017) Filamentous fungi or molds are formed by tubular structures called hyphae, the aggregate of which forms the mycelium. Among their characteristics, they are: multicellular organisms; they present septate or coenocytic hyphae, reproduce by means of spores, and grow on decomposing organic matter. Among filamentous molds, the following are cited as examples: *Aspergillus*, *Penicillium*, and *Rhizopus*

GENERAL OBJECTIVE

To observe and identify molds using microscopic techniques, recognizing their main vegetative and reproductive structures.

SPECIFIC OBJECTIVES

1. To identify the main microscopic structures present in molds.
2. To differentiate types of molds through morphological and reproductive observation.

LEARNING OUTCOMES

- Recognizes the vegetative and reproductive structures of molds through microscopic observation.
- Relates the morphological characteristics of molds to their ecological and agronomic importance.

METHODOLOGY AND TECHNIQUES

The lab practice is developed under an experimental-descriptive approach through macroscopic and microscopic observation of mold colonies grown on food or culture media.

The techniques used include:

- Observation of fungal colonies.
- Microscopic preparation of fungal structures.
- Staining with lactophenol blue.
- Taxonomic identification through morphological characteristics (Alexopoulos et al., 2022).

PROCEDURE

PART A: SAMPLE COLLECTION

1. Select food with visible presence of molds (bread, fruits, vegetables, or organic remains).
2. Place the samples in Petri dishes or clean containers.
3. Observe macroscopic characteristics:
 - Color
 - Texture
 - Growth form
 - Presence of mycelium

Molds develop mainly in humid environments rich in organic matter (Kumar et al., 2024).

PART B: MICROSCOPIC PREPARATION

1. Take a small portion of the mold using a microbiological needle or tweezers.
2. Place the sample on a slide.
3. Add a drop of lactophenol blue.
4. Carefully place the coverslip, avoiding the formation of bubbles.
5. Remove excess stain with absorbent paper.

Lactophenol blue allows for the staining of fungal structures and facilitates their microscopic observation (Ferreira et al., 2023).

PART C: MICROSCOPIC OBSERVATION

1. Place the slide on the microscope stage.
2. Observe initially with the 4X objective and then at 10X.
3. Progressively change to 40X to visualize structural details.
4. Identify:
 - Hyphae
 - Mycelium
 - Sporangia
 - Conidia
 - Spores
 - Conidiophores

Reproductive structures allow for the differentiation of mold genera such as *Rhizopus*, *Penicillium*, and *Aspergillus*

PART D: IDENTIFICATION

1. Compare the observed structures with images and taxonomic keys.
2. Classify the observed mold according to morphological characteristics.

The most common genera include:

- *Rhizopus* sp.
- *Aspergillus* sp.
- *Penicillium* sp.

Taxonomic identification is mainly based on spore arrangement, conidiophore shape, and mycelium type (Alexopoulos et al., 2022).

MATERIALS AND REAGENTS

Materials

- Optical microscope
- Slides
- Coverslips
- Petri dish
- Tweezers
- Microbiological needle
- Absorbent paper
- Dropper

Reagents

- Lactophenol blue
- 70% alcohol

- Distilled water

RESULTS AND OBSERVATIONS

During the lab practice, mold colonies with different colorations and textures were observed. Some species presented a white cottony growth, while others showed green, black, or bluish shades associated with spore production.

Microscopically, the following were identified:

- Septate and non-septate hyphae
- Vegetative mycelium
- Sporangia
- Conidia
- Conidiophores
- Spores

In *Rhizopus* sp., spherical sporangia supported by sporangiophores were observed. In *Penicillium* sp., branched conidiophores resembling brushes were identified, while *Aspergillus* sp. presented radiated conidial structures.

The observations allowed for the differentiation of molds through their reproductive structures and mycelium organization.

DRAWINGS, DIAGRAMS, AND DESCRIPTIONS

HYPHAE

Microscopic filaments that make up the vegetative body of the fungus.

MYCELIUM

Aggregate of hyphae responsible for nutrient absorption.

SPORANGIA

Closed structures where spores are produced.

CONIDIA

Asexual spores produced externally on conidiophores.

CONIDIOPHORES

Specialized structures that support conidia.

SPORES

Reproductive structures responsible for dispersal and propagation.

Microscopic structures allow for the identification of mold genera and species of agricultural and environmental importance (Kumar et al., 2024).

GENERAL OBSERVATIONS

The molds presented great morphological and pigmentary diversity depending on the observed species and environmental growth conditions.

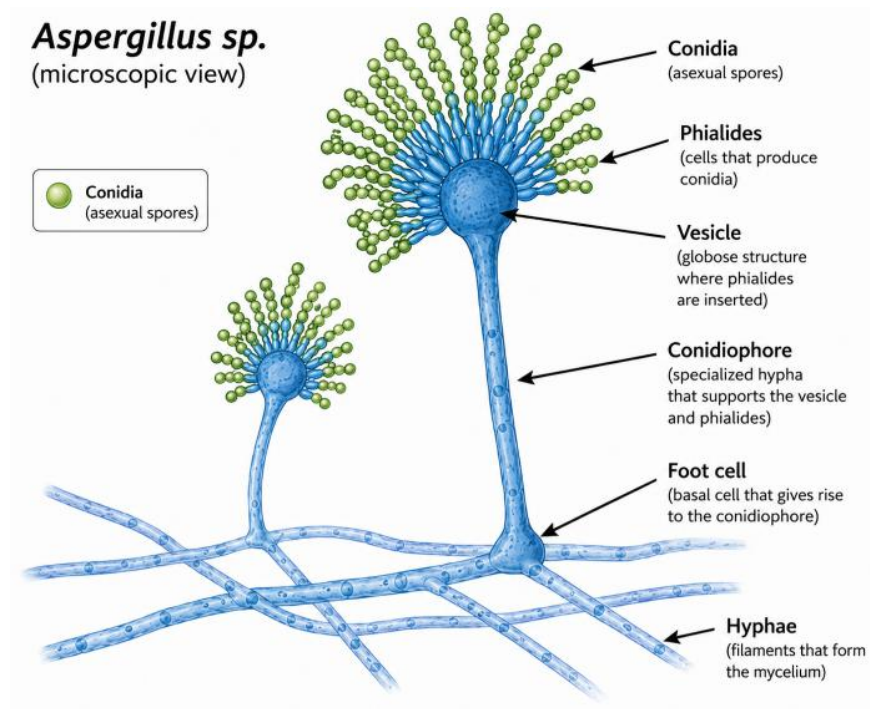
Microscopic observation allowed for the clear identification of reproductive structures used in taxonomic classification. The proper use of stains facilitated the visualization of hyphae and spores.

CONCLUSIONS

1. Molds are multicellular microscopic fungi with great ecological and agronomic importance.
2. Vegetative and reproductive structures allow for the differentiation of microscopic mold genera.
3. Microscopic observation constitutes a fundamental tool for the identification of filamentous fungi.
4. Some molds possess phytopathological importance because they affect crops and stored food.
5. The study of molds has important applications in agricultural microbiology, biotechnology, and phytosanitary control.

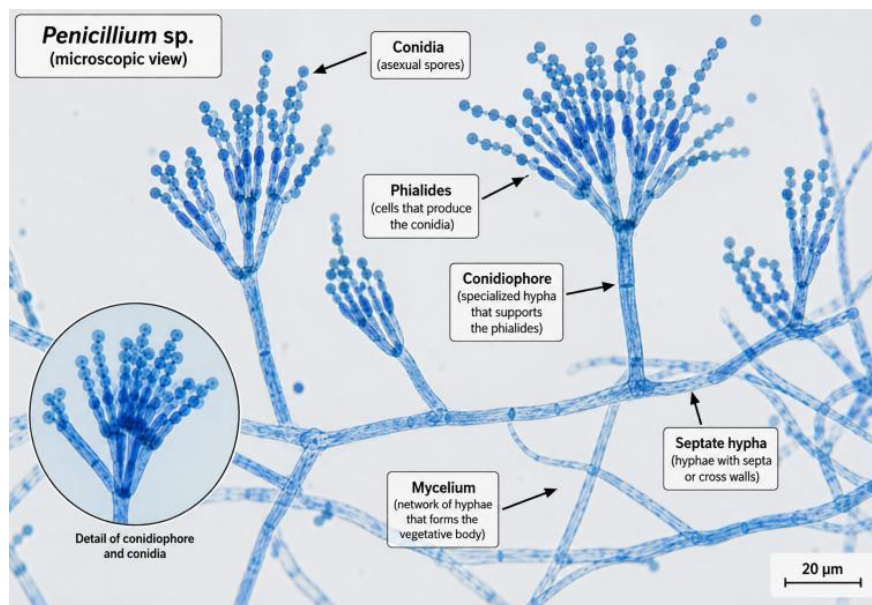
Reference images

Image 22.- Parts of the mold *Aspergillus* sp



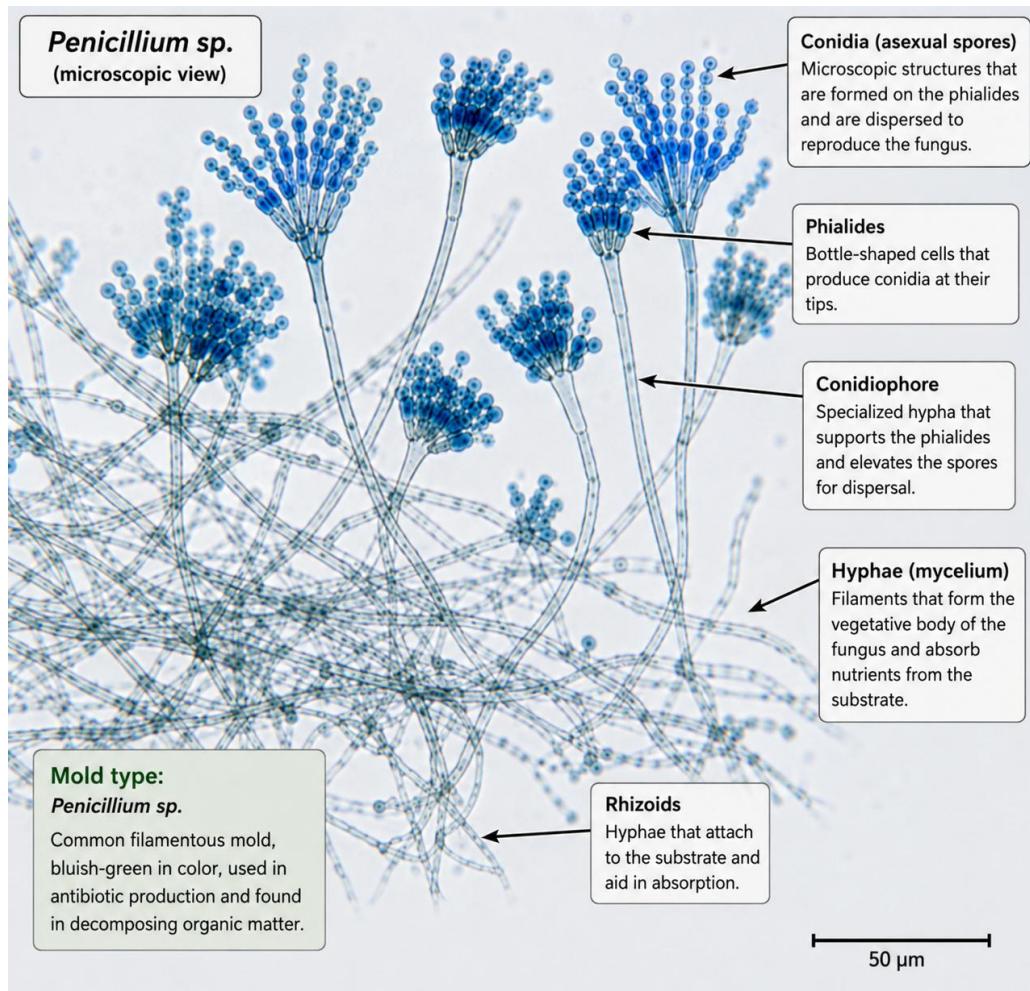
Source: (Python, 2022)

Image 23.- *Penicillium* mold seen under an optical microscope



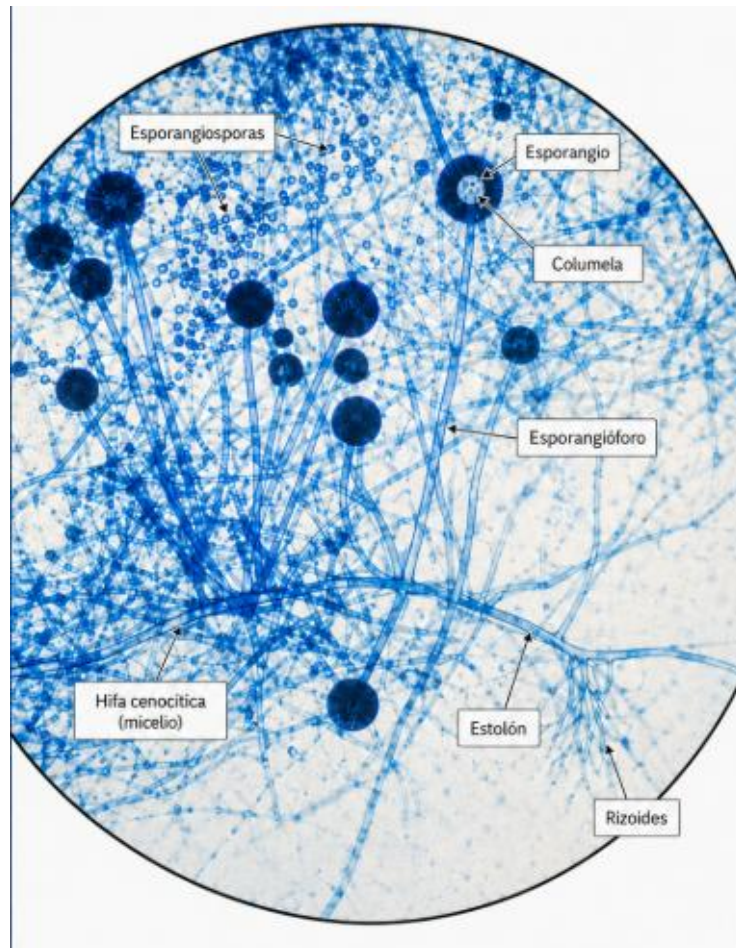
Source: (Idelmedical, 2026)

Image 24.- Penicillium mold seen under an optical microscope in the Phytopathology Laboratory of the Agrarian University of Ecuador



Source: Authors, 2026

Image 25.- Rhizopus mold seen under an optical microscope in the Phytopathology Laboratory of the Agrarian University of Ecuador



Source: Authors, 2026

QUESTIONNAIRE

True or False

1. _____ Molds are multicellular microscopic fungi formed by structures called hyphae.
2. _____ Molds only develop in dry environments without organic matter.
3. _____ Lactophenol blue is used to facilitate the microscopic observation of fungal structures.
4. _____ The mycelium corresponds to the aggregate of hyphae of the fungus.
5. _____ Conidia are asexual reproductive structures produced by some molds.
6. _____ *Rhizopus* sp., *Penicillium* sp., and *Aspergillus* sp. are common mold genera.
7. _____ Microscopic observation does not allow for the differentiation of reproductive structures of molds.

ANSWERS

1. True
2. False
3. True
4. True
5. True
6. True
7. False

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LABORATORY PRACTICE 8

OBSERVATION AND IDENTIFICATION OF YEASTS

INTRODUCTION

Yeasts are eukaryotic unicellular fungi belonging mainly to the phylum Ascomycota. These microorganisms possess great biological, industrial, and agricultural importance due to their ability to carry out fermentative processes and degrade organic compounds. (Cordoba, Reynaldi, & Rosa, 2021) According to them, yeasts are made up of simple and isolated cells, with spherical, ovoid, cylindrical, or triangular shapes, which reproduce by fission or bud formation.

According to (Wijayawardene, 2018) The phylum Ascomycota consists of three subphyla, namely: Pezizomycotina (including 13 classes, 124 orders, and 507 families), Saccharomycotina (including one class, one order, and 13 families), and Taphrinomycotina (five classes, five orders, and six families). Approximately 6600 genera have been listed under different taxonomic ranks, including auxiliary (intermediate) taxonomic ranks.

According to (Jácome, et al., 2023) The yeast *Saccharomyces Cerevisiae* is characterized by being unicellular, and it is used in the production of many food products (Kastdalen Mendoza, 2017) and beverages, including wine, beer, bread, and cider. It is a very versatile and resilient yeast that can adapt to a wide range of fermentation conditions and produce different compounds that contribute to the quality and flavor of the final product.

The microscopic observation of yeasts allows for the identification of morphological and reproductive characteristics used in agricultural microbiology and industrial biotechnology.

GENERAL OBJECTIVE

To observe and identify yeasts using microscopic techniques, recognizing their main cellular and reproductive characteristics.

SPECIFIC OBJECTIVES

1. To identify the main cellular structures present in yeasts.
2. To recognize reproduction processes by budding through microscopic observation.

LEARNING OUTCOMES

- Recognizes the morphological and reproductive characteristics of yeasts through microscopic observation.

- Relates the biotechnological and agricultural importance of yeasts to their metabolic processes.

METHODOLOGY AND TECHNIQUES

The lab practice is developed under an experimental-descriptive approach through microscopic observation of commercial or fermentative yeast samples.

The techniques used include:

- Preparation of wet mounts.
- Microbiological staining.
- Microscopic observation.
- Morphological and reproductive identification of yeast cells (Ferreira et al., 2023).

PROCEDURE

PART A: SAMPLE PREPARATION

1. Place a small amount of commercial yeast in a beaker.
2. Add warm water and mix gently.
3. Let it rest for 5 minutes to activate the cells.

Yeasts are activated in the presence of moisture and moderate temperatures due to their fermentative metabolism (Kumar et al., 2024).

PART B: MICROSCOPIC PREPARATION

1. Place a drop of yeast suspension on a clean slide.
2. Add a drop of methylene blue or Lugol's iodine.
3. Carefully place the coverslip, avoiding the formation of bubbles.
4. Remove excess stain with absorbent paper.

Stains allow for a better visualization of cellular structures and budding processes (Raven et al., 2021).

PART C: MICROSCOPIC OBSERVATION

1. Place the slide on the microscope stage.
2. Observe initially with the 10X objective.
3. Subsequently change to 40X to observe cellular details.
4. Identify:
 - Cell wall
 - Cytoplasm
 - Vacuoles
 - Nucleus

- Budding

Yeasts present oval or rounded unicellular cells, frequently grouped and with visible reproductive buds (Alexopoulos et al., 2022).

PART D: IDENTIFICATION

1. Compare the observed structures with reference images and microbiological keys.
2. Record shape, size, and presence of budding.

The most common species belong to the genus:

- *Saccharomyces sp.*
- *Candida sp.*
- *Cryptococcus sp.*

Microscopic identification is mainly based on cellular morphology and type of reproduction (Ferreira et al., 2023).

MATERIALS AND REAGENTS

Materials

- Optical microscope
- Slides
- Coverslips
- Dropper
- Beaker
- Pipettes
- Absorbent paper

Reagents

- Commercial yeast (*Saccharomyces cerevisiae*)
- Distilled water
- Methylene blue
- Lugol's iodine

OBSERVATIONS AND RESULTS

During the lab practice, yeast cells with oval and spherical shapes grouped in small cell clusters were observed. Some cells presented clearly visible budding processes associated with asexual reproduction.

Microscopically, the following were identified:

- Cell wall
- Cytoplasm
- Vacuoles
- Nucleus
- Buds or budding

Cells stained with methylene blue showed better structural contrast, allowing for clearer observation of cell boundaries and internal structures.

The observed yeasts showed high reproductive activity through bud formation, a typical characteristic of *Saccharomyces cerevisiae*.

DRAWINGS, DIAGRAMS AND DESCRIPTIONS

CELL WALL

Rigid external structure responsible for protection and maintenance of cell shape.

CYTOPLASM

Internal medium where cellular metabolic processes occur.

VACUOLES

Structures related to substance storage and osmotic regulation.

NUCLEUS

Organelle containing the cellular genetic material.

BUDDING

Asexual reproduction process through the formation of a cell bud or outgrowth.

The observed structures allow for the differentiation of yeasts from other microscopic microorganisms and the recognition of their reproductive processes (Ferreira et al., 2023).

GENERAL OBSERVATIONS

The yeasts presented a large number of active cells and visible budding processes under 40X magnification. Microbiological staining facilitated the observation of cellular structures and differentiation of living cells.

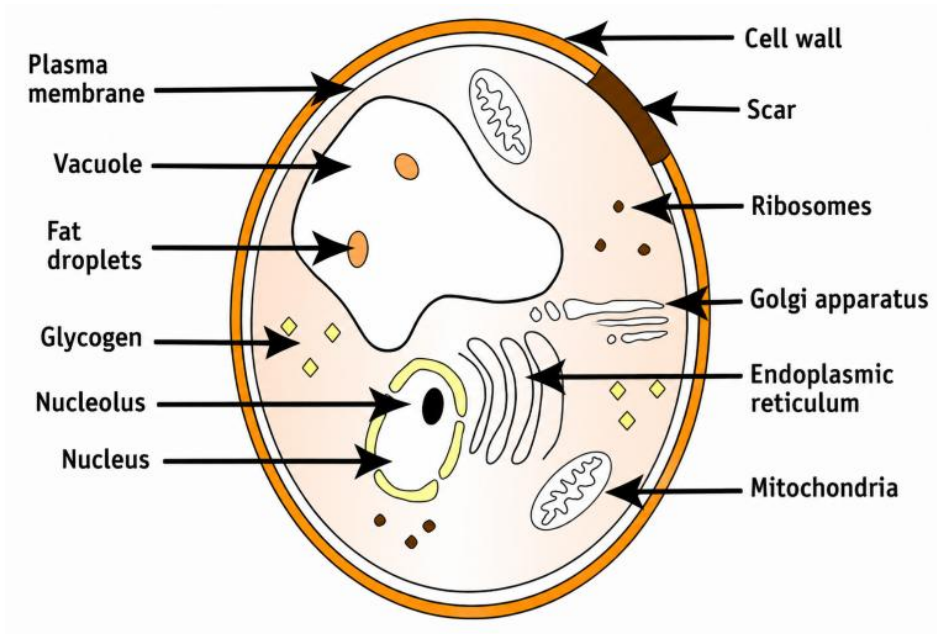
The correct use of the microscope allowed for a clear observation of morphological characteristics specific to fermentative unicellular fungi.

CONCLUSIONS

1. Yeasts are eukaryotic unicellular fungi of great industrial, agricultural, and biotechnological importance.
2. Microscopic observation allows for the identification of cellular structures and reproductive processes characteristic of yeasts.
3. Reproduction by budding constitutes a distinctive feature of many yeast species.
4. Yeasts participate in fermentative processes of great economic and biological importance.
5. The proper use of stains and microscopy facilitates the identification and study of unicellular microorganisms.

Reference images

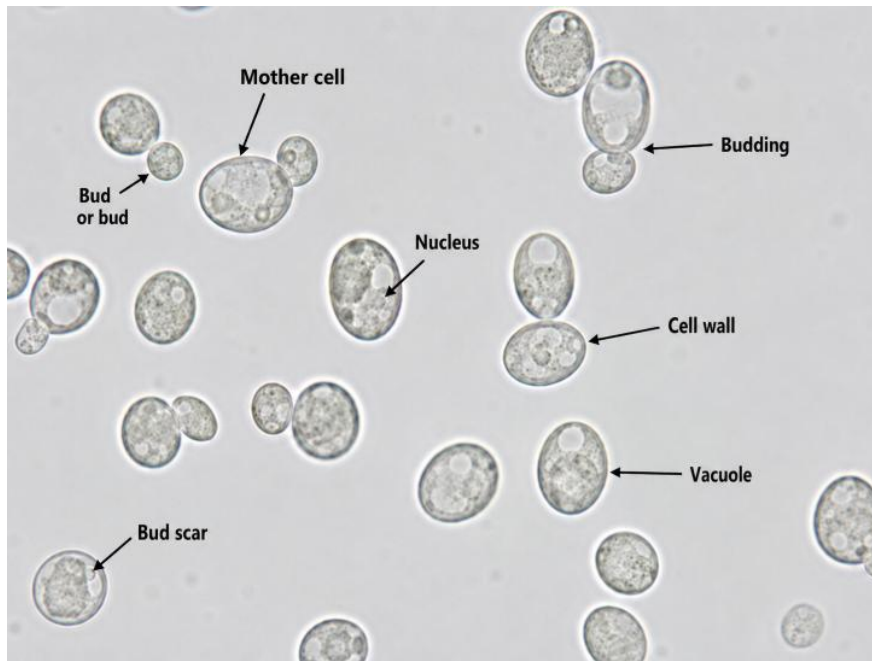
Image 26.- Structure of a yeast, its parts and functions



Source: (Silvera, 2025)

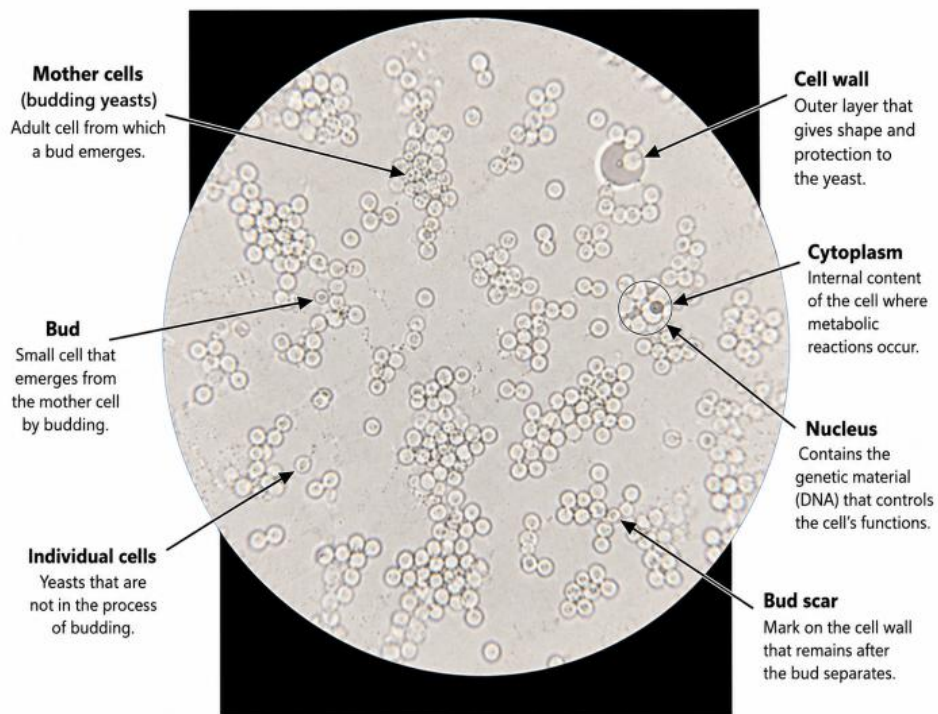
Yeast Structure	Function
Cell Wall	Protects the cell and provides shape and structural rigidity.
Plasma Membrane	Regulates the exchange of substances between the cell interior and the external environment.
Vacuole	Stores water, nutrients, and waste substances; also regulates osmotic balance.
Lipid Droplets	Energy reserves used during metabolic processes.
Glycogen	Energy storage substance of the yeast cell.
Nucleolus	Participates in ribosome formation.
Nucleus	Contains the genetic material (DNA) and controls cellular activities.
Ribosomes	Carry out protein synthesis.
Golgi Apparatus	Modifies, packages, and transports proteins and other cellular substances.
Endoplasmic Reticulum	Participates in the synthesis and transport of proteins and lipids.
Mitochondrion	Produces energy through cellular respiration.
Bud Scar	Mark left after the budding process or asexual reproduction.

Image 27.- Microscopic observation of yeasts and cellular structures identified through optical microscopy



Source: (Juarez, 2023)

Image 28.- Microscopic observation of yeasts and their budding process, carried out in the phytopathology laboratory of the Agrarian University of Ecuador



Source: Authors, 2026

QUESTIONNAIRE

1. To which group do yeasts belong?

- a) Prokaryotic bacteria
- b) Eukaryotic unicellular fungi
- c) Microscopic algae
- d) Protozoans

Correct answer: b)

2. What is the primary reproduction mechanism observed in yeasts?

- a) Sporulation
- b) Fragmentation
- c) Budding
- d) Binary fission

Correct answer: c)

3. Which stain was used to improve the microscopic visualization of yeasts?

- a) Crystal violet
- b) Methylene blue
- c) Malachite green
- d) Safranin

Correct answer: b)

4. Which cellular structure contains the genetic material of yeasts?

- a) Vacuole
- b) Cytoplasm
- c) Nucleus
- d) Cell wall

Correct answer: c)

5. Which is one of the most widely used yeast species in fermentative processes?

- a) *Aspergillus niger*
- b) *Rhizopus stolonifer*
- c) *Saccharomyces cerevisiae*
- d) *Penicillium* sp.

Correct answer: c)

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LABORATORY PRACTICE 9

IDENTIFICATION OF VASCULAR TISSUES IN MONOCOTYLEDONOUS PLANTS

INTRODUCTION

Differentiated plant tissues are organized into three main systems that fulfill specific functions for growth, protection, and transport within the plant, such as: Dermal system: it is the tissue responsible for protecting the plant's surface against physical damage, water loss, and organism attacks. It consists of: epidermis: present in organs with primary growth. Periderm: replaces the epidermis in organs with secondary growth. The Ground system: constitutes most of the plant body and performs functions of photosynthesis, water and nutrient storage, and mechanical support. Furthermore, it forms the cortex when located between the dermal and vascular tissues, and the pith when located inside the vascular tissue. It is composed of: Parenchyma: storage and photosynthesis. Collenchyma: flexible support in young organs. Sclerenchyma: rigid support and mechanical resistance. And finally, the Vascular system: It is the system responsible for transporting water, minerals, and nutrient substances throughout the plant. It consists of: Xylem: conducts water and mineral salts from the root to the aerial parts. Phloem: transports sugars and other organic substances produced during photosynthesis (Alonso-Peña, 2011)

According to (Cayambe Cajo, 2022) Monocots possess a single cotyledon in the seed embryo. They are characterized by presenting leaves with parallel veins, fasciculated or fibrous roots, and flowers whose floral parts appear in multiples of three. Furthermore, the vascular bundles of the stem are scattered throughout the stem, and the pollen generally presents a single pore or furrow.

The microscopic observation of plant sections allows for the identification of vascular tissues and the understanding of their relationship with physiological processes and agricultural productivity.

GENERAL OBJECTIVE

To identify the vascular tissues of monocotyledonous plants through microscopic observation of plant sections.

SPECIFIC OBJECTIVES

1. To recognize the anatomical characteristics of xylem and phloem in monocotyledonous plants.
2. To differentiate the arrangement of vascular bundles present in monocotyledonous plant tissues.

LEARNING OUTCOMES

- Identifies vascular tissues through microscopic observation of plant samples.
- Relates the anatomical structure of monocots to their physiological functions.

METHODOLOGY AND TECHNIQUES

The lab practice is developed under an experimental-descriptive approach through microscopic observation of cross-sections of monocotyledonous stems and leaves.

The techniques used include:

- Preparation of plant sections.
- Histological staining.
- Microscopic observation.
- Anatomical identification of vascular tissues (Evert & Eichhorn, 2023).

PROCEDURE

PART A: OBTAINING THE PLANT SAMPLE

1. Select fresh samples of monocotyledonous plants such as corn, onion, or grass.
2. Cut small sections of the stem or leaf using a scalpel.

Monocots present scattered vascular bundles within the ground tissue of the stem.

PART B: PREPARATION OF PLANT SECTIONS

1. Make thin cross-sections of the plant tissue.
2. Place the section on a clean slide.
3. Add a drop of distilled water or plant stain.
4. Carefully place the coverslip.
5. The preparation of thin sections allows for a clear observation of the anatomical organization of vascular tissues.

PART C: STAINING OF TISSUES

1. Add a drop of safranin or methylene blue onto the sample.
2. Wait approximately 1 to 2 minutes.
3. Remove excess stain using absorbent paper.

Histological stains facilitate the differentiation of xylem and phloem due to the differential affinity of plant tissues.

PART D: MICROSCOPIC OBSERVATION

1. Place the sample on the microscope stage.

2. Observe initially with the 4X objective.
3. Subsequently change to 10X and 40X to visualize anatomical details.
4. Identify:
 - Xylem
 - Phloem
 - Vascular bundles
 - Epidermis
 - Parenchyma

Monocots present closed and scattered vascular bundles, without the formation of a vascular cambium.

MATERIALS AND REAGENTS

Materials

- Optical microscope
- Slides
- Coverslips
- Scalpel
- Tweezers
- Dropper
- Absorbent paper

Plant material

- Corn stem
- Onion
- Grass or gramineae

Reagents

- Distilled water
- Safranin
- Methylene blue

RESULTS AND OBSERVATIONS

During the lab practice, cross-sections of monocotyledonous tissues with scattered vascular bundles within the ground tissue were observed.

Microscopically, the following were identified:

- Xylem
- Phloem
- Vascular bundles
- Epidermis

- Parenchyma

The xylem presented larger cells and lignified walls intensely stained with safranin, while the phloem showed smaller cells related to nutrient transport.

It was observed that the vascular bundles in monocots do not form continuous rings, but instead remain irregularly distributed within the ground tissue of the stem.

DRAWINGS, DIAGRAMS, AND DESCRIPTIONS

XYLEM

Conducting tissue responsible for transporting water and minerals from the root to the aerial part of the plant.

PHLOEM

Tissue responsible for transporting sugars and organic substances produced during photosynthesis.

VASCULAR BUNDLE

Aggregate formed by xylem and phloem.

EPIDERMIS

Protective outer layer of the plant organ.

PARENCHYMA

Ground tissue responsible for storage and cellular metabolism.

The scattered arrangement of vascular bundles constitutes a distinctive anatomical characteristic of monocots.

GENERAL OBSERVATIONS

The vascular tissues presented visible differences in coloration and cellular structure due to the use of plant stains.

Microscopic observation allowed for the clear identification of scattered vascular bundles, an anatomical characteristic specific to monocotyledonous plants.

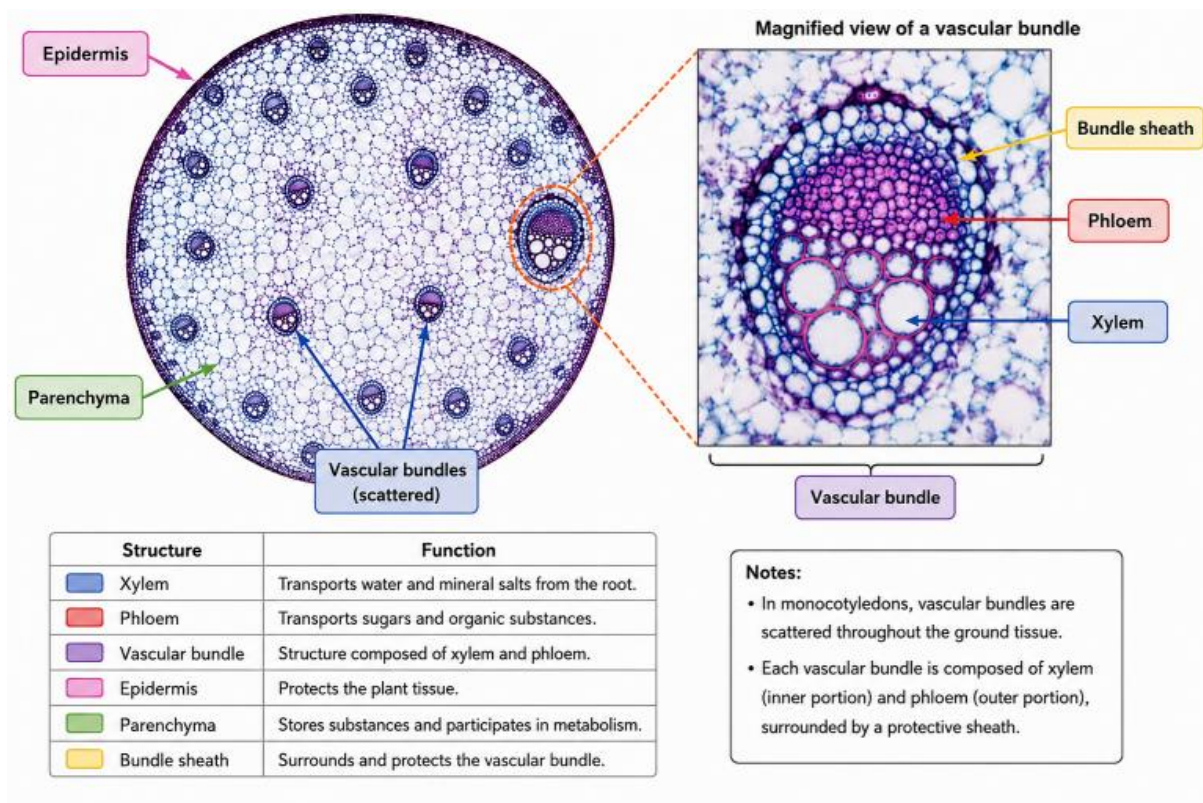
CONCLUSIONS

1. Monocotyledonous plants present scattered vascular bundles within the ground tissue.

2. Xylem and phloem fulfill essential functions in the transport of substances within the plant.
3. Histological stains facilitate the anatomical identification of plant tissues.
4. Microscopic observation constitutes a fundamental tool for plant anatomical studies.
5. Knowledge of vascular tissues is important in plant physiology and agricultural production.

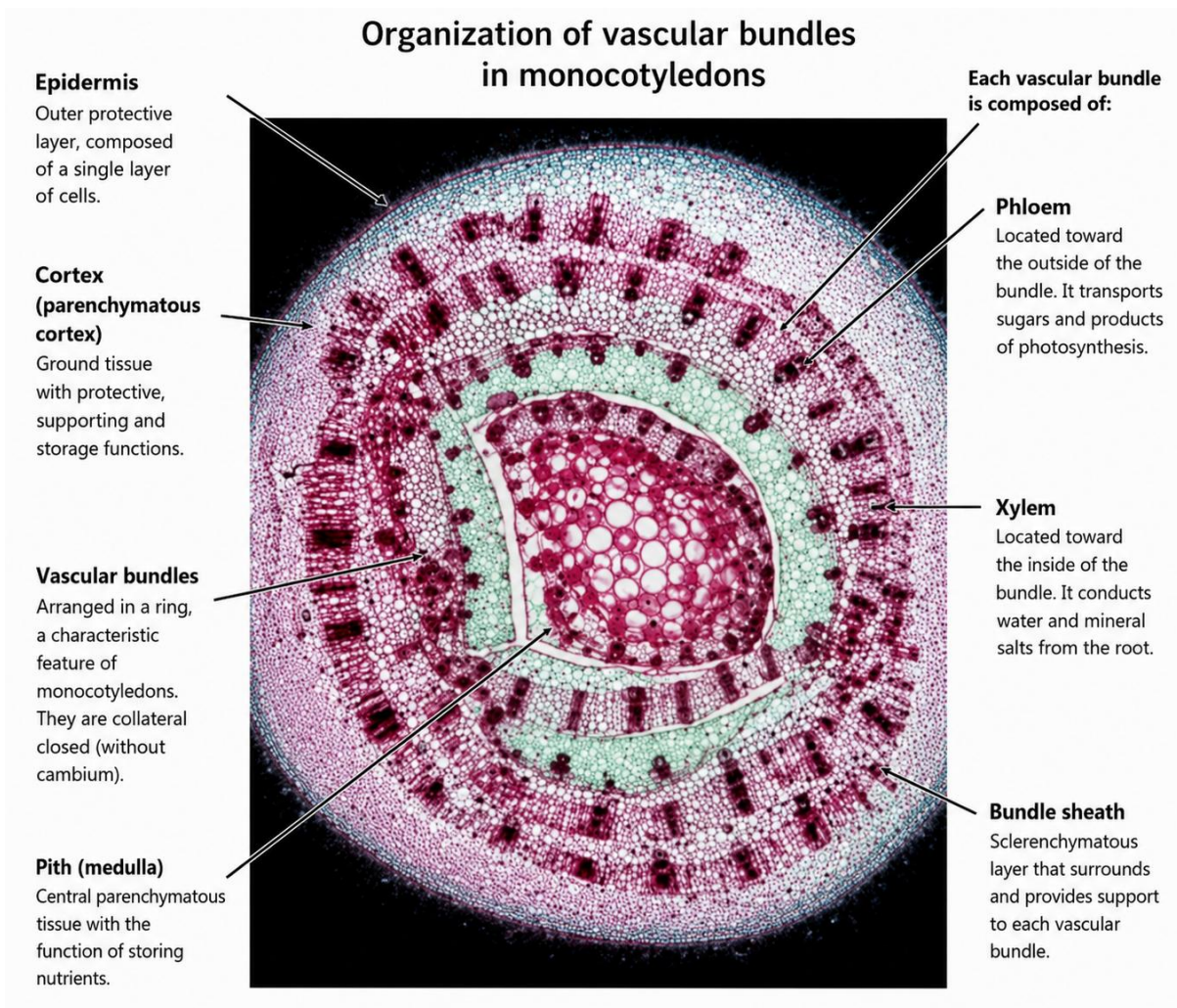
Reference images

Image 29.- Cross section of a monocotyledonous corn stem (*Zea mays L.*) observed under an optical microscope showing xylem, phloem, epidermis, parenchyma, and vascular bundle sheath



Source: (Mendoza, 2023)

Image 30.- Optical microscope view under 40X objective of a corn stem, through a cross section, in the Phytopathology Laboratory of the Agrarian University of Ecuador



Source: Authors, 2026

QUESTIONNAIRE

True or False

1. _____ Xylem transports water and mineral salts from the root to the aerial parts of the plant.
2. _____ Phloem is the tissue responsible for transporting organic substances produced during photosynthesis.
3. _____ In monocots, vascular bundles form continuous rings within the stem.
4. _____ Safranin and methylene blue help differentiate plant tissues during microscopic observation.
5. _____ Parenchyma is a tissue related to cellular storage and metabolism.
6. _____ Monocots present scattered vascular bundles within the ground tissue of the stem.
7. _____ Xylem is made up of small cells responsible exclusively for storage.
8. _____ The epidermis corresponds to the protective outer layer of the plant organ.
9. _____ Microscopic observation allows for the identification of structures such as xylem, phloem, and parenchyma.
10. _____ The use of the microscope is not important in plant anatomical studies.

ANSWERS

1. True
2. True
3. False
4. True
5. True
6. True
7. False
8. True
9. True
10. False

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LABORATORY PRACTICE 10

IDENTIFICATION OF VASCULAR TISSUES IN DICOTYLEDONOUS PLANTS

INTRODUCTION

Differentiated plant tissues are organized into three main systems that fulfill specific functions for growth, protection, and transport within the plant, such as: Dermal system: it is the tissue responsible for protecting the plant's surface against physical damage, water loss, and organism attacks. It consists of: epidermis: present in organs with primary growth. Periderm: replaces the epidermis in organs with secondary growth. The Ground system: constitutes most of the plant body and performs functions of photosynthesis, water and nutrient storage, and mechanical support. Furthermore, it forms the cortex when located between the dermal and vascular tissues, and the pith when located inside the vascular tissue. It is composed of: Parenchyma: storage and photosynthesis. Collenchyma: flexible support in young organs. Sclerenchyma: rigid support and mechanical resistance. And finally, the Vascular system: It is the system responsible for transporting water, minerals, and nutrient substances throughout the plant. It consists of: Xylem: conducts water and mineral salts from the root to the aerial parts. Phloem: transports sugars and other organic substances produced during photosynthesis (Alonso-Peña, 2011)

(Cayambe Cajo, 2022) Dicotyledonous plants possess two cotyledons in the embryo. Their leaves present branched or reticulated veins, flowers usually have floral parts in multiples of four or five, and their root system is taproot. The vascular bundles are arranged forming a ring in the stem, and the pollen generally has three or more pores or furrows.

The anatomical observation of vascular tissues allows for the understanding of plant physiological processes related to nutrition, transport, and structural development of agricultural crops of economic importance such as bean, tomato, cocoa, and sunflower.

GENERAL OBJECTIVE

To identify the vascular tissues of dicotyledonous plants through microscopic observation of plant sections.

SPECIFIC OBJECTIVES

1. To recognize the anatomical characteristics of xylem and phloem in dicotyledonous plants.
2. To differentiate the arrangement of vascular bundles present in dicotyledonous plant tissues.

LEARNING OUTCOMES

- Identifies vascular tissues through microscopic observation of dicotyledonous plant tissues.
- Relates the anatomical structure of dicots to their physiological functions and secondary growth.

METHODOLOGY AND TECHNIQUES

The lab practice is developed under an experimental-descriptive approach through microscopic observation of cross-sections of dicotyledonous stems and leaves.

The techniques used include:

- Preparation of plant sections.
- Histological staining.
- Microscopic observation.
- Anatomical identification of vascular tissues

PROCEDURE

PART A: OBTAINING THE PLANT SAMPLE

1. Select fresh samples of dicotyledonous plants such as bean, tomato, sunflower, or cocoa.
2. Make small cross-sections of the stem using a scalpel.

Dicots present vascular bundles organized in a circular shape around the pith.

PART B: PREPARATION OF PLANT SECTIONS

1. Make thin and uniform sections of the plant tissue.
2. Place the section on a clean slide.
3. Add a drop of distilled water or plant stain.
4. Carefully place the coverslip, avoiding the formation of bubbles.

The proper preparation of the sections facilitates the anatomical differentiation of conducting tissues.

PART C: STAINING OF TISSUES

1. Apply a drop of safranin or methylene blue onto the sample.
2. Wait between 1 and 2 minutes.
3. Remove excess stain with absorbent paper.

Histological stains allow for the visualization of lignified structures of the xylem and soft tissues of the phloem.

PART D: MICROSCOPIC OBSERVATION

1. Place the slide on the microscope stage.
2. Observe initially with the 4X objective.
3. Subsequently change to 10X and 40X to identify cellular structures.
4. Identify:
 - Xylem
 - Phloem
 - Vascular cambium
 - Pith
 - Epidermis
 - Parenchyma

Dicots present open vascular bundles due to the presence of vascular cambium between xylem and phloem (Evert & Eichhorn, 2023).

MATERIALS AND REAGENTS

Materials

- Optical microscope
- Slides
- Coverslips
- Scalpel
- Tweezers
- Dropper
- Absorbent paper

Plant material

- Bean stem
- Tomato stem
- Sunflower
- Cocoa

Reagents

- Distilled water
- Safranin
- Methylene blue

RESULTS AND OBSERVATIONS

During the lab practice, cross-sections of dicotyledonous stems with vascular bundles organized in a circular shape around the pith were observed.

Microscopically, the following were identified:

- Xylem

- Phloem
- Vascular cambium
- Pith
- Epidermis
- Cortical parenchyma

The xylem presented larger vessels and lignified walls intensely stained with safranin. The phloem showed smaller cells located towards the outer part of the vascular bundle.

The presence of vascular cambium between the xylem and phloem was clearly observed, a distinctive characteristic of dicots related to the secondary growth of the stem.

DRAWINGS, DIAGRAMS, AND DESCRIPTIONS

XYLEM

Conducting tissue responsible for transporting water and minerals from the root to aerial organs.

PHLOEM

Tissue responsible for transporting sugars and organic substances produced during photosynthesis.

VASCULAR CAMBIUM

Meristematic tissue responsible for secondary growth and the formation of new vascular tissues.

PITH

Central storage tissue present in the stem.

EPIDERMIS

Protective outer layer of the plant organ.

PARENCHYMA

Ground tissue responsible for storage and cellular metabolism.

The circular arrangement of vascular bundles constitutes a distinctive anatomical characteristic of dicots.

GENERAL OBSERVATIONS

The vascular tissues presented visible differences in organization and staining due to the structural composition of each tissue.

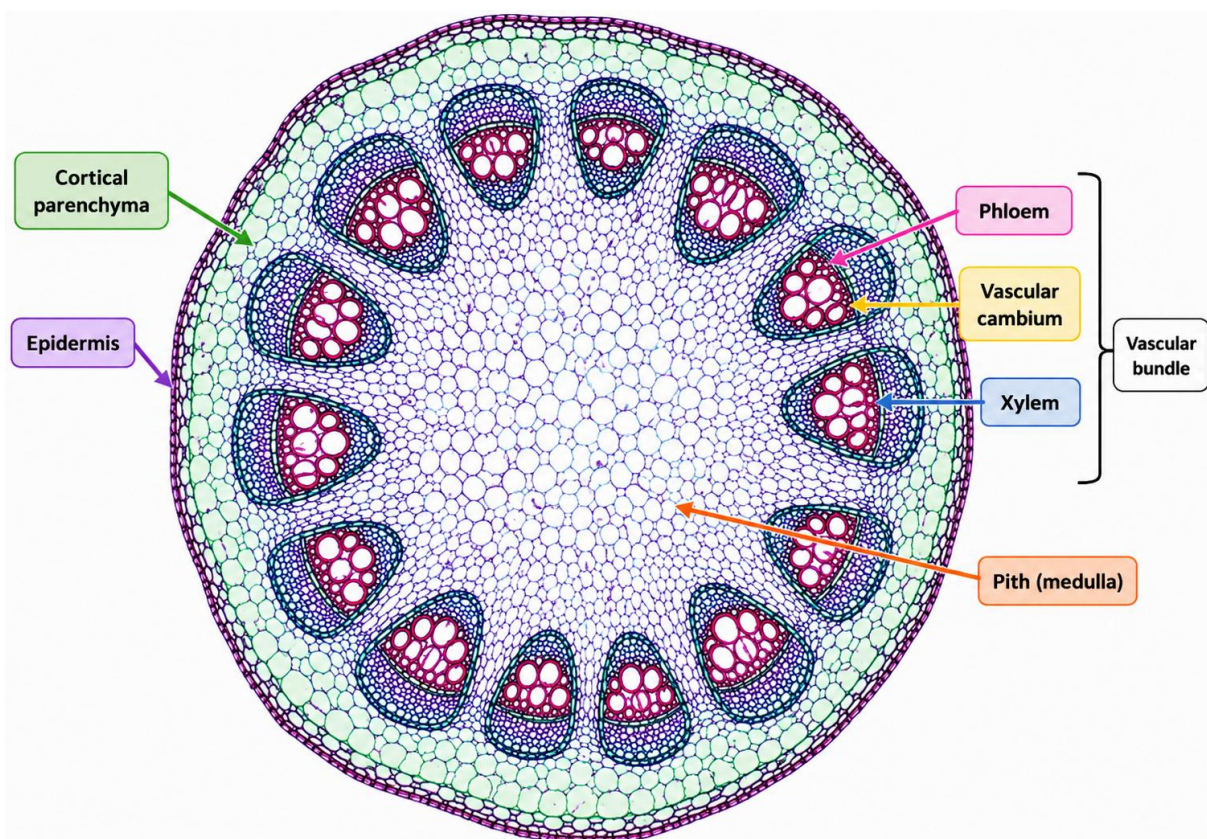
Microscopic observation allowed for the clear differentiation of the circular arrangement of vascular bundles and the presence of vascular cambium in dicotyledonous plants.

CONCLUSIONS

1. Dicotyledonous plants present vascular bundles organized in a circular shape around the pith.
2. Xylem and phloem fulfill fundamental functions in the transport of substances within the plant.
3. The vascular cambium constitutes a distinctive characteristic related to secondary growth.
4. Histological stains facilitate the anatomical identification of plant tissues.
5. Microscopic observation constitutes a fundamental tool in plant anatomical and physiological studies.

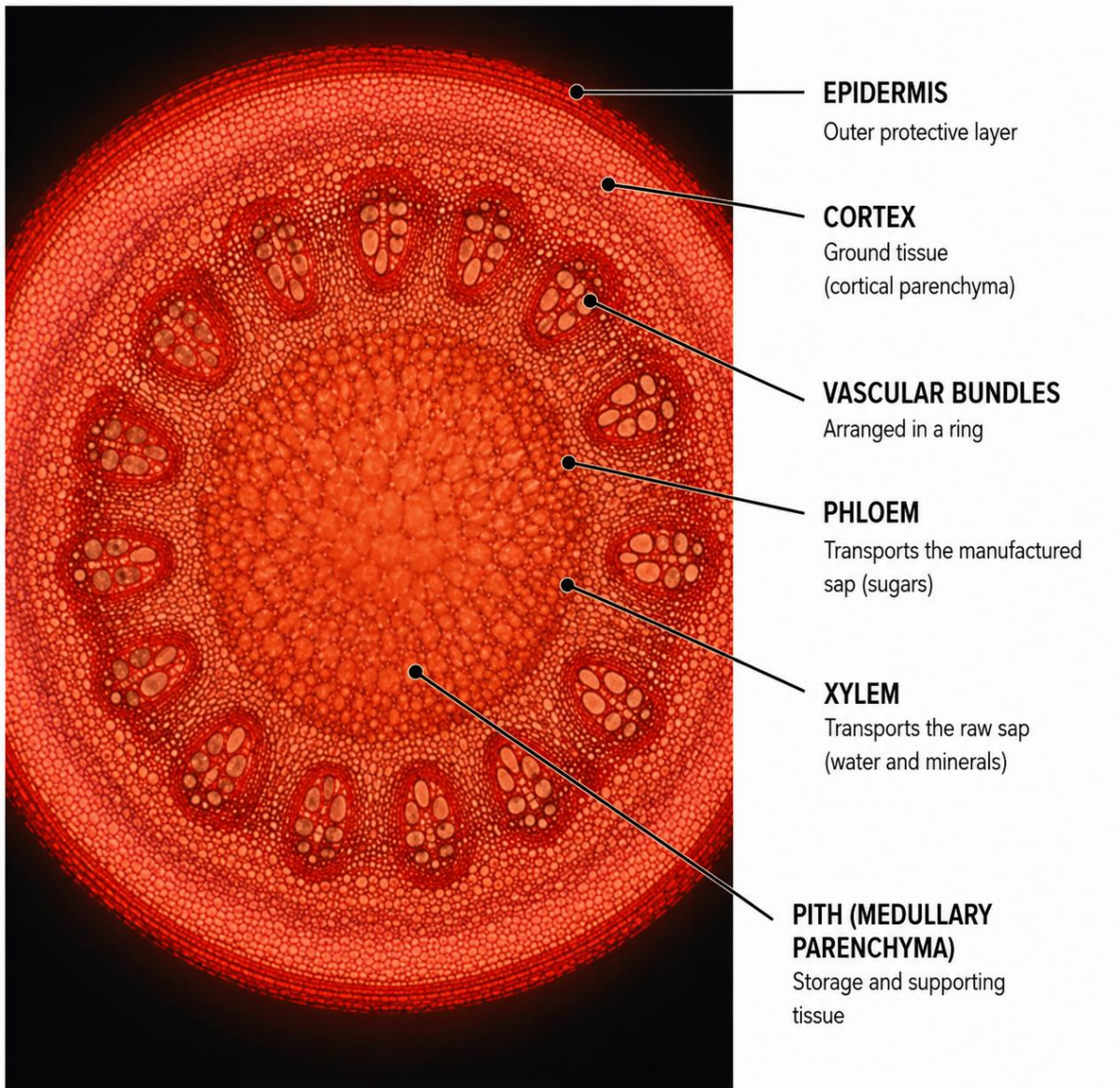
Reference images

Image 31.- Cross section of a stem of a dicotyledonous plant



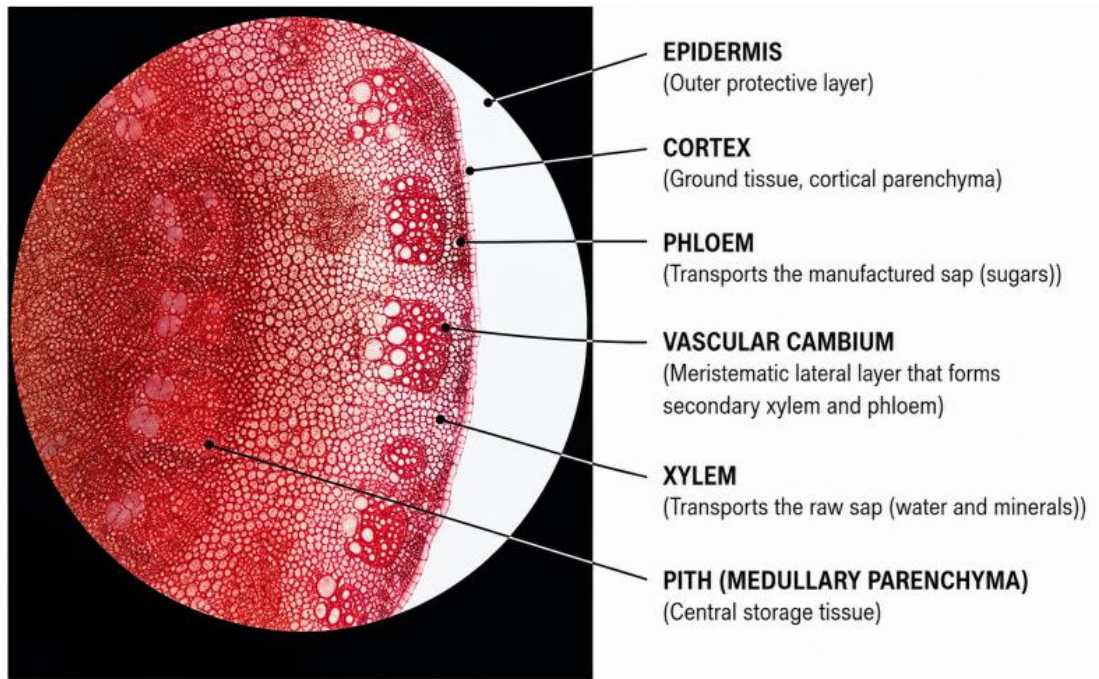
Source: (Numerade, 2022)

Image 32.- Through microscopic observation of a root portion, with cross sections of a mango plant, the epidermis, vascular bundles, and epidermis are observed



Elaborated: Authors, 2026

Image 33.- Through microscopic observation of a stem portion of a lime plant in the growth stage, cross sections were made where the epidermis, vascular bundles, and epidermis were observed



Elaborated: Authors, 2026

QUESTIONNAIRE

True or False

1. _____ Xylem transports water and mineral salts from the root to the leaves of the plant.
2. _____ Dicotyledonous plants present vascular bundles scattered irregularly within the stem.
3. _____ The vascular cambium participates in the secondary growth of dicots.
4. _____ Phloem transports sugars and organic substances produced during photosynthesis.
5. _____ The epidermis corresponds to the protective outer layer of the plant organ.
6. _____ Histological stains help differentiate plant structures during microscopic observation.
7. _____ Parenchyma is a tissue related to cellular storage and metabolism.
8. _____ Dicots present vascular bundles organized in a circular shape around the pith.
9. _____ The use of the microscope is not important in plant anatomical studies.
10. _____ The vascular cambium is located between the xylem and the phloem.

ANSWERS

1. True
2. False
3. True
4. True
5. True
6. True
7. True
8. True
9. False
10. True

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Alonso-Peña, J. (2011). *Manual de histología vegetal*. Madrid. Mexico: Ediciones Mundi-Prensa.

Cayambe Cajo, F. R. (2022). *Clasificación automática de plantas monocotiledóneas y dicotiledóneas usando minería de datos*. Cotopaxi, Ecuador: Universidad Técnica de Cotopaxi.

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LABORATORY PRACTICE 11

DISECTION OF FLOWERS OF MONOCOTYLEDONOUS PLANTS: IDENTIFICATION OF FEMALE AND MALE PARTS

INTRODUCTION

Monocots constitute an important group of angiosperms characterized by having a single cotyledon in the embryo, leaves with parallel veins, fasciculated roots, and scattered vascular bundles in the stem. One of their most distinctive features is that their flowers present floral parts generally organized in multiples of three, a trait of great utility for their taxonomic identification. Monocotyledonous flowers are the reproductive organs responsible for sexual reproduction. They are formed by clearly differentiated male and female structures. The androecium corresponds to the male part and is composed of the stamens, integrated by the filament and the anther, where pollen grains are produced and stored. Pollen contains the male gametes involved in fertilization.

The female part of the flower corresponds to the gynoecium or pistil, formed by the stigma, responsible for receiving the pollen; the style, which connects the stigma with the ovary; and the ovary, where the ovules are located, structures that will give rise to the seeds after fertilization.

During the floral dissection practice, the careful separation of the floral parts allows for the identification of each of these reproductive organs and the understanding of their function in the processes of pollination, fertilization, and the formation of fruits and seeds. Furthermore, the observation of flowers from species such as lily, onion, Madonna lily, or corn facilitates the recognition of the typical characteristics of monocots.

In conclusion, the study and dissection of monocotyledonous flowers allows for the correlation of floral morphology with the reproductive function of angiosperms, contributing to botanical identification and knowledge of one of the most important plant groups from an ecological and agricultural standpoint. (Gutierrez & Lucchetti, 2014)

GENERAL OBJECTIVE

To identify the female and male reproductive structures of monocotyledonous flowers through floral dissection techniques.

SPECIFIC OBJECTIVES

1. To recognize the main structures of the androecium and gynoecium in monocotyledonous flowers.

2. To differentiate male and female reproductive parts through direct observation and floral dissection.

LEARNING OUTCOMES

- Identifies the male and female reproductive structures present in monocotyledonous flowers.
- Relates floral morphology to the reproductive processes of monocotyledonous angiosperms.

METHODOLOGY AND TECHNIQUES

The lab practice is developed under an experimental-descriptive approach through macroscopic observation and dissection of fresh monocotyledonous flowers.

The techniques used include:

- Floral dissection.
- Macroscopic observation.
- Microscopic observation of pollen and reproductive structures.
- Floral anatomical identification.

PROCEDURE

PART A: SAMPLE SELECTION

1. Select fresh monocotyledonous flowers such as lily, onion, corn, or Madonna lily.
2. Place the flowers on clean trays or Petri dishes.

Monocots present flowers with floral parts generally organized in multiples of three.

PART B: EXTERNAL OBSERVATION

1. Observe the complete flower and identify:
 - Tepals or petals
 - Sepals
 - Floral peduncle
 - Number of floral parts
2. Record:
 - Color
 - Size
 - Shape
 - Floral symmetry

Floral morphology allows for the recognition of adaptations related to pollination and botanical classification.

PART C: FLORAL DISSECTION

1. Using tweezers and a scalpel, carefully separate the floral parts.
2. Identify the male structures:
 - Stamens
 - Filament
 - Anther
 - Pollen
3. Identify the female structures:
 - Stigma
 - Style
 - Ovary
 - Ovules
4. Place some structures on slides for microscopic observation.

Reproductive structures allow for the development of fertilization processes and seed formation.

PART D: MICROSCOPIC OBSERVATION

1. Place pollen grains on a slide.
2. Add a drop of distilled water or Lugol's iodine.
3. Carefully place the coverslip.
4. Observe with the 4X objective, subsequently 10X and 40X.

Microscopic observation allows for the visualization of pollen grains and plant reproductive structures.

MATERIALES Y REACTIVOS

Materials

- Optical microscope
- Slides
- Coverslips
- Petri dish
- Tweezers
- Scalpel
- Dissection needle
- Absorbent paper

Plant material

- Lily flowers
- Onion flowers
- Madonna lily

- Corn

Reagents

- Distilled water
- Lugol's iodine
- Methylene blue (optional)

RESULTS AND OBSERVATIONS

During the lab practice, monocotyledonous flowers with floral parts organized in multiples of three were observed. Male and female reproductive structures were clearly identified.

The main structures observed were:

- Stamens
- Filament
- Anther
- Pollen
- Stigma
- Style
- Ovary
- Ovules

Microscopically, pollen grains with spherical shapes and resistant walls were visualized. The ovary presented internal structures related to ovule formation.

The dissected flowers showed an organized arrangement of reproductive structures, a typical characteristic of monocotyledonous angiosperms.

DRAWINGS, DIAGRAMS, AND DESCRIPTIONS

STAMEN

Male reproductive organ responsible for producing pollen.

FILAMENT

Supporting structure of the anther.

ANTHER

Structure where pollen grains are produced and stored.

POLEN

Male reproductive structure containing male gametes.

STIGMA

Receptive surface for pollen.

STYLE

Duct connecting the stigma to the ovary.

OVARY

Structure containing the ovules.

OVULES

Female reproductive structures that give rise to seeds after fertilization.

Floral structures actively participate in plant sexual reproduction processes and fruit formation (Raven et al., 2021).

GENERAL OBSERVATIONS

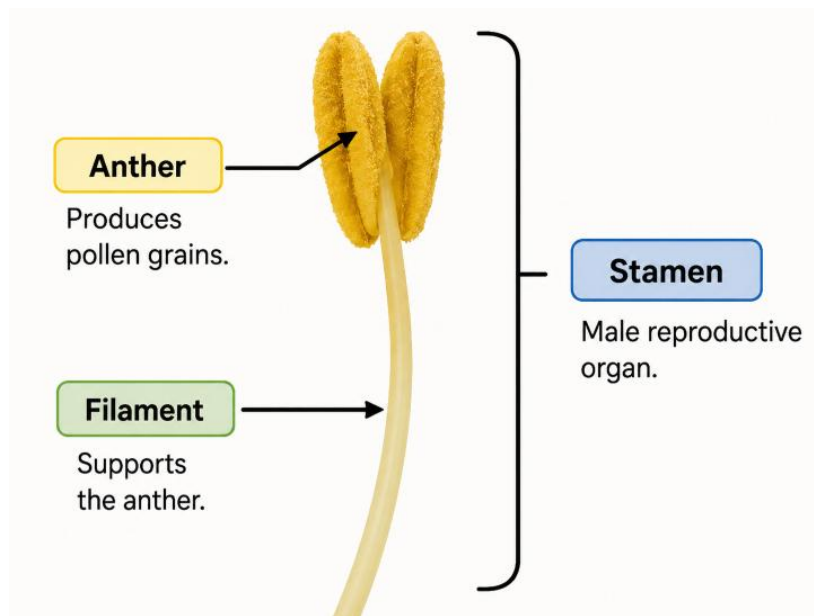
The monocotyledonous flowers presented a characteristic floral organization with parts in multiples of three and well-differentiated reproductive structures.

Floral dissection allowed for the clear identification of male and female organs, while microscopic observation facilitated the visualization of pollen grains.

CONCLUSIONS

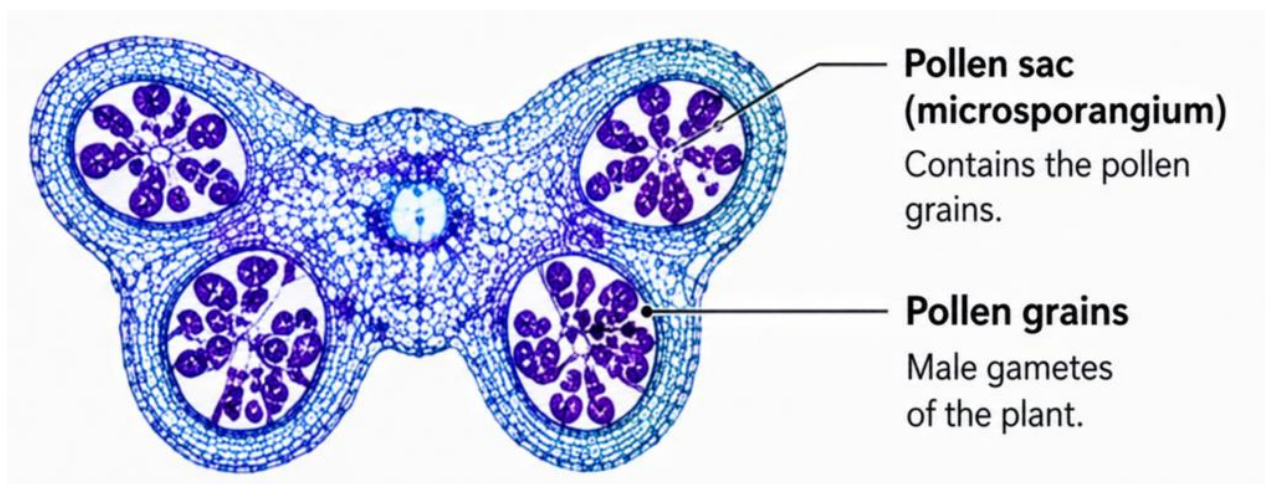
1. Monocotyledonous flowers present clearly differentiated male and female reproductive structures.
2. The androecium and gynoecium fulfill fundamental functions in plant sexual reproduction.
3. Floral dissection constitutes a useful technique for anatomical and taxonomic studies.
4. Microscopic observation allows for the visualization of reproductive structures such as pollen grains.
5. Floral study is important in botany, plant physiology, and agricultural production.

Reference images Image 34-Male structure (androecium)



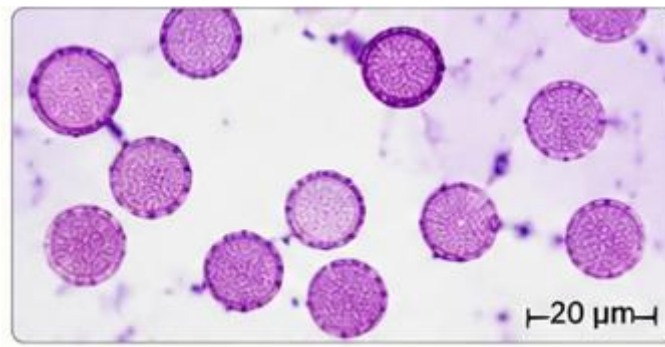
Source: (Torres & Villalobos, 2016)

Image 35.- Cross section of the anther



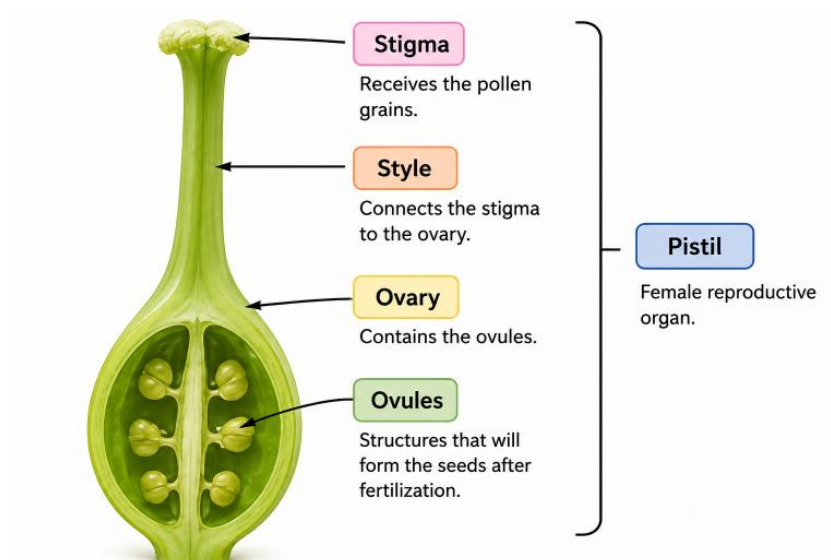
Source: (Torres & Villalobos, 2016)

Image 36.- Microscopic view of pollen grains



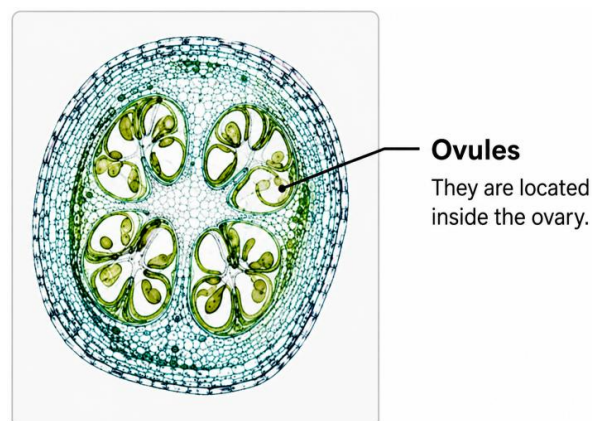
Source: (Torres & Villalobos, 2016)

Image 37.- Female structure (gynoecium)



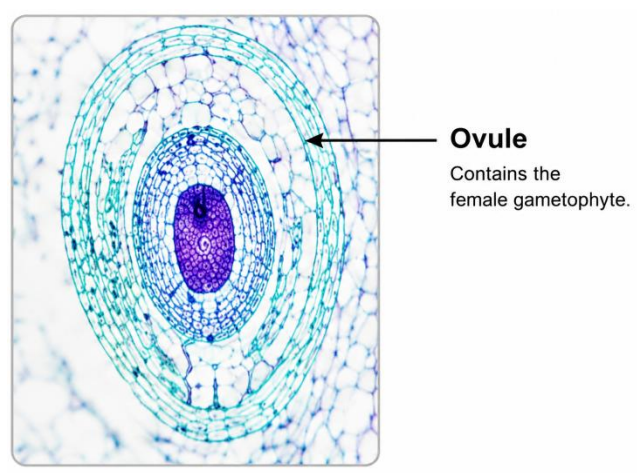
Source: (Torres & Villalobos, 2016)

Image 38.-Cross section of the ovary



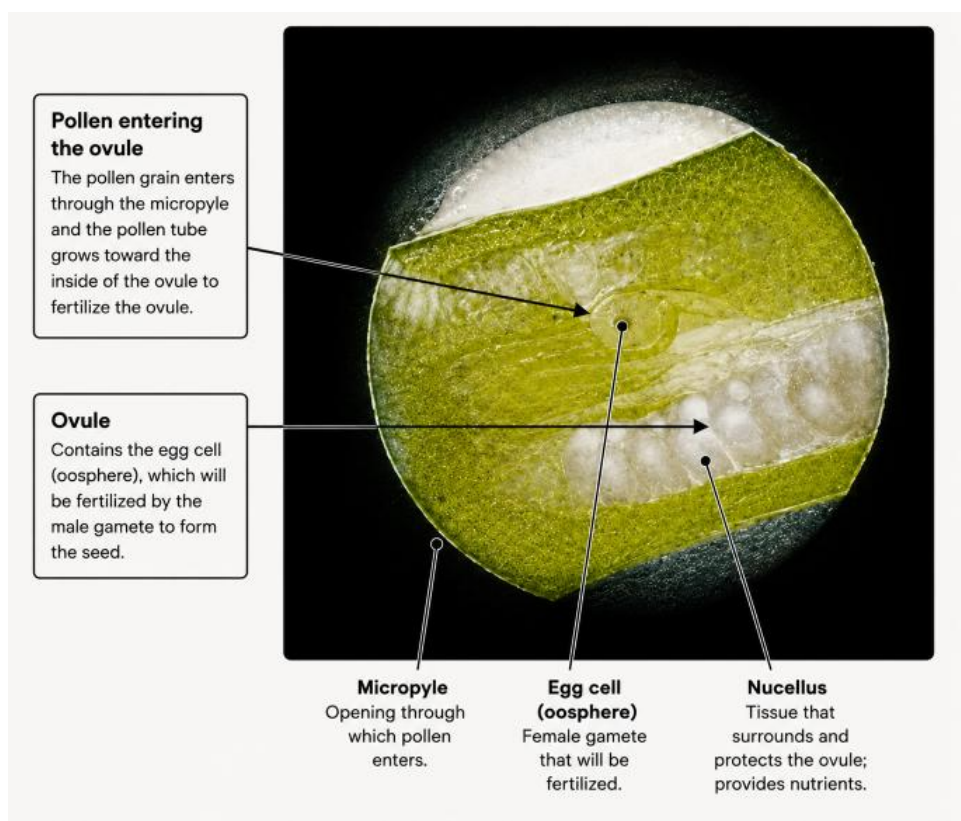
Source: (Torres & Villalobos, 2016)

Image 39.- Microscopic view of an ovule



Source: (Torres & Villalobos, 2016)

Image 40.- Microscopic view of the female reproductive system.



Source: Autores, 2026

QUESTIONNAIRE

True or False

1. _____ Monocotyledonous flowers present floral parts generally organized in multiples of three.
2. _____ The androecium corresponds to the female reproductive structure of the flower.
3. _____ The anther is the structure where pollen is produced and stored.
4. _____ The ovary contains the ovules that will give rise to seeds after fertilization.
5. _____ The stigma is the receptive surface for pollen.
6. _____ Microscopic observation allows for the visualization of pollen grains and plant reproductive structures.
7. _____ The filament supports the anther within the stamen.
8. _____ Monocotyledonous flowers do not possess differentiated reproductive structures.
9. _____ Floral dissection helps in anatomical and taxonomic studies of plants.
10. _____ Pollen contains male gametes related to plant reproduction.

ANSWERS

1. True
2. False
3. True
4. True
5. True
6. True
7. True
8. False
9. True
10. True

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LABORATORY PRACTICE 12

CHARACTERIZATION AND IDENTIFICATION OF NON-VASCULAR PLANTS (MOSESSES)

INTRODUCTION

Mosses belong to the bryophyte group, non-vascular plants that lack specialized conducting tissues such as xylem and phloem. Due to this characteristic, they largely depend on environmental humidity to perform their vital functions. Bryophytes inhabit a wide variety of ecosystems, from humid forests and rainforests to deserts and mountainous areas, where they play important ecological roles.

General characteristics of mosses

- They are non-vascular plants, so water transport occurs mainly by diffusion.
- They do not present true roots; they possess rhizoids, structures that allow them to attach to the substrate.
- Their size is usually small, and they grow forming colonies or mats on soil, rocks, trunks, and other substrates.
- They require humid environments to complete their reproductive cycle.
- Their dominant phase is the gametophyte, which corresponds to the observable green plant.

Bryophytes are frequent in environments where water is available. In forests and rainforests, they can grow on trunks, branches, rocks, and damp soil. They are also capable of colonizing extreme environments such as deserts, where they develop adaptations to resist desiccation.

Furthermore, mosses are considered pioneer organisms, as they are usually among the first to establish themselves on newly exposed or disturbed surfaces, subsequently favoring the establishment of other plant species.

Mosses fulfill various functions in ecosystems:

- They contribute to soil formation and conservation.
- They retain water and help maintain environmental humidity.
- They participate in successional processes by colonizing new substrates.
- They serve as a microhabitat for small invertebrates.
- Some species act as environmental bioindicators, due to their ability to accumulate metals and other elements present in the environment.

Bryophytes maintain interactions with numerous organisms:

- They associate with bacteria that can favor their growth.

- They produce chemical substances that inhibit the development of microorganisms and other plants, a phenomenon known as allelopathy.
- They constitute a refuge and food source for various arthropods, such as mites, insects, and spiders.

Reproduction and dispersal occur mainly through spores, which are transported by the wind. They can also disperse by the action of water or through animals that accidentally transport spores to new sites.

For a spore to germinate successfully, it must find suitable conditions of:

- Moisture.
- Temperature.
- Light (photoperiod).
- Favorable substrate.

Aspects to observe during the lab practice

During the characterization and identification of mosses, it is recommended to recognize:

1. Type of substrate where it grows (soil, rock, trunk).
2. Presence of rhizoids.
3. Structure of the gametophyte (stem and simple leaves).
4. Presence of the sporophyte:
 - Seta.
 - Sporangial capsule.
5. Coloration and growth form.
6. Moisture status of the habitat.

Mosses are non-vascular plants of great ecological importance due to their ability to colonize diverse environments, participate in soil formation, retain moisture, and serve as environmental indicators. Their study allows for a better understanding of the evolution of land plants and the adaptations necessary to survive in different ecological conditions. (Delgadillo & Cárdenas, 1990)

GENERAL OBJECTIVE

To characterize and identify non-vascular plants (mosses) through macroscopic and microscopic observation of their vegetative and reproductive structures.

SPECIFIC OBJECTIVES

1. To identify the main morphological structures present in mosses.
2. To differentiate vegetative and reproductive structures of non-vascular plants.

LEARNING OUTCOMES

- Recognizes the anatomical and morphological characteristics of mosses through direct observation.
- Relates the structure of non-vascular plants to their ecological adaptations.

METHODOLOGY AND TECHNIQUES

The lab practice is developed under an experimental-descriptive approach through macroscopic and microscopic observation of moss samples collected in humid environments.

The techniques used include:

- Collection of plant samples.
- Macroscopic observation.
- Microscopic preparation.
- Morphological and anatomical identification of vegetative and reproductive structures.

PROCEDURE

PART A: SAMPLE COLLECTION

1. Collect samples of mosses present on rocks, damp trunks, walls, or soil.
2. Place the samples in clean, damp containers to prevent dehydration.
3. Label the samples indicating the place and date of collection.

Mosses grow preferentially in humid environments due to the absence of specialized conducting tissues.

PART B: MACROSCOPIC OBSERVATION

1. Place the samples on a Petri dish or observation tray.
2. Identify:
 - Cauloids
 - Phylloids
 - Rhizoids
 - Sporangial capsules
 - Sporophyte
3. Record:
 - Color
 - Size
 - Shape
 - Growth type

The observed structures allow for the differentiation of phases in the biological cycle of mosses.

PART C: MICROSCOPIC PREPARATION

1. Take a small portion of phylloids or sporangial capsules.
2. Place the sample on a slide.
3. Add a drop of distilled water or Lugol's iodine.
4. Carefully place the coverslip.
5. Observe initially with the 4X objective and subsequently at 10X and 40X.

Microscopic observation allows for the visualization of plant cells, spores, and simple tissues present in mosses.

PART D: OBSERVATION AND IDENTIFICATION

1. Identify vegetative structures:
 - Phylloids
 - Cauloids
 - Rhizoids
2. Identify reproductive structures:
 - Capsule
 - Seta
 - Spores
3. Compare the observed structures with reference images and taxonomic keys.

Mosses present alternation of generations with a predominance of the haploid gametophyte.

MATERIALS AND REAGENTS

- Materials
- Optical microscope
- Slides
- Coverslips
- Petri dish
- Tweezers
- Dropper
- Dissection needle
- Absorbent paper

Biological material

- Fresh moss samples

Reagents

- Distilled water
- Lugol's iodine

- Methylene blue (optional)

RESULTS AND OBSERVATIONS

During the lab practice, mosses with compact growth on humid surfaces were observed. Vegetative and reproductive structures characteristic of non-vascular plants were clearly identified.

The main structures observed were:

- Phylloids
- Cauloids
- Rhizoids
- Sporangial capsules
- Sporophyte
- Spores

Microscopically, simple plant cells and spores present within the reproductive capsules were visualized. An absence of true vascular tissues such as xylem and phloem was observed.

The sporangial capsules presented structures related to spore dispersal, while the rhizoids allowed for attachment to the substrate.

DRAWINGS, DIAGRAMS, AND DESCRIPTIONS

PHYLLOIDS

Leaf-like structures responsible for photosynthesis.

CAULOIDS

Stem-like structures that support the phylloids.

RHIZOIDS

Filaments that attach the moss to the substrate and help in water absorption.

SPOROPHYTE

Diploid reproductive structure formed by a seta and a capsule.

SPORANGIAL CAPSULE

Structure where spores are produced and stored.

SPORES

Reproductive cells responsible for dispersal and reproduction.

The reproductive structures of mosses allow for adaptation and survival in humid terrestrial environments.

GENERAL OBSERVATIONS

The mosses presented growth associated with humid and shaded environments. It was observed that the vegetative structures possess a simple organization and an absence of true conducting tissues.

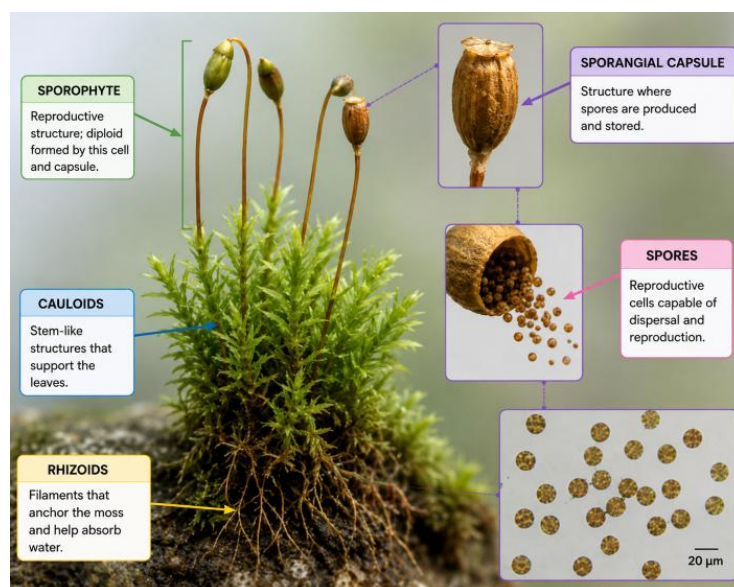
Microscopic observation allowed for the visualization of spores and cellular structures related to reproduction and dispersal.

CONCLUSIONS

1. Mosses are non-vascular plants that present simple structures adapted to humid environments.
2. The absence of xylem and phloem differentiates bryophytes from vascular plants.
3. Vegetative and reproductive structures allow for the identification of phases in the biological cycle of mosses.
4. Microscopic observation facilitates the recognition of spores and plant cellular structures.
5. Mosses possess great ecological importance due to their participation in moisture retention and soil formation.

Reference images

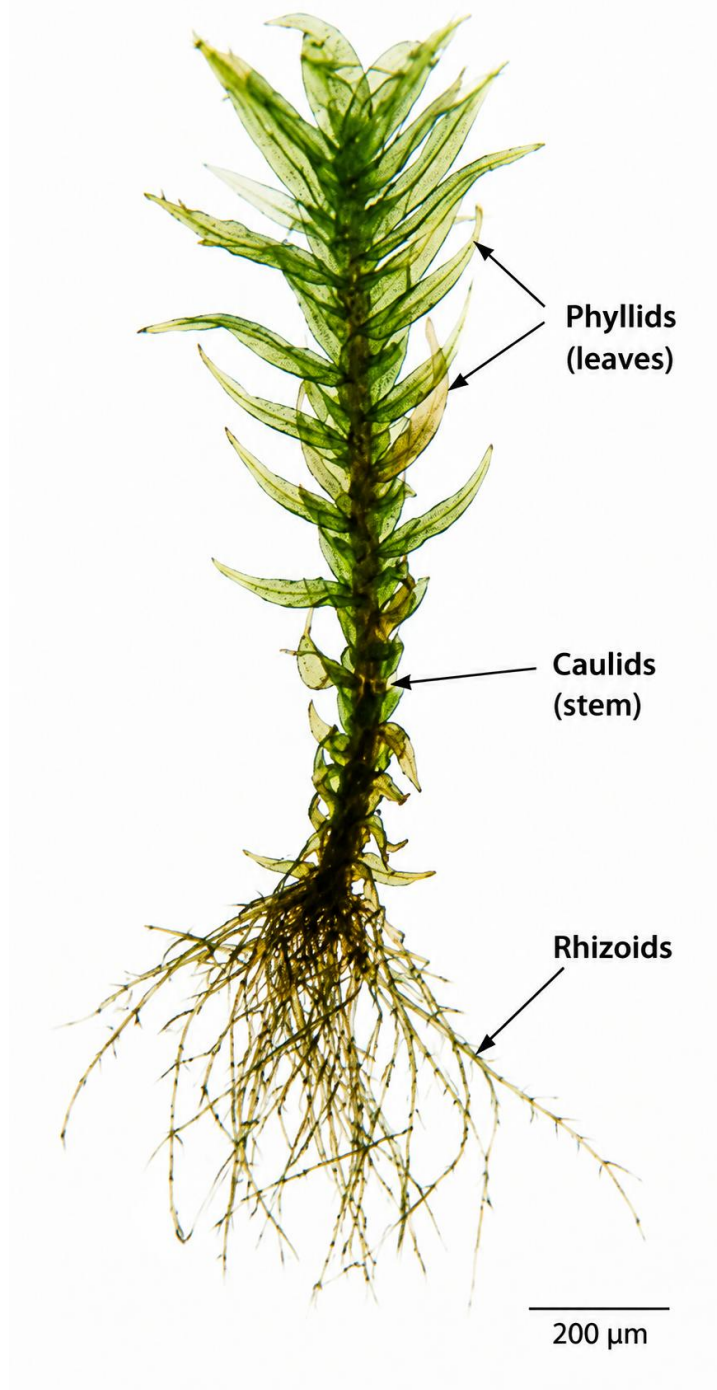
Image 41.- Structure of mosses (non-vascular plants)



Source: (Torres & Villalobos, 2016)

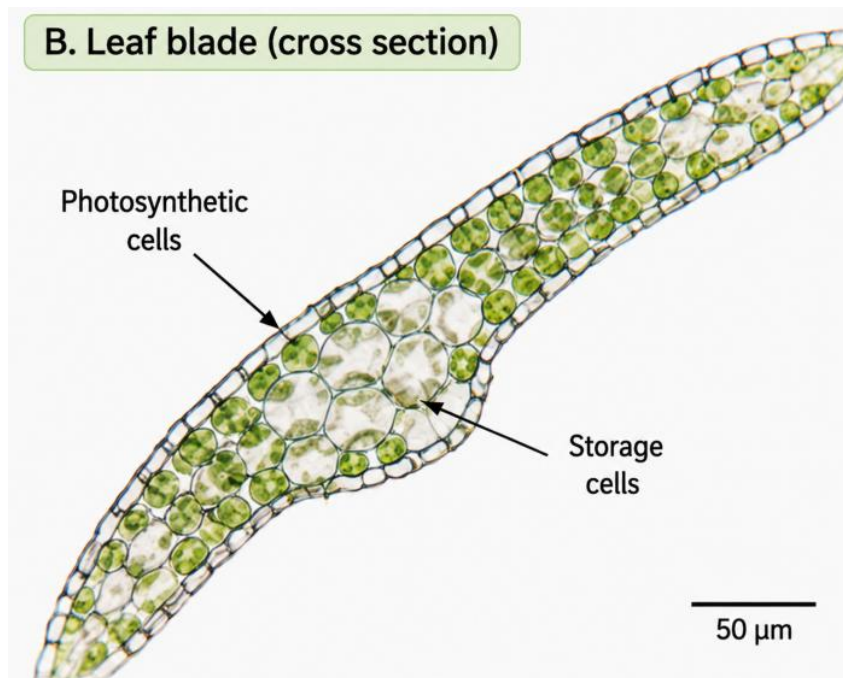
Image 42.- Moss viewed under an optical microscope

A. General view of the gametophyte



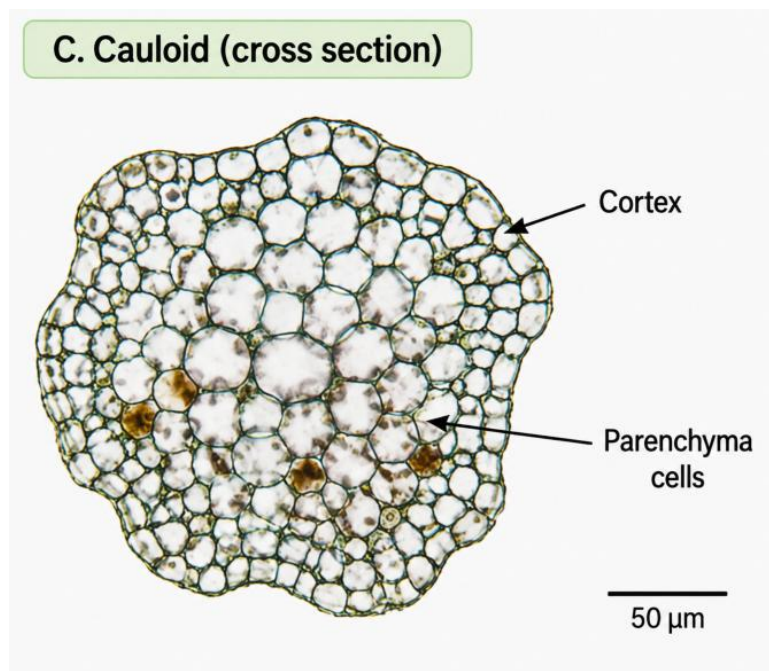
Source: (Shaw, 2022)

Image 43.- Moss viewed under an optical microscope



Source: (Shaw,2022)

Image 44.- Moss viewed under an optical microscope



Source: (Shaw, 2022)

Image 45.- Moss viewed under an optical microscope

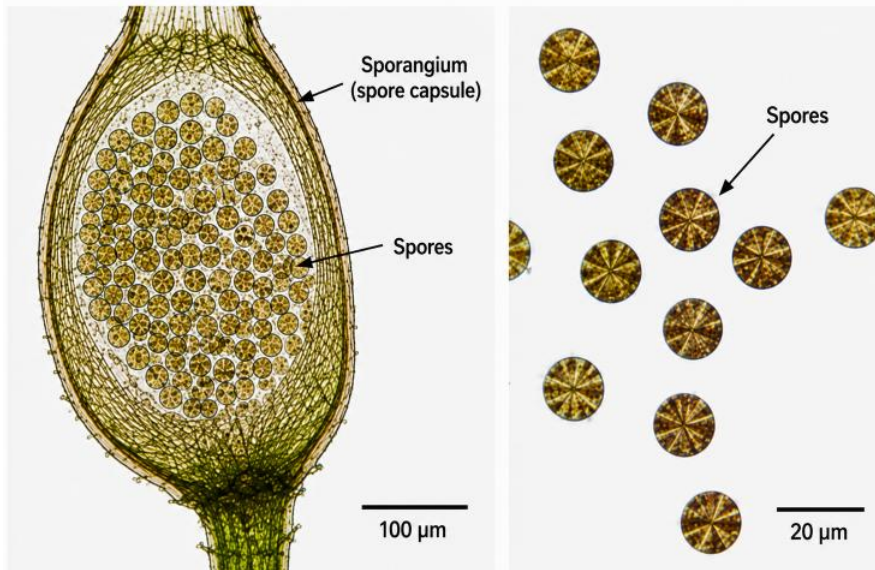
D. Rhizoids



Source: (Shaw, 2022)

Image 46.- Moss viewed under an optical microscope

E. Sporangium (spore capsule) and spores



Source: (Shaw, 2022)

QUESTIONNAIRE

True or False

1. _____ Mosses are non-vascular plants that lack true xylem and phloem.
2. _____ Phylloids perform functions similar to leaves in mosses.
3. _____ Rhizoids are structures responsible for producing seeds in mosses.
4. _____ Mosses grow preferentially in humid and shaded environments.
5. _____ The sporophyte corresponds to a reproductive structure formed by a seta and a capsule.
6. _____ Sporangial capsules store and produce spores.
7. _____ Mosses possess highly developed vascular tissues.
8. _____ Microscopic observation allows for the visualization of plant cells and spores present in mosses.
9. _____ Cauloids are stem-like structures that support the phylloids.
10. _____ Spores participate in the dispersal and reproduction processes of mosses.

ANSWERS

1. True
2. True
3. False
4. True
5. True
6. True
7. False
8. True
9. True
10. True

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Delgadillo, C., & Cárdenas, M. (1990). *Manual de Briofitas*. Mexico: Universidad Nacional Autonoma de Mexico.

Shaw, A. (2022). *Bryophyte Biology*. Cambridge, Reino Unido: Cambridge University .

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LABORATORY PRACTICE 13

CHARACTERIZATION AND IDENTIFICATION OF NON-VASCULAR PLANTS (LIVERWORTS)

INTRODUCTION

Liverworts are plants belonging to the bryophyte group, non-vascular organisms that lack specialized conducting tissues such as xylem and phloem. Due to this characteristic, they depend on environments with sufficient moisture to perform their physiological functions and complete their life cycle. Liverworts represent one of the oldest groups of land plants and constitute an important component of humid ecosystems, where they participate in fundamental ecological processes.

Liverworts present a simple structural organization and can be found in the form of flattened thalli or with a leafy appearance. Like other bryophytes, they do not possess true roots, stems, or leaves, but rather simple structures adapted for water absorption and attachment to the substrate.

Their main characteristics are:

- They are non-vascular plants.
- They lack true roots and present unicellular rhizoids.
- The gametophyte constitutes the dominant phase of the life cycle.
- They mainly inhabit humid and shaded environments.
- They reproduce through spores and also by vegetative reproduction.
- They present high sensitivity to environmental changes and desiccation.

Liverworts present sexual and asexual reproduction.

Sexual reproduction: It is carried out through reproductive structures that produce male and female gametes. Fertilization requires the presence of water to allow the displacement of male gametes toward the female ones.

Asexual reproduction: Many liverworts produce gemmae or propagules, small structures capable of giving rise to new individuals without the need for fertilization.

Dispersal: Dispersal occurs mainly through:

- Spores transported by the wind.
- Rainwater.
- Thallus fragmentation.
- Vegetative gemmae.

For spores to germinate successfully, suitable conditions of moisture, temperature, and substrate are required.

During the characterization and identification of liverworts, it is recommended to observe:

1. Growth type (thalloid or leafy).
2. Shape and coloration of the gametophyte.
3. Presence of rhizoids.
4. Type of substrate where it develops.
5. Visible reproductive structures.
6. Presence of gemmae or gemma cups.
7. Relationship with environmental moisture.

Liverworts are non-vascular plants of great ecological importance that contribute to moisture conservation, soil formation, and the colonization of new environments. Their study allows for an understanding of the early evolution of land plants, as well as the adaptations they have developed to survive in humid environments. The characterization and identification of these species provides fundamental tools for the knowledge of plant biodiversity and the functioning of ecosystems (Delgadillo & Cárdenas, 1990)

GENERAL OBJECTIVE

To characterize and identify non-vascular plants (liverworts) through macroscopic and microscopic observation of their vegetative and reproductive structures.

SPECIFIC OBJECTIVES

1. To identify the main morphological structures present in liverworts.
2. To differentiate vegetative and reproductive structures of liverwort plants.

LEARNING OUTCOMES

- Recognizes the vegetative and reproductive structures present in liverworts through direct observation.
- Relates the anatomical characteristics of liverworts to their ecological and evolutionary adaptations.

METHODOLOGY AND TECHNIQUES

The lab practice is developed under an experimental-descriptive approach through macroscopic and microscopic observation of liverwort samples collected in humid environments.

- The techniques used include:
- Collection of plant samples.
- Macroscopic observation.
- Microscopic preparation.

- Morphological and anatomical identification of vegetative and reproductive structures.

PROCEDURE

PART A: SAMPLE COLLECTION

1. Collect samples of liverworts present on damp rocks, trunks, soil, or walls with moisture.
2. Place the samples in clean, damp containers to prevent dehydration.
3. Label the samples indicating the place and date of collection.

Liverworts require humid environments due to the absence of specialized vascular tissues.

PART B: MACROSCOPIC OBSERVATION

1. Place the samples on a Petri dish or observation tray.
2. Identify:
 - Thallus
 - Rhizoids
 - Gemma cups
 - Reproductive structures
 - Sporophyte
3. Record:
 - Color
 - Shape
 - Growth type
 - Size

Thalloid liverworts present flattened structures with characteristic dichotomous branching.

PART C: MICROSCOPIC PREPARATION

1. Take a small portion of the thallus or reproductive structures.
2. Place the sample on a slide.
3. Add a drop of distilled water or Lugol's iodine.
4. Carefully place the coverslip.
5. Observe initially with the 4X objective and subsequently at 10X and 40X.

Microscopic observation allows for the visualization of simple plant cells and reproductive structures present in liverworts.

PART D: OBSERVATION AND IDENTIFICATION

1. Identify vegetative structures:

- Thallus
 - Rhizoids
 - Air chambers
2. Identify reproductive structures:
- Antheridia
 - Archegonia
 - Sporangia
 - Spores
3. Compare the observed structures with reference images and taxonomic keys.

Liverworts present alternation of generations with a predominance of the haploid gametophyte.

MATERIALS AND REAGENTS

Materials

- Optical microscope
- Slides
- Coverslips
- Petri dish
- Tweezers
- Dissection needle
- Dropper
- Absorbent paper

Biological material

- Fresh liverwort samples

Reagents

- Distilled water
- Lugol's iodine
- Methylene blue (optional)

RESULTS AND OBSERVATIONS

During the lab practice, liverworts growing on humid and shaded surfaces were observed. Simple vegetative structures with a characteristic thalloid organization were identified.

The main structures observed were:

- Thallus
- Rhizoids
- Air chambers

- Antheridia
- Archegonia
- Sporangia
- Spores

Microscopically, simple plant cells organized in simple tissues and reproductive structures related to gamete and spore production were visualized. An absence of true vascular tissues such as xylem and phloem was observed.

The reproductive structures presented adaptations related to sexual reproduction and spore dispersal in humid environments.

DRAWINGS, DIAGRAMS, AND DESCRIPTIONS

THALLUS

Flattened vegetative structure where photosynthetic processes occur.

RHIZOIDS

Filaments responsible for attachment to the substrate and water absorption.

AIR CHAMBERS

Internal spaces related to gas exchange.

ANTHERIDIA

Male reproductive organs that produce antherozoids.

ARCHEGONIA

Female reproductive organs where the oosphere is produced.

SPORANGIUM

Structure where spores are produced and stored.

SPORES

Reproductive cells responsible for dispersal and reproduction.

The reproductive structures of liverworts represent primitive adaptations of land plants.

GENERAL OBSERVATIONS

The liverworts presented growth associated with humid and shaded environments. Simple plant organization and an absence of true conducting tissues were observed.

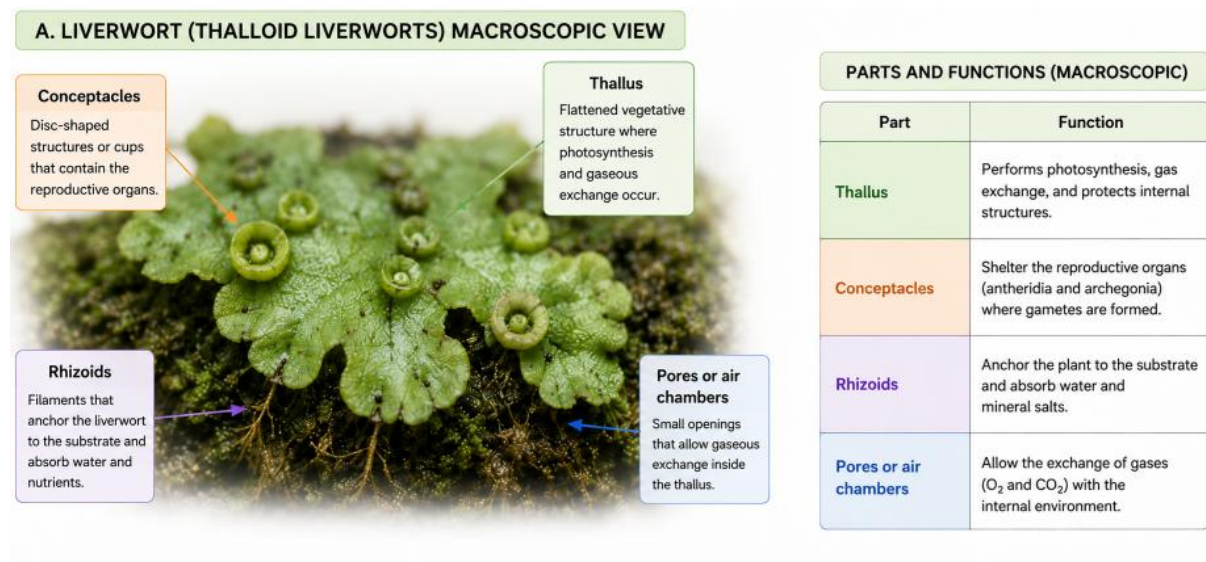
Microscopic observation allowed for the identification of reproductive structures and plant cells related to reproductive and physiological processes.

CONCLUSIONS

1. Liverworts are non-vascular plants adapted to humid environments.
2. The absence of conducting tissues differentiates liverworts from higher vascular plants.
3. Vegetative and reproductive structures allow for the identification of taxonomic characteristics of liverworts.
4. Microscopic observation facilitates the recognition of reproductive and cellular structures.
5. Liverworts possess great ecological importance due to their participation in moisture retention and the colonization of terrestrial environments.

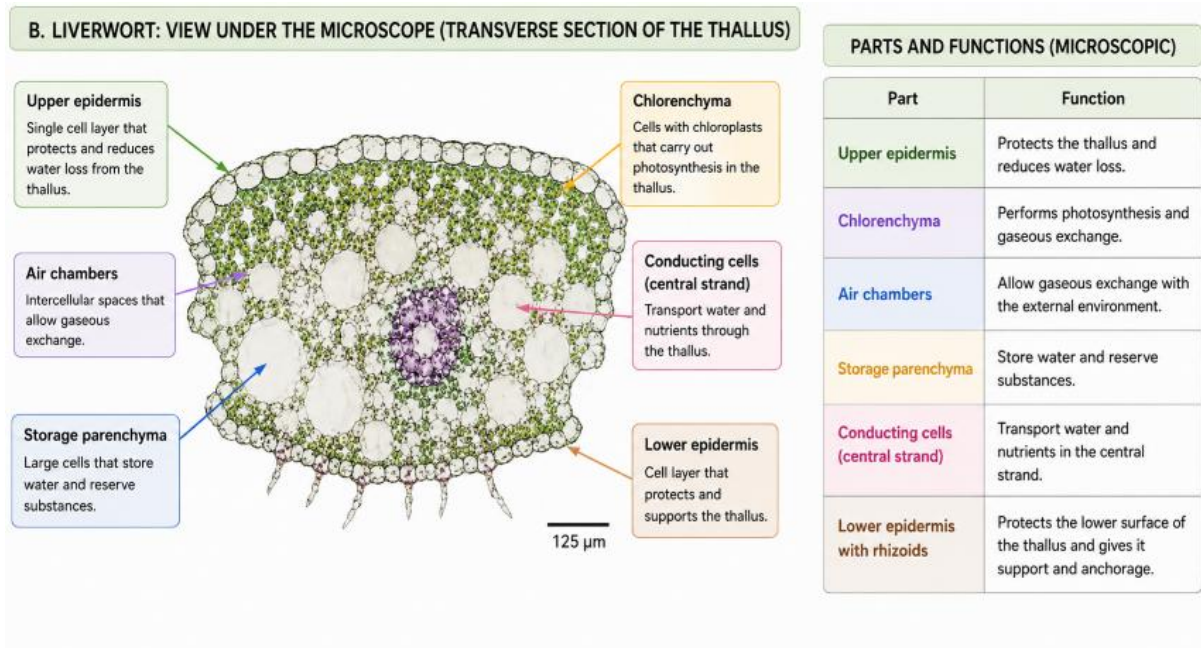
Reference images

Image 47.- Parts of a Bryophyte



Source: (Shaw, 2022)

Image 48.- Parts of a bryophyte viewed under an optical microscope



Source: (Shaw, 2022)

QUESTIONNAIRE

True or False

1. _____ Liverworts are non-vascular plants that lack true xylem and phloem.
2. _____ Thalloid liverworts present a flattened vegetative body called a thallus.
3. _____ Rhizoids are structures responsible for producing seeds in liverworts.
4. _____ Antheridia are male reproductive organs that produce antherozoids.
5. _____ Archegonia correspond to female reproductive organs where the oosphere is produced.
6. _____ Liverworts grow mainly in dry and arid environments.
7. _____ Air chambers participate in gas exchange in liverworts.
8. _____ Liverworts present alternation of generations with a predominance of the haploid gametophyte.
9. _____ Microscopic observation allows for the identification of reproductive structures and plant cells in liverworts.
10. _____ Spores participate in the dispersal and reproduction processes of liverworts.

ANSWERS

1. True
2. True
3. False
4. True
5. True
6. False
7. True
8. True
9. True
10. True

Bibliography

Delgadillo, C., & Cárdenas, M. (1990). *Manual de Briofitas*. Mexico: Universidad Nacional Autónoma de México.

Shaw, A. (2022). *Bryophyte Biology*. Cambridge, Reino Unido: Cambridge University .

LABORATORY PRACTICE 14

CHARACTERIZATION AND IDENTIFICATION OF NON-VASCULAR PLANTS (HORNWORTS)

INTRODUCTION

Hornworts (Division Anthocerotophyta) are non-vascular plants belonging to the bryophyte group. They are characterized by lacking specialized conducting tissues (xylem and phloem), meaning they depend on humid environments for their growth, reproduction, and dispersal. Like other bryophytes, they are usually found on damp soil, rocks, tree trunks, and shaded areas where the water supply is constant. Bryophytes are pioneer organisms capable of colonizing recently disturbed environments, actively participating in ecological succession processes. These plants contribute to soil formation, moisture retention, and the establishment of other plant species.

Hornworts present a dominant gametophyte with a thalloid, flat appearance, generally dark green in color. Their most distinctive characteristic is the presence of an elongated and cylindrical sporophyte, resembling a horn, from which their common name derives. This sporophyte emerges from the gametophyte and produces numerous spores that will be dispersed by the wind when they reach maturity.

From an ecological standpoint, bryophytes play fundamental roles in ecosystems. They help conserve soil moisture, reduce erosion, participate in nutrient recycling, and serve as a microhabitat for various organisms. Furthermore, some species can act as bioindicators of environmental pollution due to their sensitivity to changes in environmental conditions.

The reproduction of hornworts depends on water. The male antherozoids require a film of water to travel to the female archegonia and achieve fertilization. Subsequently, the sporophyte develops, which will produce spores responsible for dispersal and the formation of new individuals.

Diagnostic characteristics of hornworts:

Characteristic	Description
Plant group	Bryophytes (non-vascular plants)
Conducting tissues	Absent

Dominant generation	Gametophyte
Gametophyte form	Flattened, green thallus
Sporophyte	Elongated, cylindrical, horn-shaped
Reproduction	Sexual reproduction through antheridia and archegonia
Dispersal	Spores transported primarily by wind
Habitat	Moist, shaded environments with high water availability

Ecological importance of hornworts

- They act as pioneer organisms in the colonization of bare substrates.
- They favor soil formation and stabilization.
- They retain water and help maintain environmental humidity.
- They participate in nutrient cycles.
- They provide shelter for microorganisms and invertebrates.
- Some species establish symbiotic associations with nitrogen-fixing cyanobacteria, contributing to soil fertility.

Aspects to observe during the lab practice

1. Morphology of the thallus.
2. Presence of rhizoids.
3. Coloration and texture of the gametophyte.
4. Horn-shaped sporophytes.
5. Location on the substrate (soil, rock, or trunk).
6. Maturity stage of the sporophytes.
7. Adaptations related to moisture conservation.

Hornworts constitute a group of non-vascular plants of great ecological importance due to their role in environmental colonization, moisture conservation, and soil formation. Their study allows for an understanding of the early evolution of land plants and the recognition of the adaptations that enable them to survive in humid environments where they complete their life cycle through the production and dispersal of spores (Delgadillo & Cárdenas, 1990).

GENERAL OBJECTIVE

To characterize and identify non-vascular plants (hornworts) through macroscopic and microscopic observation of their vegetative and reproductive structures.

SPECIFIC OBJECTIVES

1. To identify the main anatomical and reproductive structures present in hornworts.
2. To differentiate the vegetative and reproductive structures of hornworts through microscopic observation.

LEARNING OUTCOMES

- Recognizes the main morphological and reproductive structures present in hornworts.
- Relates the anatomical characteristics of hornworts to their ecological and evolutionary adaptations.

METHODOLOGY AND TECHNIQUES

The lab practice is developed under an experimental-descriptive approach through macroscopic and microscopic observation of hornwort samples collected in humid environments.

The techniques used include:

- Collection of plant samples.
- Macroscopic observation.
- Microscopic preparation.
- Anatomical and reproductive identification of plant structures.

PROCEDURE

PART A: SAMPLE COLLECTION

1. Collect samples of hornworts present on damp soil, rocks, or surfaces with abundant moisture.
2. Place the samples in damp containers to prevent dehydration.
3. Label the samples indicating the date and place of collection.

Hornworts grow mainly in humid environments due to the absence of specialized vascular tissues.

PART B: MACROSCOPIC OBSERVATION

1. Place the samples on a Petri dish or observation tray.

2. Identify:
 - Thallus
 - Rhizoids
 - Sporophyte
 - Elongated capsule
 - Plant surface
3. Record:
 - Color
 - Size
 - Shape
 - Growth type

The elongated sporophyte constitutes one of the distinctive characteristics of hornworts.

PART C: MICROSCOPIC PREPARATION

1. Take a small portion of the thallus or sporangial capsule.
2. Place the sample on a clean slide.
3. Add a drop of distilled water or Lugol's iodine.
4. Carefully place the coverslip.
5. Observe initially with the 10X objective and subsequently at 40X.

Microscopic observation allows for the visualization of plant cells, spores, and reproductive structures present in hornworts.

PART D: OBSERVATION AND IDENTIFICATION

1. Identify vegetative structures:
 - Thallus
 - Rhizoids
 - Mucilaginous cavities
2. Identify reproductive structures:
 - Sporophyte
 - Sporangial capsule
 - Spores
3. Compare the observed structures with reference images and taxonomic keys.

Hornworts present a persistent sporophyte capable of continuous growth through basal meristematic activity.

MATERIALS AND REAGENTS

Materials

- Optical microscope

- Slides
- Coverslips
- Petri dish
- Tweezers
- Dissection needle
- Dropper
- Absorbent paper

Biological material

- Fresh hornwort samples

Reagents

- Distilled water
- Lugol's iodine
- Methylene blue (optional)

RESULTS AND OBSERVATIONS

During the lab practice, hornworts growing on humid and shaded surfaces were observed. Simple vegetative structures and elongated sporophytes characteristic of the group were identified.

The main structures observed were:

- Thallus
- Rhizoids
- Mucilaginous cavities
- Sporophyte
- Sporangial capsule
- Spores

Microscopically, simple plant cells and reproductive structures related to spore production and dispersal were visualized. An absence of true vascular tissues such as xylem and phloem was observed (Raven et al., 2021).

The sporangial capsules presented a large amount of mature spores related to plant reproduction and dispersal (Ferreira et al., 2023).

DRAWINGS, DIAGRAMS, AND DESCRIPTIONS

THALLUS

Flattened vegetative structure responsible for photosynthesis and water absorption.

RHIZOIDS

Filaments responsible for attachment to the substrate and moisture absorption.

MUCILAGINOUS CAVITIES

Internal spaces where symbiotic cyanobacteria can develop.

SPOROPHYTE

Elongated reproductive structure responsible for spore production.

SPORANGIAL CAPSULE

Structure where spores are formed and stored.

SPORES

Reproductive cells used for dispersal and reproduction.

The reproductive structures of hornworts represent primitive adaptations of non-vascular land plants.

GENERAL OBSERVATIONS

The hornworts presented growth associated with humid and shaded environments. Simple plant organization and an absence of specialized conducting tissues were observed.

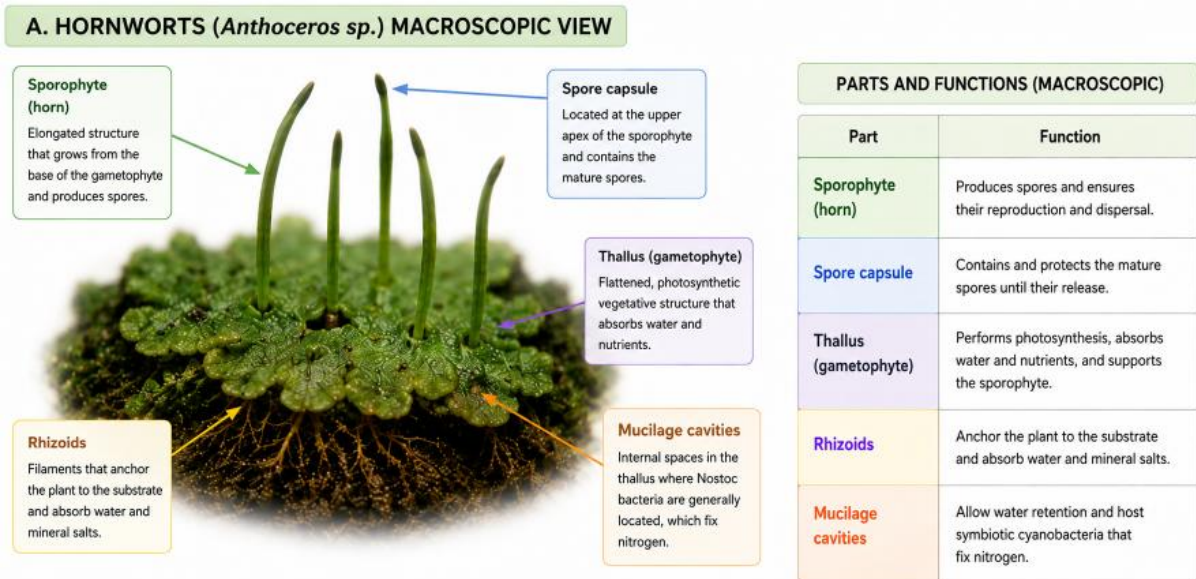
Microscopic observation allowed for the visualization of cellular and reproductive structures related to spore dispersal and ecological adaptation.

CONCLUSIONS

1. Hornworts are non-vascular plants adapted to humid and shaded environments.
2. The absence of true vascular tissues differentiates hornworts from higher plants.
3. The elongated sporophyte constitutes a distinctive characteristic of this plant group.
4. Microscopic observation facilitates the identification of vegetative and reproductive structures.
5. Hornworts possess great ecological importance due to their participation in moisture retention and the formation of microhabitats.

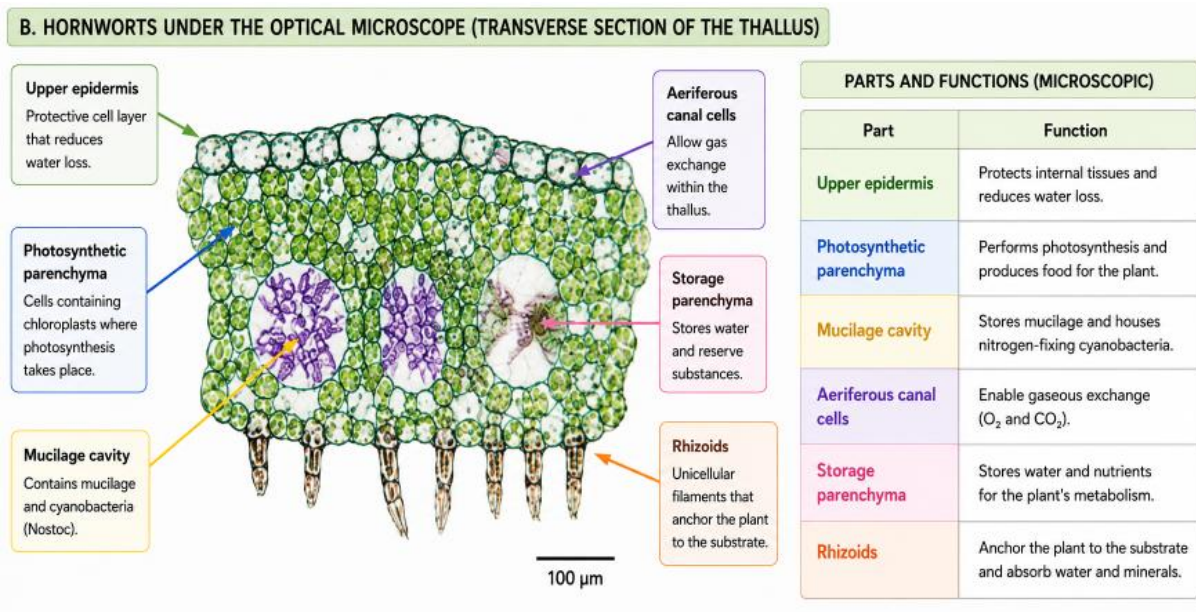
Reference images

Image 49.- Images of bryophytes



Source: (Shaw, 2022)

Image 50.- Images of bryophytes



Source: (Shaw, 2022)

QUESTIONNAIRE

True or False

1. _____ Hornworts are non-vascular plants that lack true xylem and phloem.
2. _____ The sporophyte of hornworts presents an elongated appearance resembling a horn.
3. _____ Hornworts develop mainly in dry and desert environments.
4. _____ Mucilaginous cavities can contain symbiotic cyanobacteria of the genus Nostoc.
5. _____ Rhizoids participate in attachment to the substrate and moisture absorption.
6. _____ Hornwort spores participate in plant reproduction and dispersal processes.
7. _____ Hornworts present a thalloid gametophyte responsible for performing photosynthesis.
8. _____ Microscopic observation allows for the identification of spores and reproductive structures in hornworts.
9. _____ Hornworts possess highly developed conducting tissues.
10. _____ The thallus of hornworts participates in water absorption and photosynthetic processes.

ANSWERS

1. True
2. True
3. False
4. True
5. True
6. True
7. True
8. True
9. False
10. True

Bibliography

Delgadillo, C., & Cárdenas, M. (1990). *Manual de Briofitas*. Mexico: Universidad Nacional Autónoma de México.

Shaw, A. (2022). *Bryophyte Biology*. Cambridge, United Kingdom: Cambridge University.

LABORATORY PRACTICE 15

CHARACTERIZATION AND IDENTIFICATION OF THE STRUCTURES OF PTERIDOPHYTE PLANTS

INTRODUCTION

According to (Pérez-Atilano, 2023), within vascular plants, we find pteridophytes, gymnosperms, and angiosperms. The former are represented by ferns and lycopods; they share reproduction by means of spores. Like bryophytes, they possess greater richness in humid places.

Pteridophytes are lower vascular plants commonly known as ferns, lycopods, and horsetails. They are characterized by possessing specialized conducting tissues (xylem and phloem), which represents an important evolutionary advance compared to bryophytes. They present an alternation of generations, where the sporophytic phase (diploid) predominates over the gametophytic phase (haploid). The gametophyte is represented by a prothallus, generally small, green, and photosynthetic. The body of the adult plant is differentiated into stem, leaves, and root, although the roots do not reach the degree of development observed in spermatophytes. Their leaves can vary from simple structures to complex leaves called fronds, characteristic of the most evolved ferns. Reproduction occurs through spores, produced in structures called sporangia, which are usually located on the underside of the fronds and can be found isolated or grouped forming sori or strobili. Sporangia possess specialized structures such as the indusium, the archesporium, and the tapetum, which participate in the protection and nutrition of the spores during their development. Fertilization requires the presence of water, as the mobile antherozoids produced in the antheridia must move to the oosphere contained in the archegonia. Subsequently, a new sporophyte develops, which initially obtains nutrients from the gametophyte through a structure called a foot. (Rodríguez, 2023)

Macroscopic and microscopic observation of pteridophytes allows for the recognition of vegetative and reproductive structures related to ecological adaptation and plant evolution.

GENERAL OBJECTIVE

To characterize and identify the vegetative and reproductive structures of pteridophyte plants through macroscopic and microscopic observation.

SPECIFIC OBJECTIVES

1. To identify the main vegetative structures present in pteridophytes.
2. To recognize reproductive structures related to spore production and dispersal.

LEARNING OUTCOMES

- Recognizes the main vegetative and reproductive structures of pteridophytes.
- Relates the anatomical characteristics of pteridophytes to their evolutionary and ecological importance.

METHODOLOGY AND TECHNIQUES

The lab practice is developed under an experimental-descriptive approach through macroscopic and microscopic observation of fresh samples of ferns and other pteridophytes.

The techniques used include:

- Macroscopic observation of plant organs.
- Microscopic preparation of reproductive structures.
- Anatomical and morphological identification of plant tissues.
- Observation of sori and sporangia.

PROCEDURE

PART A: SAMPLE COLLECTION

1. Collect fresh samples of ferns present in gardens, nurseries, or humid environments.
2. Place the samples in damp containers to prevent dehydration.
3. Label the samples indicating the place and date of collection.

Pteridophytes develop mainly in humid environments because they require water for reproductive processes.

PART B: MACROSCOPIC OBSERVATION

1. Place the samples on an observation tray.
2. Identify:
 - Fronds
 - Rhizome
 - Roots
 - Sori
 - Petiole
3. Record:
 - Color
 - Shape
 - Size
 - Type of frond

Fronds constitute highly developed true leaves related to photosynthesis and reproduction.

PART C: MICROSCOPIC PREPARATION

1. Cut a small section from the lower part of the frond where the sori are located.
2. Place the sample on a clean slide.
3. Add a drop of distilled water or Lugol's iodine.
4. Carefully place the coverslip.
5. Observe initially with the 4X objective and subsequently at 10X and 40X.

Microscopic observation allows for the visualization of sporangia and spores present in the reproductive structures.

PART D: OBSERVATION AND IDENTIFICATION

1. Identify vegetative structures:
 - Frond
 - Rhizome
 - Roots
 - Petiole
2. Identify reproductive structures:
 - Sori
 - Sporangia
 - Spores
3. Compare the observed structures with reference images and taxonomic keys.

Sori constitute clusters of sporangia present on the lower part of the fronds.

MATERIALS AND REAGENTS

Materials

- Optical microscope
- Slides
- Coverslips
- Petri dish
- Tweezers
- Dissection needle
- Dropper
- Absorbent paper

Biological material

- Fresh fern samples

Reagents

- Distilled water
- Lugol's iodine
- Methylene blue (optional)

RESULTS AND OBSERVATIONS

During the lab practice, pteridophytes with differentiated vegetative organs and reproductive structures located on the lower part of the fronds were observed.

The main structures observed were:

- Fronds
- Rhizome
- Petiole
- Roots
- Sori
- Sporangia
- Spores

Microscopically, sporangia grouped forming sori were visualized, as well as spores related to plant reproduction and dispersal. The presence of true vascular tissues such as xylem and phloem was observed.

The fronds presented a large photosynthetic surface area and a developed vascular organization, a distinctive characteristic of pteridophyte plants.

DRAWINGS, DIAGRAMS, AND DESCRIPTIONS

FROND

True leaf responsible for photosynthesis and supporting reproductive structures.

RHIZOME

Horizontal underground stem responsible for storage and vegetative growth.

PETIOLE

Structure that joins the frond to the rhizome.

ROOTS

Organs responsible for the absorption of water and minerals.

SORI (SORI)

Clusters of sporangia located on the lower part of the fronds.

SPORANGIA

Reproductive structures where spores are produced.

SPORES

Reproductive cells responsible for dispersal and reproduction.

The reproductive structures of pteridophytes represent evolutionary adaptations related to reproduction by means of spores.

GENERAL OBSERVATIONS

The pteridophytes presented differentiated vegetative structures and well-developed vascular tissues. A great morphological diversity in the fronds and arrangement of the sori was observed.

Microscopic observation allowed for the clear visualization of sporangia and spores present in reproductive structures.

CONCLUSIONS

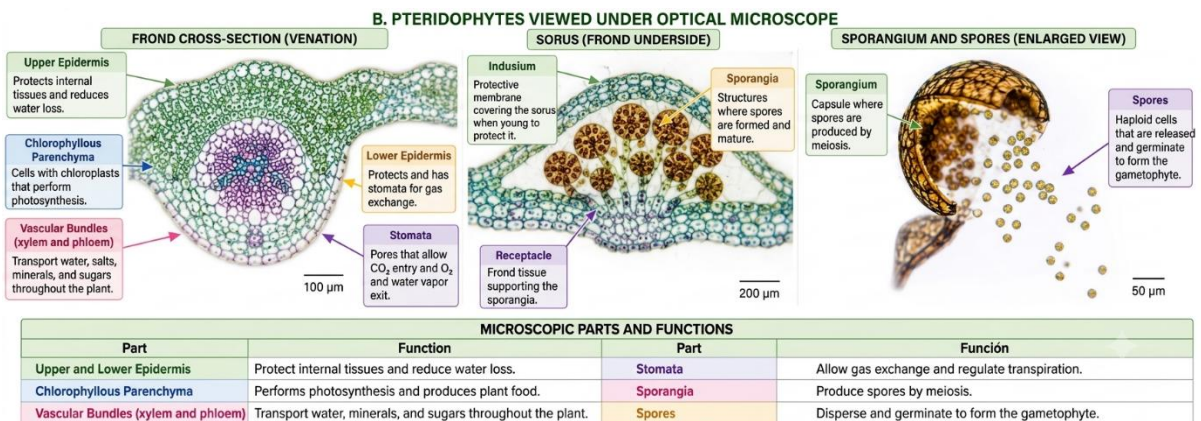
1. Pteridophytes are primitive vascular plants that reproduce by means of spores.
2. Fronds constitute highly specialized vegetative structures related to photosynthesis and reproduction.
3. Sori and sporangia allow for the identification of reproductive structures characteristic of pteridophytes.
4. The presence of vascular tissues differentiates pteridophytes from bryophytes.
5. Microscopic observation facilitates the anatomical and reproductive identification of pteridophyte plants.

Reference images Image 51.- Characterization of ferns, carried out in the phytopathology laboratory of the Agricultural University of Ecuador



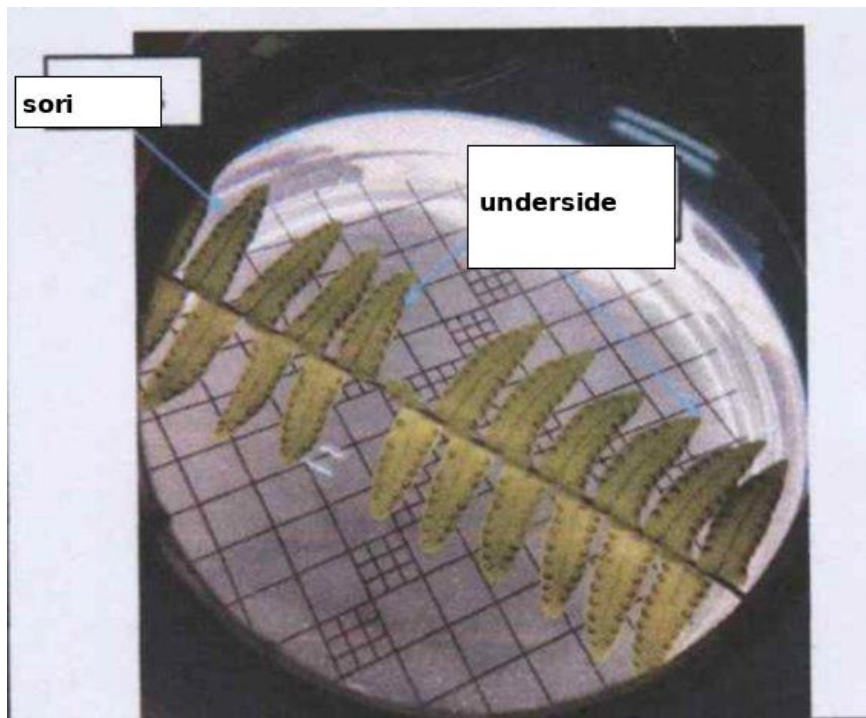
Source: Authors, 2026

Image 52.- Image of ferns with their parts viewed under an optical microscope



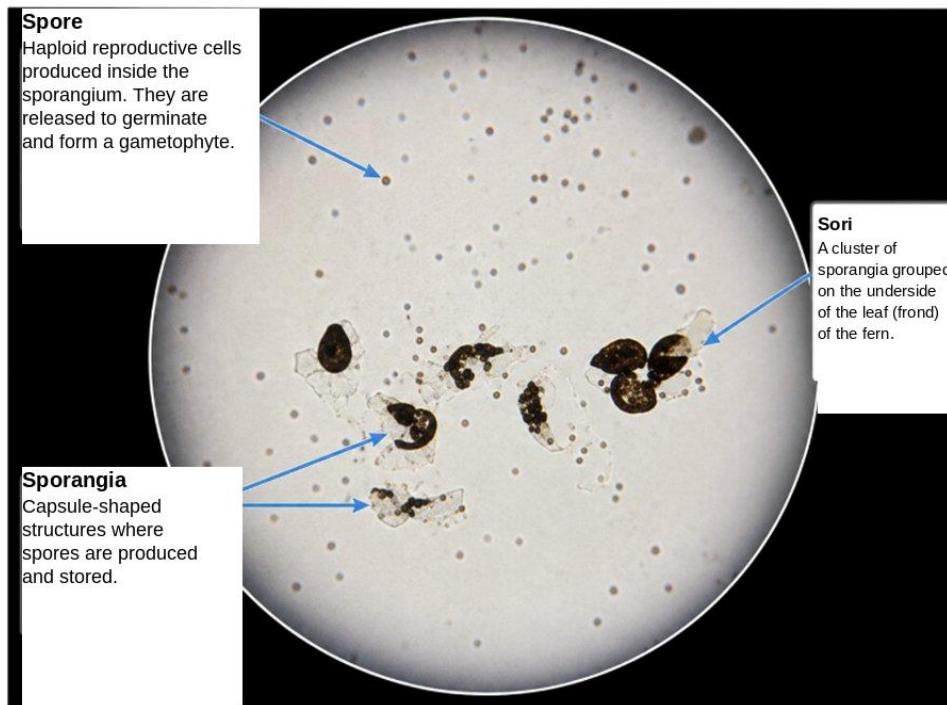
Source: (Taiz, 2023)

Image 53.- Observation of a fern frond and sori on the underside using a binocular microscope at the phytopathology laboratory of the Agricultural University of Ecuador



Source: Authors, 2026

Image 54.- Microscopic observation of fern spores and sporangia at the phytopathology laboratory of the Agricultural University of Ecuador



Source: Authors, 2026

QUESTIONNAIRE

True or False

1. _____ Pteridophytes are vascular plants that possess true xylem and phloem.
2. _____ Pteridophytes produce flowers and seeds for their reproduction.
3. _____ Fronds are true leaves related to photosynthesis and reproduction.
4. _____ Sori are clusters of sporangia located on the underside of the fronds.
5. _____ The rhizome is an underground stem responsible for storage and vegetative growth.
6. _____ Spores participate in the reproduction and dispersal of pteridophytes.
7. _____ The roots of pteridophytes absorb water and minerals from the environment.
8. _____ Microscopic observation allows for the identification of sporangia and spores present on the fronds.
9. _____ Pteridophytes completely lack vascular tissues.
10. _____ The presence of xylem and phloem differentiates pteridophytes from bryophytes.

ANSWERS

1. True
2. False
3. True
4. True
5. True
6. True
7. True
8. True
9. False
10. True

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LABORATORY PRACTICE 16

OBSERVATION AND ANALYSIS OF HERBACEOUS, ARBOREAL, AND SHRUBBY PLANTS

INTRODUCTION

Plants present different growth forms that allow them to be grouped into herbaceous, shrubby, and arboreal. Each of these groups possesses particular characteristics related to the structure of their stems, their size, lifespan, and the functions they perform both in natural environments and in productive and ornamental activities. Knowing these differences is fundamental to choosing the most appropriate species for gardening, landscaping, reforestation, and green area conservation projects, as aspects such as the height they reach, their development, resistance, and aesthetic or productive value directly influence their adaptation and utilization (Patiño, Valenzuela, Romero, & Herrera, 2025).

Herbaceous plants are characterized by presenting soft, flexible, and minimally lignified stems, meaning they have scarce wood production. Generally, they possess short or medium life cycles and stand out for their rapid growth. Within this group, many agricultural, ornamental, and wild species are found. According to the document, most monocotyledonous plants, such as grasses and some ornamental plants, present this type of growth.

Shrubby plants possess woody and resistant stems, but unlike trees, they do not present a single main trunk. Generally, they develop multiple stems that emerge from the base, forming a more branched structure of lower height. Shrubs usually adapt well to different environmental conditions and constitute important components of forests, scrublands, and gardens. Some species can behave as shrubs or trees depending on the environmental conditions.

For their part, arboreal plants or trees are woody organisms that present a well-defined main trunk and a differentiated canopy. From a botanical standpoint, they usually exceed five meters in height and possess specialized tissues that produce wood or secondary xylem. Trees represent some of the largest and longest-lived living organisms on the planet, forming complex ecosystems that provide shelter, food, and protection to numerous species. Furthermore, they perform fundamental functions such as oxygen production, climate regulation, soil conservation, and carbon storage.

In conclusion, the differences among herbaceous, shrubby, and arboreal plants are mainly related to the degree of development of their woody tissues, their size, and their growth form. While herbaceous plants stand out for their flexibility and rapid development, shrubs present an intermediate woody structure, and trees reach the highest degree of structural complexity, becoming fundamental elements for the functioning and conservation of ecosystems (Medina, 2021).

Macroscopic observation of herbaceous, shrubby, and arboreal plants allows for the recognition of differences in the organization of roots, stems, leaves, and reproductive structures, contributing to the understanding of plant diversity and its ecological importance.

GENERAL OBJECTIVE

To classify herbaceous, arboreal, and shrubby plants to identify their morphological characteristics, following instructions and laboratory observation methods, strengthening critical thinking and teamwork collaboration.

SPECIFIC OBJECTIVES

1. To identify the morphological characteristics that differentiate herbaceous, shrubby, and arboreal plants.
2. To recognize the vegetative structures present in each type of plant.
3. To compare the structural adaptations related to their growth form.

LEARNING OUTCOMES

- Recognizes the morphological differences among herbaceous, shrubby, and arboreal plants.
- Identifies the main vegetative structures present in each plant group.
- Relates structural characteristics to the ecological adaptation of plants.

METHODOLOGY AND TECHNIQUES

The lab practice is developed under a descriptive-comparative approach through direct observation of different plant species present in gardens, green areas, or agricultural plots.

The techniques used include:

- Macroscopic observation of plant structures.
- Morphological identification of vegetative organs.
- Comparison of structural characteristics.
- Recording of observations and development of descriptive diagrams.

PROCEDURE

PART A: SAMPLE COLLECTION

1. Select an herbaceous, a shrubby, and an arboreal plant present in the environment.
2. Observe the plants without causing damage to the plant structure.
3. Record the common name, location, and date of observation.
4. Take 153nálisi of fallen leaves or small branches when necessary for 153nálisis.

The structural differences among these plant groups are related to the degree of development of supporting and conducting tissues.

PART B: MACROSCOPIC OBSERVATION

1. Carefully observe each plant.
2. Identify the following structures:

Herbaceous plant

- Stem
- Leaves
- Roots
- Flowers (if present)

Shrubby plant

- Multiple woody stems
- Leaves
- Branches
- Flowers or fruits

Arboreal plant

- Main trunk
 - Canopy
 - Branches
 - Leaves
 - Visible roots
3. Record:
 - Approximate height
 - Coloration
 - Stem type
 - Presence of reproductive structures
 - Characteristics of the leaves

The characteristics of the stem constitute one of the primary 154riterio to differentiate these plant groups.

PART C: COMPARATIVE ANALYSIS

1. Compare the observed characteristics among the three plant forms.
2. Record differences related to:
 - Size
 - Growth type
 - Degree of lignification
 - Number of main stems
 - Canopy development

- Lifespan duration
3. Develop a comparative table with the identified characteristics.

Structural adaptations allow each plant group to occupy different ecological niches.

PART D: IDENTIFICATION AND CLASSIFICATION

1. Classify each observed sample as corresponding to:
 - Herbaceous
 - Shrubby
 - Arboreal
2. Justify the classification using the observed characteristics.
3. Compare the observations with bibliographic material or plant identification keys.

Classification based on growth form constitutes a fundamental tool for the study of general botany.

MATERIALS AND REAGENTS

Materials

- Field notebook
- Pencil
- Camera or mobile phone
- Measuring tape
- Hand lens
- Observation tray

Biological material

- Herbaceous plants
- Shrubby plants
- Arboreal plants

Reagents

No reagents are required for this lab practice.

RESULTS AND OBSERVATIONS

During the lab practice, different forms of plant growth corresponding to herbaceous, shrubby, and arboreal plants were observed.

Main characteristics observed

Herbaceous plants

- Soft and flexible stems.

- Scarce lignification.
- Shorter height.
- Rapid growth.

Shrubby plants

- Presence of several woody stems.
- Branching from the base.
- Intermediate height.
- Greater structural resistance.

Arboreal plants

- Well-defined main trunk.
- Highly developed woody tissues.
- Great height.
- Widely branched canopy.

The observations allowed for the recognition of clear differences in the structural and functional organization of each plant group.

DRAWINGS, DIAGRAMS, AND DESCRIPTIONS

HERBACEOUS PLANT

Plant with a soft and minimally lignified stem, generally of small or medium size.

HERBACEOUS STEM

Flexible structure responsible for support and substance transport.

SHRUBBY PLANT

Woody plant with several stems emerging from the base.

SHRUBBY STEMS

Multiple woody structures providing support and branching.

ARBOREAL PLANT

Large plant with a well-defined main trunk.

TRUNK

Main woody stem that supports the canopy of the tree.

CANOPY

Set of branches and leaves responsible for light interception for photosynthesis.

The observed structural differences reflect different levels of adaptation to the environment and growth strategies.

COMPARATIVE TABLE

Feature	Herbaceous	Shrubby	Arboreal
Stem type	Soft and flexible	Woody and branched	Woody with a main trunk
Wood production	Scarce or none	Moderate	High
Height	Low	Intermediate	High
Lifespan	Short to medium	Medium to long	Long
Branching	Limited	From the base	Mainly in the canopy
Examples	Grasses, corn, orchids	Rose, hibiscus, laurel	Oak, pine, eucalyptus

GENERAL OBSERVATIONS

The observed plants presented significant differences in size, structure, and degree of lignification. Herbaceous plants showed greater flexibility, while shrubby and arboreal plants presented more developed woody tissues.

The comparison allowed for an understanding of how structural adaptations influence the growth, survival, and ecological distribution of each plant group.

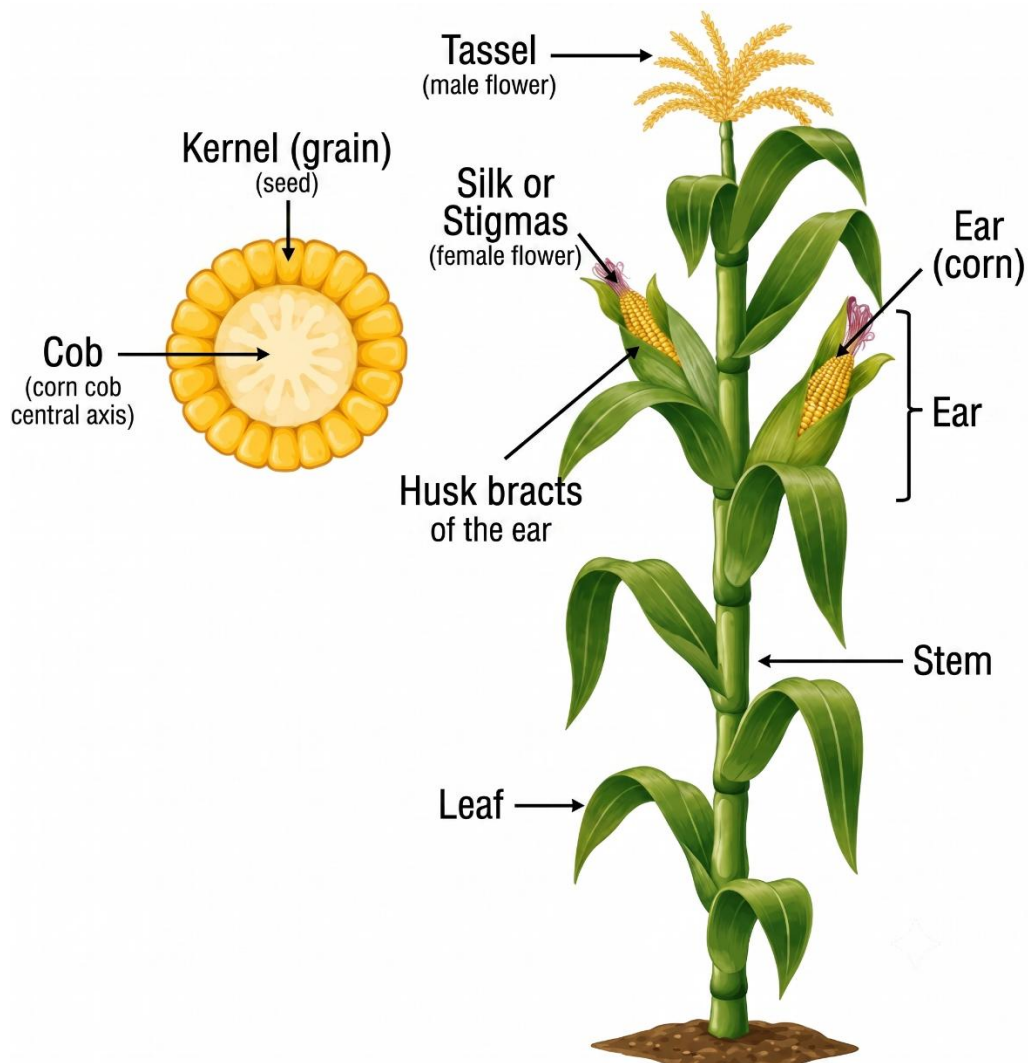
CONCLUSIONS

1. Herbaceous, shrubby, and arboreal plants present morphological differences related to the degree of development of their supporting tissues.
2. Herbaceous plants possess soft and minimally lignified stems, whereas shrubby and arboreal plants present woody tissues.
3. Shrubby plants are characterized by presenting multiple main stems that emerge from the base.

4. Arboreal plants possess a well-defined main trunk and reach larger dimensions.
5. Comparative observation allowed for the identification of structural adaptations related to the survival and growth of each plant group.

Reference images

Image 55.- Herbaceous plant (*Zea mays*), characterized by presenting a soft stem and scarce lignification.



Source: (Ramírez-Esparza, 2024)

Image 56.- Shrubby plant (Hibiscus, Hibiscus rosa-sinensis)



Source: (Rudenskaya, 2024)

Image 57.- Example of an oak arboreal plant. A well-defined main trunk and a leafy canopy formed by numerous branches and leaves are observed, characteristics that differentiate trees from herbaceous and shrubby plants



Source: (Kirken, 2020)

Laboratory Practice Questionnaire 16

Instructions: Read each statement carefully and write **T** if it is true or **F** if it is false.

1. () Herbaceous plants are characterized by having soft, weakly lignified stems.
2. () Trees have several main stems arising from the base of the plant.
3. () Shrubby plants (shrubs) generally feature an intermediate height and several woody stems.
4. () Macroscopic observation allows the identification of structures such as leaves, stems, roots, and flowers.
5. () Arboreal plants (trees) are distinguished by having a well-defined main trunk.
6. () Lignification is lower in arboreal plants than in herbaceous plants.
7. () The degree of development of supporting and conducting tissues helps differentiate plant groups.
8. () Herbaceous plants typically exhibit faster growth than arboreal plants.
9. () The crown of trees is formed by branches and leaves that participate in capturing light for photosynthesis.
10. () Shrubby and arboreal plants possess more developed woody tissues than herbaceous plants.

Answers

1. T
2. F
3. T
4. T
5. T
6. F
7. T
8. T
9. T
10. T

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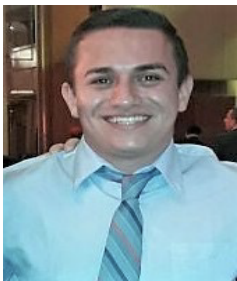
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ISBN: 978-9942-600-90-5



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