EXPERIENCES IN BIOLOGY

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Preface

"By wisdom is a house built, by understanding is it made firm, and by knowledge are its rooms filled with every precious and pleasing possession." Proverbs 24:3-4

The study of biology can be confusing because all too often the students are overwhelmed by the complexities of molecular science and biochemistry before they have learned to appreciate the down-to-earth realities of biology. The study of biology should begin with a study of those things which make up biology, the life forms of Earth. The heart of a scientist is built by observing life.

Next, the student should be given a framework in which to observe. In biology, this framework is the classification system. This system is based on structure, so one of the first topics should be the study of the structures of life.

Then, built upon a firm framework, the student is ready to fill in the gaps, the whys and hows of biology. This is cellular biology, molecular biology and biological systems.

It may be that your students have already a firm knowledge of the framework of biology. That is good. You can bypass classification and descriptive biology and go on to the more difficult parts of the year. However, few students enter the high school biology course with this type of knowledge.

This lab manual has been written in order to give students a chance to discover some things about the life forms which surround them and in the process develop a framework about which to hang the rest of their biological studies.

Our Earth is a rock in the void. In spite of that formless void, on that one planet, at least, life was breathed into lifelessness. A mantle of life was wrapped around the rock. Enjoy.

Table of Contents

L - Laboratory experiment
M - Experiment using a microscope
D - Dissection
F - Field study

Using this Lab Manual

Choose 12 - 15 Experiments

Don't do all of these experiments! There are more than enough for a one year high school biology laboratory. This biology laboratory manual has many different types of experiments. Some require the use of a microscope, others only access to a few plants. The student or the instructor can choose those experiments which fit best with the equipment you already possess. Biology equipment is usually inexpensive, with the exception, of course, of a good microscope. You will not be too limited by lack of equipment while using this lab manual.

Choose an Assortment of Experiments

There are enough experiments in this lab manual to give a good selection. You should select a few dissections (5+), a few laboratory experiments (7), several microscopic exercises (3), and at least one long Spring project in ecology. Do the experiments in any order you like.

Record-Keeping

There will not be enough space in this lab manual to record all the data for the experiments. This is done intentionally to encourage the students to keep their own data notebook to jot down notes, scrawl thoughts and observations, and make drawings. There are some blanks and leading questions which should be used as a guideline for constructing your data notebook and completing a final report for each experiment.

There is an optional databook that has been created to align with the experiments in this book available online at *www.castleheightspress.com*.

In Appendix B, you will find an example drawing page for you to copy and use throughout the manual. On many of the experiments, your student will also need extra copies of the data pages. Use data pages from the optional databook, or make copies for use within your homeschool family only.

The biologist must always have a record of the experiments, procedures, and data which he/she has completed. It is imperative that there be some sort of record in order to verify the experiment or the observations. The same is true for the student. The write-up of an experiment will show to others whether the student has understood the process and can draw conclusions from the data.

The notebook of the biologist can take various forms depending upon the type of data recorded. Likewise, the notebook of the student can vary according

Elements of a Good Report

- *Title*
- *Problem Statement*
- *Research*
- *Hypothesis*
- *Procedure (numbered short statements are ok)*
- *Drawing of equipment set-up (may use a photo, too)*
- *Data and Drawings*
- *Calculations (if needed)*
- *Conclusions (and answers to the experiment questions)*

to the requirements of the instructor, the student, and/or the data.

In a laboratory write-up, there must be an objective: a reason why you are doing the experiment. This can be in the form of a statement of **objective**, a question, or a **problem statement**. Whatever the form you use, it must be included in your writeup. There is always a reason for the experiment.

Some students have difficulty with identifying the **problem** in biological laboratories. This is because a lot of biology is simply observing and then drawing conclusions about the observations. This is no less good science than an experiment with controls and variables. A biologist must know what happens before attempting to alter a variable. So, for the problem statement, you may have a question to answer, a puzzling problem, or an unknown bit of data you wish to determine. It is OK to have as a problem statement: "I intend to observe and draw the cellular structure of a muscle." It is not OK to write: "To write up lab 37".

The **research** step for a biology laboratory experiment is really to read your text on the topic. Your instructor may require more and should if you are interested in this field. In your write-up, you can list the pages you read for this preparation, or you can briefly summarize the literature in the field.

The **hypothesis** is just your guess on the outcome of the experiment. If you do not have an experiment with variables, then you do not need to make a guess. If you are testing some physical response to a stimulus, like the speed of contracting your biceps, then you can guess about your success rate, or whether you can beat someone else's record.

The **procedure** of the experiment is what you did and how you did it. In this way another person (or you) can find a cause for an error in the experiment. Another reason for recording an exact procedure is that a scientist must be able to ensure reproducibility of the results. If you are running an experiment, just describe what you did. If you are using a procedure you found in another book, you must detail exactly your steps so that the experiment can be reproduced. Another way of fulfilling this step is to draw a picture of what you did and how you set up the equipment.

The **data** collected is best shown in a chart, but may be written out. Observations in the form of drawings should be done according to the rules in Section iv of this manual. These rules are very old and drawings made from them are accurate,

easy to read, and are recognizable (even for those like me who cannot draw).

Calculations may not be necessary for every laboratory, but should go after the data if you have them. Charts are good here for recording the results of the calculations.

The **conclusion** step is very important. You must not leave it out because this is the step which reveals what, if anything, you have learned by doing this experiment. You will explain why it happened in this step. Or, maybe you will explain why you think it happened. Both are OK. This is also the place to ask more questions. Perhaps this experiment has been done many times before. If this is true, so be it. It can still lead YOU to ask more questions. Maybe some of them have not been asked before.

A Note About Terms and Definitions

Since this lab manual is designed to be a supplementary text, space is not taken to introduce every term before its use. The textbook the student is regularly using will have definitions for these terms. If a term is not defined here, the student should look it up in the textbook.

⚠ *Safety Note*

Occasionally you will encounter Safety Notes in the text. Pay attention! Serious injury may result if you do not heed these warnings.

Notebook Guidelines

1. Keep your reports in a notebook. This will allow you to add pages.
2. Each experiment will require about two or three pages. The experiments which require drawings will be longer.
3. Keep each experiment together with the drawings you have made. Extra drawings like the traditional microscope drawing or others you make on your own for extra credit should be kept in a separate divider.
4. At the top of the page be sure to fill in your headings: name and date.

List of Materials

Kits specific to this manual are available through Home Science Tools at www.homesciencetools.com It is recommended that you review the labs first with their associated materials lists to ensure you are only buying the materials for the labs you plan to complete.

Section 1: Zoology

1.1 Classification of Animals I

1.2 Classification of Animals II

1.3 Protista: The Protozoans

- Microscope
- Protozoan culture: mixed
- Depression slides
- Prepared slides: *Amoeba proteus*, paramecium
- Methyl cellulose (slowing agent)
- *How to Know the Protozoans* by T.L. Jahn
- Cover slips
- Congo red stain
- Methylene blue stain
- Drawing papers

1.4 General Cell Structure in Animals

- Microscope
- Prepared slide: Typical animal cell
- Drawing paper
- Methylene blue
- Microscope slides: depression and flat
- Alcohol
- Cover slips
- Distilled water
- Janus green B stain
- Iodine
- Needle
- Paper towel
- Wright's stain
- Toothpicks, round end

1.5 - 1.12 Dissections

- Dissection kit:
  - scalpel
  - blades
  - scissors
  - T-pins
  - probe
- Drawing paper
- Cover slip
- Knife with thick blade
- Microscope
- Slides
- Clam
- Earthworm
- Grasshopper
- Perch
- Shark
- Starfish
- Fetal pig, injected

Section 2: Physiology

2.1 Muscular System: Fatigue

- Watch with second hand
- 3-pound weight
- Graph paper

2.2 Nervous System: Reaction Time

- Ruler
- Stop watch
- Notebook

2.3 Respiratory System: Rate

- Ammonium hydroxide (household ammonia)
  - (or sodium hydroxide)
- Erlenmeyer flask or glass
- Dropper
- Watch with second hand
- Phenolphthalein solution or Litmus paper
- Measuring cup or Graduated cylinder

Straw, large diameter approx. 6mm
Water

Section 3: Cellular Biology

3.1 Diffusion and Osmosis

Carrots or potatoes
Knife
Glasses (3)
Salt or sugar
Plastic wrap
Distilled water
Kitchen scale
Fruit
Bowl

3.2 Reproduction: Cellular

Prepared slide: onion root tip l.s.
Microscope
Drawing paper
Optional items:
Onion or carrot
Slide
Methylene blue
Cover slip
Paper towels
Dropper
Water
Sharp knife

Section 4: Botany

4.1 Cell Structure: Plant

Microscope
Prepared slide: Typical plant cell or *Zea mays*
Drawing paper
Slides
Cover slips
Stains: Iodine
Methylene blue
Scalpel
Potato
Celery
Carrot
Ligustrum leaf

4.2 Chlorophyll and Photosynthesis

Plant, such as geranium
Alcohol
Heavy paper
Coffee filter paper (or chromatography paper)
Dropper
Acetone
Test tubes
Test tube rack
Corks
Paper clips for hooks
Paper clips
Pot
Pencil
Goggles

4.3 Internal Leaf Structure

Microscope
Prepared slides: monocot and dicot leaf c.s.
Drawing paper
Slide
Cover slip
Dropper
Ligustrum plant, *Ficus benjamina*, or lettuce

4.4 Plant Growth: Leaves

Drawing paper
Ruler
Marker
Plants, such as geranium or popcorn plant

4.5 Plant Anatomy: Stems

Microscope
Prepared slides: monocot and dicot stem c.s.
Drawing paper

4.6 Plant Growth: Stems

Cookie sheet
Indelible ink pen or paint
Plastic wrap
Ruler
Seedlings (3 or 4 types)

Towel/paper toweling
Water

4.7 Plant Anatomy: Roots

Drawing paper
Gelatin
Prepared slide: onion root tip l.s.
Microscope
Ruler

4.8 Sexual Reproduction: Fruit and Flowers

Dissection kit
Drawing paper
Flowers, several types
Fruits: apple, peas, corn, fig, beans, etc.

4.9 Reproduction: Pollen Germination

Microscope
Depression slides
Cover slips
Sugar
Distilled water
Petroleum jelly
Drawing paper
Flowers: lily or daffodil

4.10 Plant Sensitivity: Gravity

Paper towels
Petri dish (or jars)
Water
Tape
Popcorn kernels

Section 5: Ecology

5.1 - 5.2 Field work

Thermometer
Litmus paper
Drawing paper
Notebook
Wildlife identification book such as:
North American Wildlife by Readers' Digest
First aid kit
Sunscreen, hat
Pencil
Ruler
Camera
Backpack
Data notebook
Drawing equipment
Drinking water, lunch
First aid kit
Insect repellent

5.3 Pond Environment Study

Length of cord
Disc-like object, such as a metal washer
Litmus paper
Distilled water
Thermometer
Sealable container for water and sludge collection
Ziploc bags for specimen collection
Backpack
Sunscreen
Camera for recording
Measuring tape
Wildlife identification handbook
Data notebook
Drawing equipment
Drinking water, lunch
First aid kit
Hat
Insect repellent

5.4 Population Transect Study

Stakes
String
Outdoor thermometer
Backpack
Sunscreen
Camera for recording
Measuring tape or ruler
Wildlife identification handbook
Data notebook
Drawing equipment

Drinking water, lunch
First aid kit
Insect repellent
Hat

5.5 Population Succession Study

Cover slips
Drawing paper
Dropper
Depression slides
Hay or grass
Jar
Microscope
Petroleum jelly
Protozoan slowing agent
Rice
Distilled Water

Microscopic Work

Slide box
Stains:
- Methylene blue stain
- Janus green B stain
- Iodine
- Congo red stain
- Wright's stain

Cover slips
Flat slides
Depression slides
Prepared Slides:
- *Spirogyra vegetative / conjugative repro.*
- *Planaria*
- *Bacteria 3 types*
- *Hydra budding*
- *Onion Root Tip l.s.*
- *Typical Plant Cell or Zea mays*
- *Monocot & Dicot leaf c.s.*
- *Monocot & Dicot stem c.s.*
- *Typical Animal Cell*
- *Paramecium conjugation*
- *Paramecium fission*
- *Amoeba proteus*
- *Mold 3 types*
- *Helianthus*
- *Muscle tissue*
- *Trachea c.s.*
- *Spinal ganglion*
- *Artery and vein c.s.*

Fundamentals for the Biology Student

These are concepts and areas of knowledge that the high school student should be reasonably familiar with before going on to the college level biology course. Look for patterns in biology. The needs for all life forms on Earth are constant; the methods of meeting those needs are different. The student should be familiar with both the needs and the methods. Plan on spending about one-fifth of your class time on lab work.

1. Know the areas of study in biology and their names.

2. Know the classification system with emphasis on its structure, criteria for classification of the organisms, and be familiar with groupings and examples down to class and order.

3. Know the names and be able to recognize the common species of your area. Understand their roles in the area. Example: Rice: economic importance as food source. Fields provide habitats for nutria, fish, amphibians. Grown where ground may be too wet for other grains.

4. Know the cycles of life and how they vary from phylum to phylum - class to class.

5. Understand the fundamental premise that every organism must perform functions to survive and that these are similar in all life forms. The things that make each life form unique are the methods by which these functions are carried out. It is the combination of the structural differences which make the types of life interesting as well as variant.

6. Know the systems that function within organisms, and how they work together.

7. Be able to relate the needs of all organisms to specific organisms and explain how their special form meets the need. Example: oxygen is needed by all the cells in any organism. Gaseous exchange is a function whereby this need is met. Some organ-

isms perform gas exchange with lungs, some with gills, some use blood to circulate the oxygen, some have closed circulatory systems, some open, some do gas exchange through the skin. You get the idea, I hope, that each species meets the same need in a different way.

8. Be able to recognize various major organs of different life forms from dissection experience or from drawings.

9. Understand the cell theory and the basic structure of the living cell.

10. Know the process whereby life characteristics are transferred to future generations. Mitosis and meiosis, reproductive systems.

11. Know the various types of reproduction used as well as examples of each. Example: vegetative propagation.

12. Know the cell types and how they work together in tissues. Know the different types of tissues and be able to explain how their structure is related to what work they do.

13. Understand basic types of inheritance and how they impact humans and domesticated life forms.

14. Know the processes of photosynthesis and respiration and their relationships to living things.

15. Osmosis, diffusion, and active transport: distinguish and explain with examples.

16. Know the uses of enzymes in the bodies of life forms.

17. Know the uses of hormones and their effect on the body.

18. Be able to explain and construct an energy pyramid.

19. Know some effects of environmental change on organisms and interrelationships between them.

20. Know some population studies including these factors: over-population, density-induced stress, density-induced diseases (both physical and psychological). Know

1.3 Protista: The Protozoans

***Materials**:*
Microscope
Prepared slides:
Amoeba proteus
paramecium
How to Know the Protozoans
** Protozoan culture: mixed*
Depression slides
Cover slips
Methyl cellulose (slowing agent)
Congo red stain
Methylene blue stain
Drawing papers

** See note on page 30 to prepare*

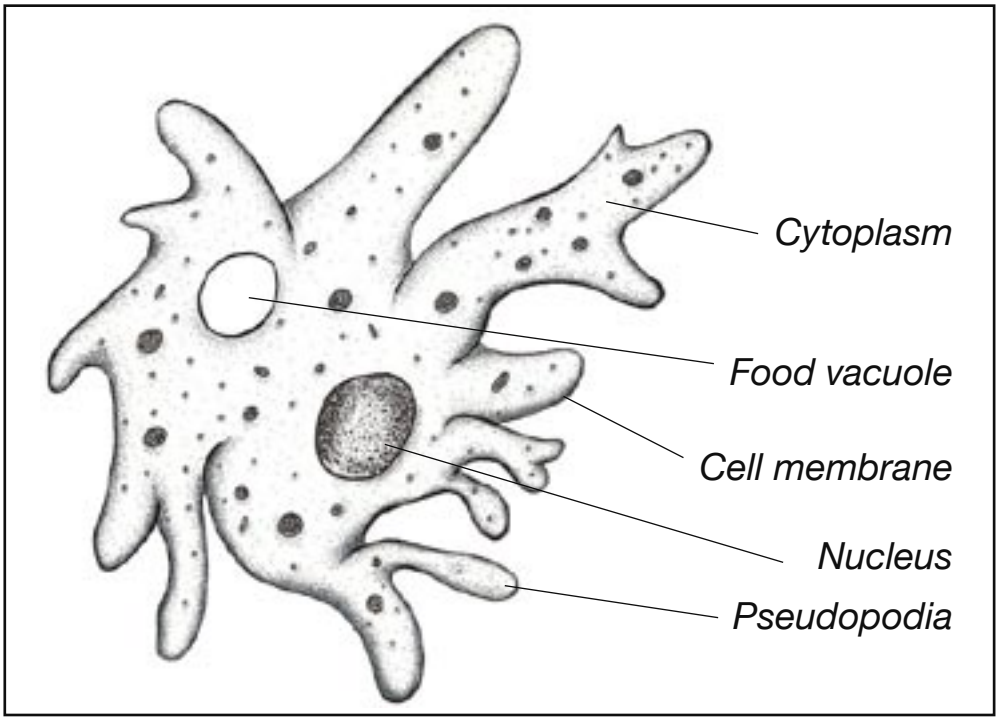
Introduction

The study of microscopic life does not only refer to animals, but to all those things which live in the scale of a drop of water. These can be one-celled plants or animals, or they may not be one-celled at all. Some of these small organisms can be easily classified into a group, for example, a mayfly larva is one of the arthropoda. Others, however, classify with difficulty as the definitions we use with larger life forms are pulled down to the smaller scale. Sometimes this works; sometimes it does not.

There are strange organisms which possess features of both plants and animals. That is, they move and make food from light using chlorophyll or a similar pigment. How should these be classified? The Protista Kingdom is an attempt by scientists to solve this dilemma. As well, some scientists just avoid the whole question and concern themselves with the organisms and not their classification.

In this section of the manual, you will look at some animal-like protists. Later, you will look at some plant-like protists, the phytoplankton, and still later, you will have a chance to observe them all together in their more normal habitat.

Your mixed culture of protozoans should have at least five types of protozoans within it. You might have available a copy of *How To Know The Protozoans* by T.L. Jahn in order to identify the individuals. This helpful book can be found at a library.



Protozoan: Amoeba.

Procedure A

1. Look at your prepared slide of *Amoeba proteus* under low power with your microscope.

2. This is an organism which was long considered to be very simple. The cellular membrane is flexible