





AMERICAN UNIVERSITY OF BEIRUT

HANDS-ON LABORATORY ACTIVITIES FOR GRADE 9  
BIOLOGY STUDENTS: THEORIES AND EXPERIMENTS

by  
JANA ABOU ORM AL RAWAS

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AMERICAN UNIVERSITY OF BEIRUT

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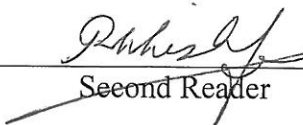
by  
JANA ABOU ORM AL RAWAS

Approved by:

\_\_\_\_\_  
Dr. Saouma B. BouJaoude, Professor  
Department of Education

  
\_\_\_\_\_  
First Reader

\_\_\_\_\_  
Dr. Rola F. Khishfe, Associate Professor  
Department of Education

  
\_\_\_\_\_  
Second Reader

Date of project presentation: February, 2014

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## AN ABSTRACT OF THE PROJECT OF

Jana Abou Orm El Rawass for Master of Science  
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Title: Hands-on Laboratory Activities for Grade 9 Biology Students:  
Theories and Experiments

Research has shown that science hands-on laboratories improve the comprehension of science concepts and develop the desired practical and cognitive skills and the scientific attitudes among students. Additionally, hands-on laboratory work develops scientifically literate students by encouraging them to investigate and experiment. A hands-on laboratory is the context in which students observe, formulate hypothesis, decide on material to use, write a procedure, and draw out conclusions. Experimenting with laboratory equipment helps students understand facts, concepts, ideas, models, theories, laws, and principles. This situation creates the need for laboratory manuals as components of the science curricula. The general objectives of the Lebanese Science Curriculum emphasize the need to develop students' investigative skills. However, these objectives have not been translated into classroom activities because of the absence of appropriately designed laboratory manuals. Consequently, the purpose of this project was to produce a biology laboratory manual for Grade 9 Biology classes. This laboratory manual provides experiments that help Grade 9 students to develop science process skills by involving them in inquiry activities that are different from the typical laboratory activities. Therefore, students discover concepts by following the scientific method for examining phenomena, acquiring new knowledge, or correcting and assimilating prior knowledge based on empirical evidence.

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# CHAPTER I

## INTRODUCTION

This chapter provides a summary of the theoretical framework, research, and practice associated with hands-on biology. Additionally, it presents the history of hands-on biology in both the Western and Lebanese contexts.

### **Evolution of Hands-On Laboratory**

In 1800s, hands-on laboratory work was considered the core of science teaching by science community. During hands-on laboratory work, students read instructions, collect data, report results, and make generalizations. This enhances reading, writing, and arithmetic skills which were the targets of science teaching at that time (Deboer, 1991). Despite being a central component of science education during the nineteenth century, laboratory teaching was not well integrated into the science curriculum. There was no agreement on the goals of instructional approaches to hands-on laboratory work. Thus, teachers were free to decide whether or not to involve students in laboratory work. They were also free to choose their own instructional approach.

The twentieth century was considered a transitional century for education. The main goal of science education shifted from helping students to deal with real life situations toward developing individuals who could contribute to society. To accomplish this, students were expected to work within authentic experiential settings where they can explore natural phenomenon and investigate scientific problems. Being more enjoyable and comprehensible, hands-on laboratory work was expected to increase students' contribution to society (Deboer, 1991).

Specifically after World War II, scientists promoted the development of new curricula that aimed at producing scientifically literate students who could also contribute to society (Deboer, 1991). Lederman and Niess (1998) define a scientifically literate student as the one who understands the content of science; utilizes the process of science; uses science to find solutions for real life problems; distinguishes between evidence and opinion; recognizes the role of science and technology in developing human welfare; and understands the nature of science.

As a result, hands-on laboratory work that develops scientifically literate students by encouraging them to investigate and experiment became essential. Hands-on laboratory is the context in which students observe, formulate hypothesis, decide on material to use, write a procedure, and draw out conclusions. Experimenting with technological equipment and instruments in laboratories helps students understand facts, concepts, ideas, models, theories, laws, and principles (Chiappetta & Kaballa, 2006). This creates the need for laboratory manuals as components of science curricula (Deboer, 1991). It is worth nothing that emphasis on hands-on laboratory work persists until today not only in developed countries but also in developing countries such as Lebanon.

### **Hands-on Laboratory Work in the Lebanese Curriculum**

The Center for Educational Research and Development (CERD) in Lebanon has established the competencies that should be developed in science. These competencies were classified under four domains: Using acquired knowledge, practicing scientific reasoning, mastering experimental techniques, and mastering communication techniques. Examples of these competencies include applying the acquired knowledge , relating the

acquired knowledge to new situations, selecting information by analyzing texts, posing a problem, interpreting results, elaborating a synthesis, using laboratory material adequately, performing experiments, following an experimental protocol, using proper scientific language and using scientific representations (CERD,1995).

Even though Lebanese official exams do not assess students' experimental skills and focus on their acquired knowledge, scientific reasoning, and communication skills (CERD, 1995), these skills are necessary for students to understand the investigative nature of science which is one of the components of scientific literacy. Consequently, this project aims to design a laboratory manual that is aligned with the Lebanese curriculum for science subjects in particular for biology at the grade nine.

### **Purpose**

The purpose of this project is to provide grade nine biology teachers with a laboratory manual that includes hands-on laboratory activities that can be used in biology class or as a model for other experiments. As mentioned earlier, science sessions that incorporate hands-on laboratories, improve students' knowledge, attitude toward science, and technical skills that help them develop their scientific literacy. From this standpoint, there is a need for curriculum designers to incorporate hands-on laboratories into the science curriculum hence encouraging science teachers to use them in their classrooms.

## CHAPTER II

### LITERATURE REVIEW

Laboratories have been found to develop students' skills and attitudes. However, not all laboratory types develop the same skills. In the following section, I discuss the skills and attitudes that are developed when students are involved in laboratories. In addition, I describe the types of laboratories and discuss theoretical frameworks that support hands-on science and conducting hands-on laboratories.

#### **Role of Laboratories in Developing Skills and Attitudes**

The ultimate goal of hands-on laboratories in science education is to enhance the development of scientific literacy. The role of hands-on laboratories is to improve three categories of skills: cognitive skills, design and technical skills, and communication skills. In addition, laboratories have the potential to improve students' attitudes. One of the roles of hands-on laboratories is to develop students' cognitive skills by helping them apply or develop science concepts. During laboratories, students are able to formulate hypotheses, analyze data, draw out conclusions, make decisions, solve problems, develop knowledge schemes, and develop conceptual understanding (Brownell, Kloser, Fukami, & Shavelson, 2012; Chiappetta & Kaballa, 2006; Heering & Wittje, 2012; Hofstein & Lunetta, 1982; Hofstein & Lunetta, 2004; Ma & Nickerson, 2006; Weaver, 1998; Zumbach, Schmitt, Reimann, & Starkloff, 2006). Another role of hands-on laboratories is to help students develop design and technical skills through choosing suitable laboratory equipment and material, planning the laboratory procedure, designing the experimental setup, and conducting the experiment (Brownell, Kloser, Fukami, & Shavelson,

2012;Chiappetta&Kaballa, 2006;Heering&Wittje,2012;Hofstein&Lunetta, 1982; Hofstein&Lunetta,2004; Ma& Nickerson,2006;Zumbach, Schmitt, Reimann, &Starkloff, 2006).

Students can work in teams in laboratories. This enhances interaction and communication among members of the same team which in return develops students' communication skills that are required in daily life. Moreover, interaction between students and the laboratory equipment would help them develop positive attitudes toward science (Brownell, Kloser, Fukami, &Shavelson, 2012; Chiappetta&Kaballa, 2006; Heering&Wittje, 2012; Hofstein&Lunetta, 1982; Hofstein&Lunetta, 2004; Ma&Nickerson, 2006; Roth, 1990; Zumbach, Schmitt, Reimann, &Starkloff, 2006).

### **Types of Laboratories**

With the development of technology, new types of science laboratories emerged. Presently, there exist three types of laboratories: hands-on laboratories, simulated laboratories, and remote laboratories (Corter, Nickerson, Esche, Chassapis, & Ma, 2007; Ma &Nickerson, 2006; Zin&Harun, 2007).

Hands-on Laboratory work is defined by Hofstein and Lunetta (1982) as “contrived learning experiences in which students interact with materials to observe a phenomenon” (p. 201-202). This means that students are physically present in the laboratory to select suitable equipment, plan procedures, investigate specific questions, and collect, record, analyze, and report data (Ma &Nickerson, 2006; Corter, Nickerson, Esche, Chassapis, & Ma, 2007). Similarly, Flick (1993) defined a hands-on laboratory as the context in which students manipulate equipment in a natural environment whether individually, in pairs, or



in groups. In a hands-on laboratory, students apply what they are taught in classrooms using their hands in real contexts (Ma & Nickerson, 2006; Corter, Nickerson, Esche, Chassapis, & Ma, 2007).

Simulated laboratory work is an imitation of the hands-on laboratory work. All the equipment is virtual rather than real which helps reduce the time needed for conducting the experiment. Students can initiate or terminate the experiment at any time they want because the experiment is being conducted in the virtual technological world (Ma & Nickerson, 2006; Zin & Harun, 2007). Remote laboratory (or web-based) work is conducted when students are not in the same spot where the experiment is being conducted. In this context, students communicate with others in different geographical areas via Internet connections (Zin & Harun, 2007). To be successful, a web-based laboratory needs a laboratory server to monitor the experiment, a server that connects remote students with the laboratory server, a webcam, and other tools that facilitate students' visual and auditory involvement in the experiment (Gomes & Bogosyan, 2009).

### **Comparing Types of Laboratories**

A small number of research studies investigated which type of laboratories best serves the goals of science education. Corter, Nickerson, Esche, Chassapis, and Ma, (2007) and Ma and Nickerson (2006) compared the effectiveness of remote, simulated, and hands-on laboratories. Results of a knowledge test showed no difference in achievement among students participating in the three types of laboratories

However, students' perceptions reveal different results. Students perceive the hands-on laboratory work as more educationally effective than the two other types because

they are in physical contact with the apparatus for a longer time (Ma & Nickerson, 2006). In addition, students can see the experimental results and collect data. If they can see the results then they believe in them more than when dealing with technology where they do not see how the data is being collected. Additionally, responses to questionnaires showed that hands-on laboratory work helps students develop social interaction more than the other types of laboratories. Students in hands-on laboratories are able to work more together on collecting, analyzing, and reporting data. In most of the stimulated and remote laboratories, however, some students are working while others are only observing which minimizes the communication and social interaction between members of the group.

Zin and Harun (2007) investigated the perceptions of 200 university lecturers about different types of laboratory work. The lecturers were interviewed and asked to complete a survey concerning their perceptions of hands-on and remote laboratories. Results of analyzing the interviews and surveys showed that lecturers think that hands-on laboratory work serves the undergraduate student best while remote laboratories are not feasible because of slow Internet connections. They added that students need to acquire some remote laboratories skills in order to work with these laboratories. In addition, they recommended assigning a specialist who can take care of remote laboratories because even lecturers are not trained and do not have the knowledge and confidence to use these laboratories.

Freedman (1997) studied the effect of hands-on laboratories on attitudes toward science and achievement in science. The participants in the study were ninth graders from a large urban high school. Students were divided into two groups: a control group who did

not conduct hands-on laboratories and an experimental group who performed hands-on laboratories in a physical science course. The midterm and the final exam scores were used to assess students' performance in physical science. Comparing the two group scores showed that the hands-on laboratory had a positive impact on students' achievement in physical science. Moreover, students' attitudes in both groups were assessed using an attitude survey. Results of the survey showed that hands-on laboratories had positively influenced students' attitude toward science.

Knox, Moynihan, and Markowitz, (2003) studied the impact of a hands-on laboratory program on students' knowledge and skills. High school students who completed a number of biology courses participated in the study. The hands-on laboratory program was related to biology concepts in particular to genetics and DNA. Throughout the course, the students' role was to select the suitable material, design the experimental setup, carry out the experiment, collect data, analyze the results, and report the results either orally via presentations or by writing a report or drawing graphs and posters. Results of data analysis showed that the hands-on laboratory had a positive impact on students' knowledge related to the concepts of interest. In addition, 80% of the students stated that hands-on laboratories had positively influenced their interest in science and performance in biology because they accessed the laboratory equipment and were able to investigate biology concepts (Knox, Moynihan, & Markowitz, 2003).

In summary, we can conclude that hands-on laboratories have been given a dominant role in science education due to their crucial role in enhancing scientific literacy and inquiry. In addition, results of most research have shown that hands-on laboratories

improve achievement and attitude toward science. Such results provide strong evidence that supports the need for incorporating hands-on laboratory work into science classrooms (Brownell, Kloser, Fukami, & Shavelson, 2012).

### **Theoretical Frameworks that Support Hands-on Science**

Theoretical support for conducting science laboratories comes from the work of many educators such as Dewey (1916/2009) and Kolb (2005) who emphasized the importance of experiential learning and Klopfer (1971) who adapted Bloom's taxonomy to include laboratory skills.

#### ***Dewey's and Kolb's Experiential Learning Theory and Hands-On Laboratory***

John Dewey was one of the enthusiastic proponents of hands-on and experiential education and learning. He suggested that "if knowledge comes from the impressions made upon us by natural objects, it is impossible to procure knowledge without the use of objects which impress the mind" (Dewey, 1916/2009, p. 217-218).

Kolb's experiential learning theory relies on the constructivist view of human learning in which experience plays a major role (Abdulwahed & Nagy, 2009; Kolb & Kolb, 2005). The experiential learning theory was built on the proposition that learning is achieved when students are engaged in a process that triggers learning, when students' knowledge is expanded through assimilation or accommodation, when learning does not deal with thinking only but with a combination of thinking, feeling, and acting, and finally when there is a relation between the learner and the environment (Kolb & Kolb, 2005).

Hands-on laboratory work is a direct application of these propositions. In the laboratory, students test their acquired knowledge about a specific topic. Being engaged in

the investigation helps students modify their prior knowledge or add to it. Students in the laboratory are in direct contact with the equipment, materials, and tools. At the same time they are communicating with each other and this communication helps develop their feelings and actions. Therefore, we can say that hands-on laboratory work is aligned with the propositions which Kolb's experiential learning theory relies on.

According to Kolb's experiential learning theory, learning occurs when students grasp and transform knowledge. Additionally, Abdulwahed and Nagy (2009, p. 285) suggested that "learning something from the experiment, or in other words, the transformation phase for constructing new knowledge through experimentation, requires first the information to be grasped or depicted". To accomplish this, students should complete four stages: concrete experience, abstract experience, reflective observation, and active experimentation. Students grasp knowledge through apprehension that is concrete experience or through comprehension that is abstract conceptualization or through both in order to transform it. Transformation of knowledge could be achieved by intension which is reflective observation or extension which is active experimentation. During the hands-on laboratory work, students are mainly in the active experimentation stage.

### ***Klopfer's Taxonomy and Hands-On Laboratory***

classification is examined. Klopfer's (1971) taxonomy of the objectives of science education comprises the following categories: knowledge and comprehension, processes of scientific inquiry, application of scientific knowledge and methods, manual skills, attitudes and interests, and orientation. Furthermore, the area of scientific inquiry is divided into the following four subcategories: observing and measuring, seeing a problem

and seeking ways to solve it, interpreting data and formulating generalization, and building, testing, and revising a theoretical model. Specifications for the knowledge and comprehension category are knowledge of specific facts, scientific terminology, concepts of science, conventions, trends and sequences, classifications, categories and criteria, scientific techniques and procedures, and scientific principles and laws (Klopfer, 1971). Additionally, application to new problems in the same or different field of science and application to new problems outside of science are some of Klopfer's specification to the application of scientific knowledge and methods category. Development of skills in using common laboratory equipment, and performance of common laboratory techniques with care and safety are two specifications for the manual skills category (Klopfer, 1971).

Klopfer's specifications for the attitudes and interests category are: manifestation of favorable attitudes towards science and scientists, acceptance of scientific inquiry as a way of thinking, adoption of scientific attitudes, enjoyment of science learning experiences, development of interest in science and science related activities, and development of interest in pursuing a career in science (Klopfer, 1971).

Similarly, Klopfer's specifications of the orientation category include: relationships among various types of statements in science, recognition of the philosophical limitations and influence of scientific inquiry, and awareness of the social and moral implications of scientific inquiry and its results.

In addition to the above, Klopfer (1971) provided specifications for the subcategories of the scientific inquiry process. In the process of scientific inquiry students observe objects and phenomena, describe them using appropriate language, and select

appropriate measuring instruments in order to measure objects and change. Also students recognize a problem, formulate a hypothesis, test the hypothesis, and design an appropriate procedure for performing experiments. Interpreting data and formulating generalizations during the process of scientific inquiry requires that students present the data in the form of functional relationship, interpret their observations, and extrapolate and interpolate. Finally, students formulate theoretical models to accommodate knowledge, deduce a new hypothesis from a theoretical model, interpret and evaluate tests of a model, and formulate a revised, refined, extended model.

### **Types of Hands-on Laboratory Approaches**

Hands-on laboratory work can be employed either to confirm an idea previously taught in class, develop manipulative skills that are essential for laboratory work, or facilitate concept development. The aim of hands-on laboratory work determines the laboratory approach. There exist five categories of laboratory approaches: science process skills, deductive, inductive, technical, or problem solving (Chiappetta&Kaballa, 2006).

#### ***Science Process Skills Laboratory Approach***

When the desired outcomes of the hands-on laboratory focus on helping students develop one or more of the mental process skills associated with science and use inquiry skills, then the laboratory approach is classified as science process skills laboratory. A sample of these skills includes observing, describing, explaining, measuring, hypothesizing, communicating, and experimenting (Chiappetta&Kaballa, 2006).

### ***Deductive Versus Inductive Laboratory Approach***

The purpose of the deductive approach is to present evidence for an abstract idea, law, or concept previously explained in class. Before going to the laboratory, teachers explain the science concepts and specify what the students are going to determine during the laboratory session. In the laboratory, the hands-on laboratory activity verifies the abstract idea taught by the teacher.

The inductive laboratory approach is the inverse of the deductive approach. Teachers provide students with hands-on laboratory experiences that help them visualize abstract ideas. Based on observations, students construct knowledge and develop concepts, principles, and laws (Chiappetta&Kaballa, 2006).

To provide an example, the inductive approach was formalized into the Learning Cycle which includes three phases: exploration, invention, and application. In the first phase, students are engaged in laboratory activities that help them experience an event and think about a concept. In the second phase, students discover relationships and explain the concepts they have just experienced. In the application phase, students discover examples that illustrate the explained concept and show applications of the concept in everyday life (Liu, Peng, Wu, & Lin, 2009). The three-step learning cycle was modified to become the 5E Learning Cycle in which the three phases were expanded into five: engagement, exploration, explanation, elaboration, and evaluation. In the engagement phase, the teacher asks questions that create interest and cause doubt in the topic of study. During exploration, the students conduct activities that help them make connections between prior and existing knowledge through exploring new resources, making designs, collecting data,



and building models. During explanation, the students demonstrate their understanding. In the elaboration phase, the students' conceptual understanding is extended by applying the acquired concept in new situations. Finally, in the evaluation phase, the students' progress throughout the learning experience is evaluated by the teacher and by the students themselves (Liu, Peng, Wu, & Lin, 2009).

### ***Technical Skill Laboratory Approach***

Laboratory techniques and manipulative skills are necessary for conducting successful hands-on laboratory activities. Examples of the techniques and manipulative skills that are essential for science hands-on laboratories are: dissecting a frog, sketching an organism, focusing a microscope, sterilizing instruments, measuring temperature with thermometer, etc... (Chiappetta&Kaballa, 2006).

### ***Problem-Solving Laboratory Approach***

This approach recommends the involvement of students in an authentic inquiry experience. Students are asked to identify a problem, design a procedure, collect data, organize and interpret the findings, and submit a report (Chiappetta&Kaballa, 2006).

Hands-on laboratory activities can be used to encourage inquiry teaching and learning. The students can work during the hands-on laboratory in a way that mirrors the way scientists work. During inquiry activities, students, the teacher, or both generate a problem that is relevant to the students' interest or need. Then students formulate hypotheses, do planning, design experiments, decide on what data to collect, analyze their data, and generalize (Chiappetta&Kaballa, 2006). Because hands-on laboratory activities come with varying levels of openness, Herron's scale was developed to classify

inquiry activities and to rate the laboratory openness. Herron's scale identified four levels of inquiry. In the first level, level 0, the problem, experimental procedure, and the results are provided to the students. In the second level, level 1, the problem and the experimental procedure which students have to follow in order to gather results are provided. In level 2 on Herron's scale, students are given the problem but this time the students had to develop a method themselves for solving the problem. In level 3, the problem, answers, and methods are open (Walker, 2007).

All of the above suggest that inquiry is a means to acquire science concepts; however, it could also be an end by itself. When inquiry is an end, it is no more a vehicle and understanding the content is no more the end. In this case, the subject matter serves as a means for the development of the abilities necessary to do inquiry in science. Teachers prepare structured laboratory activities in which students are able to conduct a full inquiry stemming from their questions (Jay, 1998).

### **Conducting Hands-on Laboratories**

Science teachers who aim to conduct hands-on laboratories should prepare thoroughly. Teachers should organize a pre-laboratory session before the laboratory activity and then follow the latter with a post-laboratory session. In the pre-laboratory session teachers review the concepts, laws, and the facts to be verified or applied. In addition, teachers give directions and discuss the steps to be followed during the laboratory session (Chiappetta&Kaballa, 2006).

During the laboratory session, teachers provide students with handouts or laboratory manuals. The problem or the aim of the experiment is clarified and students are

expected to know which materials and equipment to use and what techniques to employ. Moreover, teachers ask students to write a laboratory report that includes the problem, material, procedure, results, and conclusion. In the laboratory, students could work individually, in pairs, or in small groups. To ensure its effectiveness, teachers should provide safety and discipline during the laboratory activity. It is important to mention also that students' behavior and technical skills should be evaluated and this could be achieved through close observation (Chiappetta&Kaballa, 2006).

In a post-laboratory session, students can be asked to present their results to the class so that they can be discussed and related to what students are studying. Moreover, feedback is provided by the teacher regarding student work during the laboratory session (Chiappetta&Kaballa, 2006).

## CHAPTER III

### CONCLUSION

Laboratory activities are primarily designed to provide opportunities to improve student learning. Not all types of laboratory activities however aim at improving students' cognitive and mental skills and at developing positive scientific attitudes among students. According to Kolb's Experiential Learning Theory and Klopfer's Taxonomy gains from laboratory work are optimal when the laboratory involves the use of both physical and mental skills. Research studies have shown that hands-on laboratory activities aim at producing scientifically literate students who can investigate, discover, and make decisions depending on data gained from conducting experiments. Using the inquiry based approach, a student is able to build a hypothesis, test a hypothesis, design an experiment, conduct an experiment, collect data, and draw out a conclusion. Moreover, during hands -on laboratory activities students develop positive attitudes toward science and science laboratories (Chiappetta&Kaballa, 2006).

While research has shown that there are significant gains from conducting hands-on laboratories, more research is needed on how students' understandings of complex concepts develop from hands-on laboratory activities and how their attitudes, cognitive skills, and practical skill are fostered. In addition, more studies should address the issue of integrating hands-on laboratory activities into science classroom so that optimal understanding of concepts, development of practical skills, and positive attitudes toward science.

In conclusion, the integration of hands-on laboratory activities in the science curricula holds the promise to improve students' cognitive skills, practical skills, and attitudes.

## CHAPTER IV

### RECOMMENDATIONS

Using hands-on laboratory activities in science helps develop scientifically literate students who can investigate and experiment. These types of laboratory activities help students to grasp concepts and principals in science that require high cognitive skills. Therefore, the integration of hands-on laboratory activities into the Lebanese existing curriculum is expected to improve students' comprehension of facts, concepts, ideas, models, theories, laws, and principals. More importantly, hands-on laboratory activities provide students with opportunities to act like scientists and to verify what they have learned or construct their own knowledge. Moreover, research has shown that experimenting with technological equipment and instruments in laboratories helps to develop the desired practical skills and the desired scientific attitudes among students.

In summary, instruction which integrates hands-on laboratories can lead to higher achievement and more in-depth understanding, more positive attitudes toward science, and the development of both practical and higher cognitive skills. This demonstrates the importance of promoting hands-on laboratory activities among curriculum developers, educational policymakers, as well as encouraging science teachers to increase the use of hands-on laboratories in their classrooms.

## CHAPTER V

### INTRODUCTION TO THE HANDS-ON LABORATORY ACTIVITIES

This project focuses on hands-on laboratory experiences that have the potential to help students encounter the wonders of Biology. It is hoped that by involving students in these hands-on laboratory activities, their understanding of biology concepts, their thinking skills, and their practical skills will improve. The activities in this manual are based on the Grade 9 Lebanese Biology Curriculum. Consequently, the hands-on laboratory activities are related to the instructional objectives highlighted in the Grade 9 Biology Curriculum. These objectives focus on preparing students to conduct scientific investigations, apply scientific methods, and develop reasoning and communication skills. To achieve the objectives provided above, the manual includes inductive, deductive, science process and technical skills, and problem- solving activities. The manual includes ten activities each of which consists of the following sections:

1. Table of contents: Table 1 provides the names of the chapters and the lessons in the official textbook based on the Lebanese Curriculum. This helps teachers know to which chapter and lesson the hands on laboratory activity is related.
2. The table of contents is followed by the laboratory activities, each of which includes the following:
  - a. Laboratory exercise: This provides the title of the hands-on laboratory activity.

- b. Allotted time: This helps teachers know the time needed for the hands-on laboratory activity.
  - c. Learning outcomes: This section provides the learning outcomes that students will be expected to achieve at the end of each laboratory activity. It describes the expected outcomes the students should demonstrate in terms of knowledge or mental and practical skills. A hands-on laboratory activity could include one or more learning outcomes.
  - d. Introduction: This section includes a summary of the main details of the subject material of each concept addressed.
  - e. Laboratory approach: This section identifies the laboratory approach used in each hands-on laboratory activity. The approaches are: deductive, inductive, science process skills, technical skills, and problem- solving. Each activity follows one or a combination of approaches.
  - f. Materials: This section lists all materials required for the laboratory activity.
  - g. Procedure: This section includes step-by-step instructions for conducting the hands-on laboratory activities.
3. Questions: It includes the questions included in each laboratory activity. Such questions could be used during or after the laboratory activity.

The following are the objectives of the grade nine biology curriculum in Lebanon. It is important to note that the action verbs used in these objectives were modified to make them more aligned with Bloom's Taxonomy and with the requirements of good objectives.



Students will be able to:

1. Identify the chemical organic constituents of certain foods by using appropriate reagents (Fehling's reagent for sugars, iodine water for starch...)
2. List, based on the observation of a microscopic section of the intestinal mucosa, the characteristics of the wall of the small intestine.
3. Relate the characteristics of the small intestine, observed by the microscope, to the intestinal absorption of nutrients.
4. Discover the organization of the heart from a dissection of a sheep heart.
5. Recognize during the dissection that the heart is an organ made of cavities; two atria and two ventricles whose muscular wall is supplied with blood.
6. Formulate a hypothesis about the role of valves observed during the dissection.
7. Identify, based on the microscopic observation of a dividing cell, the different phases of cell division.
8. Perform an experiment on the digestion of starch by saliva similar to the one suggested in the textbook.
9. Measure the tidal volume and the vital capacity.
10. Identify, through an experiment, that digestive enzymes are specific.
11. Identify, through experiments, which enzymes only act under specific conditions of pH and temperature.
12. Describe, after the extraction, the chromosomes of onion cells.
13. Design an experimental setup that illustrates the digestion of protein by a commercial protease.

14. Design an experiment to investigate if your body position/posture can affect vital capacity.
15. Determine the characteristics of nutrients through analyzing the experimental results related to the passage of glucose through the cellophane membrane.

### **Illustrative Example**

Using hands-on laboratory activities in science helps develop scientifically literate students who can investigate and experiment. To illustrate, the hands-on laboratory activity on tidal volume and vital capacity, appendix vii, helps students to grasp the concept of vital capacity and tidal volume. Therefore, the integration of this hands-on laboratory activity into the Lebanese existing curriculum is expected to improve students' comprehension of the ideas related to the volume of inhaled and exhaled air. Moreover, this hands-on laboratory activity provides students with opportunities to measure the diameter of the balloon, calculate its volume, formulate a hypothesis to test the relation between body posture and vital capacity on one hand and tidal volume on another, design an experimental procedure, and explain the effect of smoking on vital capacity and tidal volume. Students' persistence to repeat the experiment three times, their ability to calculate the capacity and the tidal volume of their own lung and to explain the effect of smoking are also developed in this hands-on activity. Thus, the integration of this hands-on laboratory activity helps students to grasp concepts and facts and to develop the desired practical skills and the desired scientific attitudes. Table 1 presents the hands-on laboratory activities included in this project, related chapter from the grade 9 textbook published by CERD, and the learning outcomes of each of the activities.

Table 1

*Hands-On Laboratories Included in the Project, Related Chapters and Lessons and Learning Outcomes*

Hands-on laboratory	Related Chapters	Learning Outcomes
1. Chemical Composition of Food	Transformation of Food into Nutrients: Digestion	<ul style="list-style-type: none"> <li>- identify composition of food</li> <li>- perform laboratory tests to identify composition of food</li> </ul>
2. Digestion of Starch	Transformation of Food into Nutrients: Digestion	<ul style="list-style-type: none"> <li>- verify the digestion of starch into reducing sugar.</li> </ul>
3. Digestion of Protein	Transformation of Food into Nutrients: Digestion	<ul style="list-style-type: none"> <li>- formulate hypothesis</li> <li>- control variables</li> <li>- design an experiment that allows protein digestion.</li> <li>- observe results</li> <li>- interpret results</li> </ul>
4. Properties of Enzyme	Transformation of Food into Nutrients: Digestion	<ul style="list-style-type: none"> <li>- conclude that enzymes work best at specific temperature and pH.</li> <li>- conclude that enzymes digest specific substrates</li> </ul>
5. Characteristics of Nutrients	Transformation of Food into Nutrients: Digestion	<ul style="list-style-type: none"> <li>- determine characteristic of nutrients based on experiment results</li> <li>- conclude that nutrients can pass the cell membrane to enter the cell</li> </ul>
6. Structure of Small Intestine	Transformation of Food into Nutrients: Digestion	<ul style="list-style-type: none"> <li>- label parts of microscope</li> <li>- identify the role of each part</li> <li>- use microscope</li> <li>- identify the structure of small intestine based on observation</li> </ul>
7. Tidal Volume and Lung Capacity	From Nutrients to Energy : Respiration	<ul style="list-style-type: none"> <li>- measure tidal volume and vital capacity</li> <li>- design an experiment to investigate a factor that can affect the vital capacity</li> </ul>
8. Heart Dissection	Transport and Distribution of Nutrients and Oxygen to Organs	<ul style="list-style-type: none"> <li>- name the tools of a dissecting kit</li> <li>- identify the role of each</li> <li>- dissect a heart</li> <li>- identify the structures of a mammalian heart</li> </ul>
9. Chromosomes	Chromosomes Carriers of Genetic Information	<ul style="list-style-type: none"> <li>- Describe a chromosome : the carrier of genetic information</li> </ul>
10. Cells during Division	Confirmed Reproduction of Genetic Information	<ul style="list-style-type: none"> <li>- identify the stage of cell division</li> <li>- describe the chromosomal behavior at each stage</li> </ul>

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## APPENDIX I

### HANDS ON LABORATORY 1: CHEMICAL COMPOSITION OF FOOD (CERD, 1997; Skavaril, Finnen, Lawton, 1993)

#### **Chapter 1: Transformation of Food into Nutrients: Digestion**

#### **Activity 1: Our Food**

#### **Laboratory Exercise 1: Chemical Composition of Food**

**Allotted Time: 2 periods**

**Instructional Approaches: Inductive and Science Process Skills**

#### **Learning Outcomes:**

By the end of this Laboratory activity, you should be able to:

- 1- Identify, by using specific reagents, the chemical constituents of some kinds of food.
- 2- Perform, based on a given procedure, the laboratory tests for identifying the chemical composition of some kinds of food.

#### **Introduction**

Food is a nourishing material eaten, drunk, or otherwise metabolized by the body to sustain life, provide energy, promote growth, etc. Almost all food consumed by the organisms, of animal or plant origin, contains inorganic substances such as water and minerals and at least one of the organic substances, proteins, carbohydrates, and lipids.

The organic and inorganic constituents of food can be identified through specific chemical reactions. For each organic constituent, there is a corresponding reagent identifying it. Iodine solution tests the presence of starch, Fehling's reagent tests the presence of sugars, Biuret reagent tests the presence of proteins, and Sudan III tests the presence of lipids.

#### **Carbohydrates**

Carbohydrates are known as energy sources. Carbohydrates may be classified as monosaccharides, disaccharides, or polysaccharides. Monosaccharides are simple sugars such as: fructose, galactose, and glucose. Glucose is a readily usable energy source.

Two monosaccharides bonded together form a disaccharide. A common disaccharide is sucrose, a table sugar. It consists of one glucose unit bonded to one fructose unit. Maltose and lactose are other examples of disaccharides. Maltose is made



of two glucose units while lactose is made of one glucose unit and another galactose unit.

Three or more bonded monosaccharides form a polysaccharide. Starch, cellulose, and glycogen are examples of polysaccharides. These consist of many glucose units bonded together in a chain. Starch and cellulose are found in plants while glycogen is found in animals.

## **Proteins**

Proteins have important roles in the living organisms. Proteins are major components of body tissues for example blood and muscles. They are large complex molecules consisting of many simple molecules bonded together. Protein molecules consist of multiple amino acid molecules linked together in a long chain. The protein has a specific structure and if it is disturbed then the protein loses its function.

## **Lipids**

Lipids contain at least twice the energy storing capacity as carbohydrates do. Lipids are compounds composed of a glycerol molecule (an alcohol) bonded to three fatty acid molecules. Lipids include fats, oils, steroids, phospholipids, and cholesterol. Lipids do not dissolve in water. Instead they are soluble in solvents like ether or acetone.

### **Activity 1.1: Fehling Test for Sugars**

Testing for sugars. Some sugars are called reducing sugars and these react with Fehling's reagent. Upon heating the reaction, Fehling's reagent changes its color from blue to orange. This change is a positive test.

You will test 7 kinds of food using Fehling's reagent to determine which of them contain sugars.

#### **Materials Needed:**

- Minimum of seven test tubes
- Test tube holder
- Test tube rack
- Boiling water bath
- Wax pencil
- Metric ruler
- Fehling's reagent in a dropper bottle
- Distilled water
- Food samples: milk, mashed potato, honey, apple juice, grape juice, and starch solution.

#### **Experimental Procedure:**

1. Work in groups of three or four. Ask a group member to bring all the materials needed to perform the test. Ask another member to turn on the water bath, set it at 100°C, and fill it with distilled water.

2. Use the metric ruler and the wax pencil to mark one centimeter and three centimeters from the tubes bottom of the seven clean test tubes. Label the test tubes as 1, 2, 3, 4, 5, 6, &7. Place the tubes in the test tube rack.
3. Fill each test tube up to one centimeter with one of the food samples: distilled water (test tube 1), milk (test tube 2), grape juice (test tube 3), starch solution (test tube 4), honey (test tube 5), mashed potato (test tube 6), and apple juice (test tube 7).
4. Add Fehling's reagent to the three centimeter mark of all test tubes.
5. Place all test tubes in the boiling water bath and keep them for five minutes.
6. Remove the test tubes from the hot water bath using the test tube holder and place them in the test tube rack.
7. Record, in table 1.1, the observed color in each test tube.
8. When you finish, dispose the contents of each test tube as instructed by your teacher. Turn off the water bath.
9. Answer the questions on the answer sheet provided by the teacher.

## Results

Table 1.1

*Solutions and Color Reactions with Fehling's Test for Sugars*

Tube	Food	Fehling's Color Reaction	Conclusion
1	Distilled water		
2	Milk		
3	Grape juice		
4	Starch solution		
5	Honey		
6	Mashed potato		
7	Apple juice		

## Questions:

1. Use the above table to indicate which carbohydrate solution contains sugar.
2. What do scientists call the test tube containing distilled water? Indicate its importance.
3. How long does the flavor last in your chewing gum? Why it seems like the gum gets smaller after you chew it?

## **Activity 1.2: Iodine Test for Starch**

Testing for starch: Starch is stored in the seeds, the roots, and the tubers of plants. The iodine reaction with starch results in a color change from yellow to dark blue. A dark blue color, a positive result, reveals the presence of starch in the tested food samples.

You will test 7 kinds of food with iodine solution to determine which of them contain starch.

### **Materials Needed:**

- Minimum of seven test tubes
- Test tube rack
- Wax pencil
- Metric ruler
- Dropper
- Iodine solution in a dropper bottle
- Distilled water
- Food samples: milk, mashed potato, carrot juice, mashed banana, grape juice, and starch solution.

### **Experimental Procedure:**

1. Work in groups of three or four. Ask a group member to bring all the materials needed to perform the test.
2. Use the metric ruler and the wax pencil to mark one centimeter from the tubes bottom of the seven clean test tubes. Label the test tubes as 1, 2, 3, 4, 5, 6, & 7. Place the test tubes in a test tube rack.
3. Fill each test tube up to one centimeter with one of the food samples: distilled water (test tube 1), milk (test tube 2), grape juice (test tube 3), starch solution (test tube 4), mashed potato (test tube 5), carrot juice (test tube 6), and mashed banana (test tube 7).
4. Using the dropper, add 5 drops of iodine solution to all test tubes.
5. Swirl the tubes thoroughly to mix the contents.
6. Record, in table 1.2, the color observed in each test tube.
7. When you finish, dispose the contents of each test tube as instructed by your teacher.
8. Answer the questions on the answer sheet.

## Results

Table 1.2  
*Solutions and Color Reactions for Iodine solution*

Tube	Food	Iodine Color Reaction	Conclusion
1	Distilled water		
2	Milk		
3	Grape juice		
4	Starch solution		
5	Mashed potato		
6	Carrot juice		
7	Mashed banana		

### Questions:

1. Where do you see a blue black color other than in the starch solution?
2. What color would you obtain upon adding iodine solution to a green leaf that as exposed to sunlight all day. Formulate, by referring to your knowledge, a hypothesis to explain the obtained result.
3. If you mix carrot juice with Fehling's reagent in previous experiment, would a color change occur? Explain why or why not?

### Activity 1.3: Biuret Test for Protein

Testing for proteins: The amino acids are linked together by peptide bonds that react with copper sulfate. The latter is used in Biuret to test for proteins. A violet color with Biuret reagent reveals a positive result for the presence of protein.

You will test 5 kinds of food with Biuret solution to determine which of them contain protein.

### Materials Needed:

- Minimum of five test tubes
- Wax pencil
- Test tube rack

- A dropper
- Metric ruler
- 10% NaOH solution
- 1% CuSO<sub>4</sub> solution
- Distilled water
- Food samples: milk, honey, corn oil, and egg white

**Experimental Procedure:**

1. Work in groups of three or four. Ask a group member to bring all the materials needed to perform the test.
2. Use the metric ruler and the wax pencil to mark two centimeters and four centimeters measured from the tubes bottom of the five clean test tubes. Label the test tubes as 1, 2, 3, 4, & 5. Place them in the test tube rack.
3. Fill each test tube up to two centimeters with one of the food sample: distilled water (test tube 1), honey (test tube 2), corn oil (test tube 3), egg white (test tube 4), and milk (test tube 5).
4. Add 10% NaOH solution to each test tube up to the four centimeters mark.
5. Add, using a dropper, 5 drops of CuSO<sub>4</sub> solution to all test tubes.
6. Swirl thoroughly the tubes to mix the contents.
7. Record the color observed in each test tube in table 1.3
8. When you finish, dispose the contents of each test tube as instructed by your teacher.  
**Caution:** Sodium hydroxide (NaOH) causes skin burn. Wash with soap and water if contact occurs with skin.
9. Answer the questions on the answer sheet.

**Results**

Table 1.3

*Solutions and Color Reactions for Biuret solution*

Tube	Food	Biuret Color Reaction	Conclusion
1	Distilled water		
2	Honey		
3	Corn oil		
4	Egg white		
5	Milk		

**Questions:**

1. Which foods contain protein?

2. Would you expect a solution containing fresh saliva to yield a positive Biuret testing? Try it then explain the results obtained.
3. What color change would occur if Iodine solution was added to the egg white?
4. Write a paragraph that summarizes all your conclusions.

#### **Activity 1.4: Sudan III Test for lipids**

Testing for lipids: liquid Sudan III is made with ether as a solvent in which lipids can dissolve. Therefore, solubility in Sudan III can be used as a positive test for lipids. Non lipid substances will not dissolve in Sudan III. When a liquid get mixed with Sudan III, then lipid is present and consequently this is considered a positive result. If two layers, a layer of liquid and a layer of Sudan III, are observed then lipid is absent. Therefore, this is considered a negative result.

You will test 5 kinds of food with Sudan III solution to determine which of them contain lipid

#### **Materials Needed:**

- Minimum of five test tubes
- Wax pencil
- Test tube rack
- A dropper
- Metric ruler
- Sudan III liquid
- Distilled water
- Food samples: milk, honey, corn oil, and egg white

#### **Experimental Procedure:**

1. Work in groups of three or four. Ask a group member to bring all the materials needed to perform the test.
2. Use the metric ruler and the wax pencil to mark two centimeters measured from the tubes bottom of the five clean test tubes. Label the test tubes as 1, 2, 3, 4, &5. Place them in the test tube rack.
3. Fill each test tube up to two centimeters with one of the food sample: distilled water (test tube 1), honey (test tube 2), corn oil (test tube 3), egg white (test tube 4), and milk (test tube 5).
4. Use the dropper to add 10 drops of Sudan III liquid to each test tube. Swirl the tubes to mix.
5. Examine the tubes. Record the observed color in table 1.4.  
**Caution:** Sudan III liquid is a powerful stain. Avoid contact with skin and clothing.
6. When you finish, dispose the contents of each test tube as instructed by your teacher.
7. Answer the questions on the answer sheet. Hand it in to your teacher.

## Results

Table 1.4

*Solutions and Sudan III reaction for Lipid*

Tube	Food	Sudan III Reaction	Conclusion
1	Distilled water		
2	Honey		
3	Corn oil		
4	Egg white		
5	Milk		

### Questions:

1. Which food contains lipid? Justify your answer by referring to the table.
2. Which foods contain more calories: honey or corn oil? Observe the tubes, compare the results, and provide an explanation.

## APPENDIX II

### HANDS ON LABORATORY 2: DIGESTION OF STARCH (CERD, 1997)

#### **Chapter 1: Transformation of Food into Nutrients: Digestion**

#### **Activity 2: Chemical Transformation of Food**

#### **Laboratory Exercise 2: Digestion of Starch**

**Allotted Time: 1 period**

**Instructional Approaches: Deductive and Science Process Skills**

#### **Learning Outcomes:**

By the end of this Laboratory activity, you should be able to:

- 1- Perform, by following a given procedure, an experiment showing the digestion of starch into sugars.
- 2- Verify, using the suitable reagents, that starch is digested into sugars under the action of salivary amylase.

#### **Introduction**

Digestion allows the gradual breakdown of complex molecules into simple ones by the action of chemical substances called digestive enzymes. The macromolecule of starch is transformed into many molecules of glucose under the action of two enzymes: amylase and maltase. Amylase acts on starch and transforms it into maltose; maltase acts on maltose and transforms it into glucose.

Many organs of the digestive tube secrete digestive juices containing enzymes that are responsible for the chemical transformation of food. Salivary glands in the mouth secrete the digestive juice saliva that contains the enzyme amylase. On the other hand, the intestinal gland in the small intestine secretes the intestinal juice that contains the enzyme maltase.

To test for the action of salivary amylase, iodine solution and Fehling reagent should be used. If iodine solution changes from yellow to blue then starch is present. If Fehling color turns brick red upon heating, then sugar is present. These tests should be performed at the beginning and at the end of the experiment.

#### **Activity 2.1: Starch Digestion**

You will perform an experiment that would allow starch digestion into sugars.

#### **Materials Needed:**

- 10 grams of starch



- Distilled water
- 2 to 5 ml of amylase from your saliva
- Graduated cylinder
- Small beaker
- Bunsen burner
- Minimum of six test tubes
- Water bath at 37°C
- Water bath at 100°C
- Wax pencil
- Iodine solution in a dropper bottle
- Fehling's reagent in a dropper bottle
- Dropper
- Pipette
- Test tube rack
- Test tube holder

### **Experimental Procedure:**

1. Work in groups of three or four. Ask a group member to bring all the materials needed. Turn on the two water baths, set one at 37°C and the other at 100°C, and fill them with distilled water. Check the temperature frequently to make sure that the water baths are maintaining the proper temperatures.
2. Prepare the starch paste:
  - Dissolve 10 grams of starch in 100 ml of distilled water in a small beaker.
  - Shake well until you obtain a milky starch.
  - Turn on the Bunsen burner, heat the milky starch until boiling, and then turn off the burner.
3. Take two test tubes. Use wax pencil to mark the tubes A and B. place the tubes in the test tube rack.
4. Fill 1/4 of each test tube with starch paste. Make sure that both tubes contain equal amount of starch paste.
5. Using the graduated cylinder measure then add 2 ml of fresh saliva from your mouth to tube A and distilled water of the same quantity of saliva to tube B.
6. Place these tubes in a water bath at 37°C.
7. Use a pipette to take two samples from each test tube. Place each sample in a test tube. Observe the color of the tubes and record the color of the tube before adding any reagent in table 2.1.
8. Using the dropper, add to one sample from each tube 10 drops of iodine solution and swirl the tubes. Record the observed color with iodine solution at the beginning of the experiment in table 1.1
9. Use a dropper to add 20 drops of Fehling's reagent to the other sample taken from each test tube. Place the samples containing Fehling in the water bath at 100°C for 5 minutes. Use the test tube holder to remove them from the boiling water bath. Place the tubes in the test tube rack.
10. Observe the color of the test tubes with Fehling's reagent at the beginning of the experiment and record your observation in table 2.1.
11. Wait for 15 minutes.
12. Repeat the steps from 7 to 10 to observe the change in colors of the tubes at the end of the experiment.

13. When you finish, dispose the contents of each test tube as instructed by your teacher. Do not forget to turn off the water baths.
14. Answer the questions on the answer sheet provided by the teacher. Hand it in to your teacher.

### Results

Table 2.1

*Color Reactions for Iodine Solution and Fehling's Test*

Time	Tube	Color before adding reagents (original color)	Iodine Color Reaction	Fehling Color Reaction
Time =0 minutes	A			
	B			
Time = 15 minutes	A			
	B			

### Questions:

1. Identify the control and the experimental tubes.
2. Compare the color of tube A when tested with iodine and Fehling reagents at the beginning of the experiment to that at the end of the experiment.
3. Compare the color of tube B when tested with iodine and Fehling reagents at the beginning of the experiment to that at the end of the experiment.
4. Based on your comparison, verify the digestion of starch.
5. Based on your experimental results explain the following expression:  
Molecular Simplification.

## APPENDIX III

### HANDS ON LABORATORY 3: DIGESTION OF PROTEIN (CERD, 1997; Vernier Software, 2011)

#### **Chapter 1: Transformation of Food into Nutrients: Digestion**

#### **Activity 2: Chemical Transformation of Food**

#### **Laboratory Exercise 3: Digestion of Protein**

**Allotted Time: 2 periods**

**Instructional Approaches: Problem Solving and Science Process Skills**

#### **Learning Outcomes:**

By the end of this Laboratory activity, you should be able to:

- 1- Design, using the provided materials, an experiment that would allow protein digestion by proteases.
- 2- Conduct the experiment that would allow protein digestion by proteases.

#### **Introduction**

Proteins are macromolecules constituted of many amino acids bonded together by a peptide bond. The simplification of these macromolecules takes place under the action of specific enzymes and gives at first peptides which later give amino acids. Each protein macromolecule is different from that of other proteins in the number, the order, and the nature of the amino acids that constitute the proteins.

The Biuret test is used to test for the presence of proteins. If its color changes from blue to violet, then the tested material contains protein. If the Biuret color stays the same, then the tested material does not contain protein; instead, amino acids are present.

Iodine solution tests for the presence of starch. If its color changes from yellow to dark blue, then starch is present. If no change in color occurs then starch is absent.

#### **Activity 3.1: Protein Digestion**

After identifying the materials provided by the teacher, you should select the suitable ones that would help you in designing and conducting an experiment that confirms the following hypothesis: "Digestion of protein can occur only under the action of protease enzymes".

#### **Materials Needed:**

- Distilled water

- Chopped egg albumin of an egg
- Protease enzymes (could be commercial)
- Salivary amylase
- Wax pencil
- Metric ruler
- Starch solution
- Iodine solution in a dropper bottle
- Minimum of six test tubes( you can ask for more)
- Water bath at 37°C
- Pipette
- Dropper
- Biuret Reagent in a dropper bottle
- Test tube rack
- Test tube holder
- Your biology copybook

### **Experimental Procedure:**

1. Select the suitable materials for conducting an experiment that allows protein digestion by proteases. Write your selected materials (Title: *My Selected Materials*) on your biology copybook.
2. Individually, design, using the selected materials, an experimental procedure. Write the steps (Title: *My Suggested Procedure*) on your biology copybook. Remark: You are not required to use all the provided materials.
3. Share and discuss your selected materials and suggested procedure with one of your classmates. Agree on the materials and the procedure to conduct the experiment on protein digestion under the action of proteases. Finally, write the materials and the procedure (Title: *Suggested Materials and procedure – by me and my classmate*) on your biology copybook.
4. Use what you and your classmate suggested to conduct cooperatively with your classmate the designed experiment.
5. Write a title for this table. Record the experimental results with the selected reagent at time = 0 minutes and at time = 60 minutes in table 3.1. Finally, copy results (title and table) on your biology copybook. You can modify the table in case you used more than two tubes and more than two chemical reagents.
6. Answer the questions on the answer sheet provided by the teacher. Hand it in to your teacher.

## Results

Table 3.1  
*Color of Reagents 1 and 2*

Time	Tube	Color before adding reagents (original color)	Reagent 1 Reaction	Reagent 2 Reaction
Time =0 minutes	A			
	B			
Time = 60 minutes	A			
	B			

## Questions

1. Draw a table showing the contents of each test tube.
2. What are the factors that would bring about protein digestion?
3. Analyze the experimental results.
4. Explain using your experimental results, whether the suggested hypothesis that "egg albumin is digested only in the presence of protease" is valid.

## APPENDIX IV

### HANDS ON LABORATORY 4: PROPERTIES OF ENZYMES (CERD, 1997; Vernier Software, 2011)

#### **Chapter 1: Transformation of Food into Nutrients: Digestion**

#### **Activity 3: Enzymes, Agents of Digestion**

#### **Laboratory Exercise 4: Properties of Enzymes**

**Allotted Time: 2 periods**

**Instructional Approaches: Inductive and Science Process Skills**

#### **Learning Outcomes:**

By the end of this Laboratory activity, you should be able to:

1. Conclude, using the experimental results, that enzymes act on a specific substrate.
2. Conclude, based on experimental results, that enzymes work best at a convenient temperature =37°C.
3. Explain the effect of pH on the action of enzymes.

#### **Introduction**

Enzymes are biocatalysts found in digestive juices. They speed up the chemical reactions at the level of the digestive tube. This enzyme activity is affected by three factors: substrate, temperature, and pH.

#### **Enzymes and different substrates**

The basic mechanism by which an enzyme catalyzes a chemical reaction begins with the binding of a substrate to the active site of the enzyme. The active site of the enzyme has a unique geometric shape that is complementary to the geometric shape of the substrate molecule, similar to the fitting of puzzle pieces. Thus, the active site is the region where the enzyme combines with the substrate. The binding of the enzyme to the substrate causes a reaction that leads to the formation of products.

#### **Enzymes and Different Temperatures**

Enzymes are mainly proteins consisting of amino acids bonded together by peptide bonds. An enzyme has a specific shape that is related to its function. If the enzyme shape is modified, the enzyme will not function normally.

Temperature is one factor that could affect the shape of enzymes. Under high temperature that is 60 °C and beyond, the kinetic energy caused by the movement of particles will alter the enzyme shape by breaking peptide bonds of the enzyme. On the

other hand, at low temperature of 0°C, the movement of substrate molecules slows down since they do not have enough kinetic energy for the reaction to take place.

### **Enzymes and Different pH**

Similar to temperature, pH is a factor that could affect the shape of enzymes. Optimal activity for most of enzymes is generally observed between pH 5 and 9. Outside this range, the peptide bonds break, thus altering the enzyme's shape.

In this hands-on laboratory, you will perform three activities to show the direct effect of the above three factors on enzyme activity.

### **Activity 4.1: Enzymes and Different Substrates**

In this activity you will test the action of salivary amylase on different substrates.

#### **Materials Needed:**

- Boiled egg
- Knife
- 10 grams of starch
- Bunsen burner
- Small beaker
- Graduated cylinder
- 1/4 cup oil
- Distilled water
- 5 ml of fresh saliva taken from your mouth
- Minimum of 9 test tubes
- Water baths at 37°C
- Pipette
- Dropper
- Biuret reagent in a dropper bottle
- Iodine solution in a dropper bottle
- Sudan III in a dropper bottle
- Test tube rack
- Test tube holder
- Wax pencil
- Metric ruler

#### **Experimental Procedure:**

1. Work in groups of three. One member will get the materials needed for the experiment, one will read the experimental procedure, and one will perform the experiment. Make sure to switch roles in activities 4.2 and 4.3 so that each member has even chances of performing all activities.
2. Turn on the water bath, set it at 37°C, and fill it with distilled water.
3. Take three test tubes. Mark 2 cm starting from the bottom of the test tubes using the wax pencil and the metric ruler. Label the tubes A, B, and C. Place the three tubes in a test tube rack.

4. To prepare the starch paste :use a small beaker , mix 10 grams of starch in 100 ml of distilled water, and heat these on the Bunsen burner till boiling occurs. To prepare the chopped egg albumin: cut the albumin of a boiled egg into tiny pieces using a knife.Add, to the line mark, starch paste (tube A), chopped egg albumin (tube B), and oil (tube C).
5. Using the graduated cylinder, measure 1 ml of fresh saliva. Add to each of the three test tubes 1 ml of saliva and mix the contents of the tubes thoroughly.
6. Place the three test tubes in a water bath at 37°C.
7. Take using a pipette a sample from each test tube and place each sample in a test tube. Observe the color of the tubes before adding any reagent and record your observation in table 4.1. Use the dropper to add 5 drops of iodine to the sample taken from tube A, 5 drops of Biuret reagent to the sample taken from tube B, and 10 drops of Sudan III to sample taken from tube C.
8. Observe the color of the tubes with the reagents at the beginning of the experiment to record the results in table 4.1.
9. Wait for 20 minutes. While waiting, another member of the group will prepare the material needed for activity 4.2.
10. After 20 minutes, pick up the tubes from the water bath using the test tube holder and put the tubes in the test tube rack.
11. Repeat step 7 to test for the contents of the tubes at the end of the experiment. When you finish, dispose the contents of each test tube as instructed by your teacher and turn off the water bath.
12. Answer the questions on the answer sheet provided by the teacher.

## Results

Table 4.1  
*Reactions with Reagents*

Time	Color at time =0 minutes	Color at time =20 minutes
Tube A		
Tube A with Iodine solution		
Tube B		
Tube B with Biuret reagent		
Tube C		
Tube C with SudanIII		

### Questions:

1. Compare the color obtained in each test tube at time =0 minutes to that at 20 minutes.
2. Interpret the experimental results.
3. What enzymatic property is revealed in the experiment?

### Activity 4.2: Enzymes and Different Temperatures



In this activity you will test the activity of amylase enzyme at different temperatures.

### **Materials Needed**

- Starch paste ( cook 10 grams of starch in 100 ml water)
- Distilled water
- 5 ml o fresh saliva from your mouth
- Minimum of 9 test tubes
- Water bath at 37°C
- Water bath at 100°C
- Beaker containing ice cubes
- Pipette
- Dropper
- Iodine solution
- Test tube rack
- Test tube holder
- Wax pencil
- Metric ruler

### **Experimental Procedure:**

1. Work in groups of three. One member will get the material needed for the experiment, one will read the experimental procedure, and one will perform the experiment. Make sure to switch roles.
2. Turn on the two water baths, set one at 37°C and another at 100°C, and fill them with distilled water.
3. Take three test tubes. Mark 1cm and 2 cm starting from the bottom of the test tubes using the wax pencil and the metric ruler. Label the tubes A, B, and C.
4. Place the three tubes in a test tube rack. Add starch paste to the 1 cm mark and saliva to the 2 cm mark in each test tube.
5. Place each test tube in specific water conditions: test tube A in a water bath at 37°C, test tube B in the beaker containing ice cubes, and test tube C in the boiling water bath.
6. Take, using a pipette, few drops of each test tube. Place each sample in a test tube. Observe the color of the tubes and record the color in table 4.2. Use the dropper to add 5 drops of iodine to each sample.
7. Observe the changes and record the results in table 4.2.
8. Wait for 20 minutes. While waiting, another member of the group will prepare the material needed for activity 4.3.
9. After 20 minutes, pick up the tubes from the water bath using the test tube holder.
10. Repeat step 6 and 7 to test for the contents of the tubes at the end of the experiment. When you finish, dispose the contents of each test tube as instructed by your teacher and turn off the water baths.
11. Answer the questions on the answer sheet.

### **Results**

Table 4.2

### Reactions with Iodine Solution

Time	Color at time =0 minutes	Color at time =20 minutes
Tube A		
Tube A (with iodine solution)		
Tube B		
Tube B (with iodine solution)		
Tube C		
Tube C (with iodine solution)		

### Questions

1. What is the problem behind performing such an experiment?
2. Identify the tube in which starch digestion took place.
3. Draw a scheme showing the digestion of starch by amylase.
4. Explain how the experimental results help in solving the posed problem.
5. What enzyme property is revealed through the experimental results?

### Activity 4.3: Enzymes and Different pH

In the activity below, you will examine the activity of amylase in different chemical media.

#### Materials Needed

- 50 ml of 1% starch solution
- Minimum of 9 test tubes
- 5 ml of fresh saliva from your mouth
- Distilled water
- Water bath at 37°C
- Dropper
- Pipette
- Iodine solution in a dropper bottle
- Buffer solution of pH=4 , pH=6.8, and pH=9
- Wax pencil
- Test tube rack

#### Experimental Procedure:

1. Work in groups of three. One member will prepare the material needed for the experiment, another one will read the experimental procedure, and the third member will perform the experiment.
2. Turn on the water bath, set it at 37°C, and fill it with distilled water.
3. Take three test tubes. Mark the tubes as A, B, and C using the wax pencil. Place the three tubes in a test tube rack.
4. Use the pipette to add to 5 ml of 1% starch to each of the three test tubes.
5. Use the pipette to add 1 ml of pH 6.8 buffer solution to tube A, 1 ml of pH 4 buffer solution to tube B, and 1 ml of pH 9 buffer solution to tube C.
6. Add saliva from your mouth in a test tube. Transfer with a pipette 1 ml of saliva into each test tube and mix the contents thoroughly. Place all the test tubes in a water bath at 37°C.
7. Using the dropper, take few drops from each test tube, put each sample in a test tube, and observe the color of the tube to record the color in table 4.3.
8. Use the dropper to add 5 drops of iodine solution to each test tube. Record the color of the tube in table 4.3.
9. At an interval of two minutes each, repeat steps 7 and 8 to observe the change of the tubes as a function of time. Continue until the color of iodine does not change.
10. Observe the color and record the results every two minutes in the table 4.3.
11. When you are finished, dispose the contents of each test tube as instructed by your teacher and turn off the water bath.
12. Answer the questions on the answer sheet. Hand it in to your teacher.

## Results

Table 4.3

*Color of tubes before and after adding Iodine Solution*

<b>Time (minutes)</b>	<b>0</b>	<b>2</b>	<b>4</b>	<b>6</b>
Tube A				
Tube A (with iodine solution)				
Tube B				
Tube B (with iodine solution)				
Tube C				
Tube C (with iodine solution)				

## Questions

- 1- Calculate the time needed to reach a change in color in tubes A, B, and C.
- 2- Find out whether in any of the three tubes the change of color was not observed. Explain.
- 3- At which pH level is the reaction optimum? What inference do you draw about the enzyme activity from this experiment?

## APPENDIX V

### HANDS ON LABORATORY 5: CHARACTERISTICS OF NUTRIENTS (CERD, 1997; Skavaril, Finnen, Lawton, 1993)

#### **Chapter 1: Transformation of Food into Nutrients: Digestion**

#### **Activity 4: From Food to Nutrients**

#### **Laboratory Exercise 5: Characteristics of Nutrients**

**Allotted Time: 1 period**

**Instructional Approaches: Inductive and Science Process Skills**

#### **Learning Outcomes:**

By the end of this Laboratory activity, you should be able to:

- 1- Describe the difference in diffusion of large and small molecules across semi-permeable membranes.

#### **Introduction**

Big complex molecules are digested under the action of enzymes into simple molecules. These simple molecules which are the end products of digestion are called nutrients. To illustrate, the starch is transformed into small molecules of maltose under the action of salivary amylase. Maltose is also transformed into simple molecules of glucose under the action of maltase. Therefore, the simple molecule glucose which is considered the end product of starch digestion is one example of nutrients.

The membranes of our body cells are considered semi-permeable. Some molecules can diffuse through the cell membrane pores while others cannot. Thus, the cell cannot make use of all the molecules due to the selectivity of its cell membrane.

#### **Activity 5.1: Dialysis Tube Experiment**

In this activity you will test which type of molecules, the starch and /or the glucose, can pass through the cell membrane pores so that the cell can use it in producing energy.

#### **Materials Needed:**

- Dialysis tubing in water
- Distilled water
- Large test tube
- 6 test tubes
- Rubber band
- Test tube rack
- Test tube holder

- Large beaker
- Water bath at 100°C
- Dropper
- Metric ruler
- Tap water
- Fehling's reagent in a dropper bottle
- Iodine solution in a dropper bottle
- Starch solution in a squeezing bottle
- Glucose solution in a squeezing bottle

Remark: Dialysis tube is made of cellophane membrane. This membrane has extremely fine pores that are similar to those of a cell membrane.

### **Experimental Procedure:**

1. Work in pairs. Ask a group member to bring all the materials needed to perform the test.
2. Turn on the water bath, set it at 100°C, and fill it with distilled water. Discuss the use of Fehling's reagent and Iodine solution.
3. Obtain a large test tube and fill half of it with tap water. Set the tube in a large beaker so that it is supported.
4. Pick up a strip of dialysis tubing that has been soaked in water. Carefully, tie a knot at one end of the dialysis tubing. Refer to figure "a".
5. Open the free end of the dialysis tubing by rubbing it back and forth between your thumb and forefinger. Continue separating the walls of the dialysis tubing along its entire length in this same manner. Always keep the dialysis tubing wet during the process and handle it. Refer to figure "a".
6. Using the squeeze bottles and the metric ruler, fill half of the dialysis tubing with starch solution and the remaining half with glucose solution within about 5 cm of the dialysis tubing. Refer to figure "a".
7. Hold the filled dialysis tubing closed with your fingers and rinse it in running water to wash off any solution on the outside of the tubing. Refer to figure "a".
8. Place the filled dialysis tubing in water in the large test tube. Fold the top of the dialysis tubing over the rim (lip) of the test tube and keep it in place with a rubber band around the mouth of the tube. Let the dialysis tubing sit undisturbed for 20 minutes.

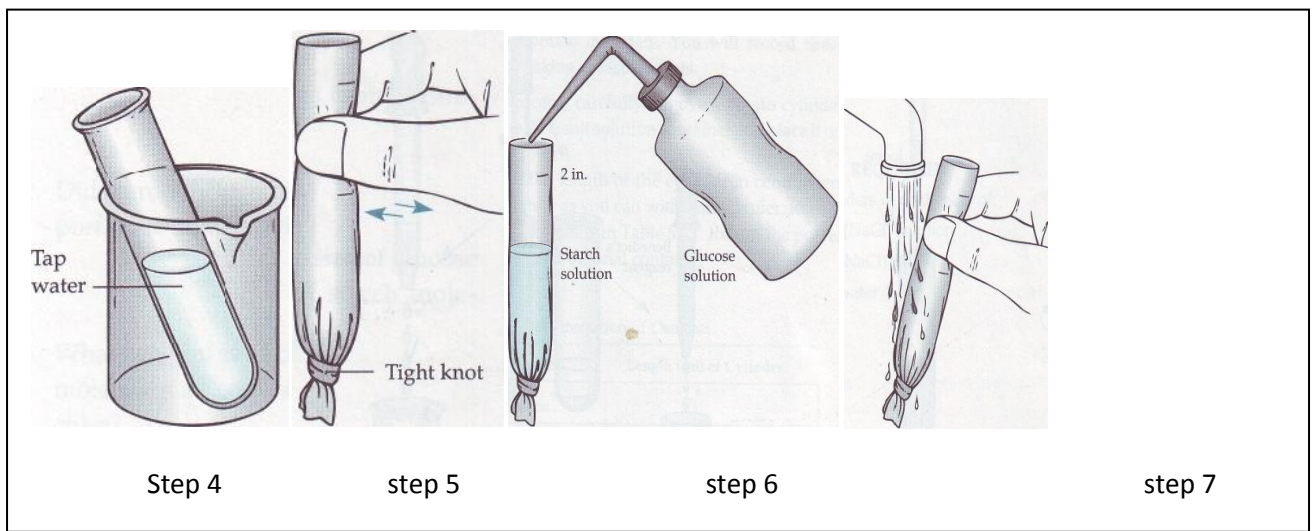


Figure "a". Preparation of dialysis bag containing starch and glucose solutions.

9. After 20 minutes, take four full droppers of the water surrounding the dialysis tubing (Refer to figure "b"). Place two full droppers in a test tube and put the test tubes in the test tube rack. Record the color in table 5.1.
10. Add one dropper of Fehling's reagent into one test tube and place the test tube in a boiling water bath for 3 minutes. Use the test tube holder to remove the tube. Observe the color with Fehling's reagent and record the observed color in table 5.1.
11. Use the dropper to add 4 drops of iodine solution into the other test tube (Refer to figure "b"). Swirl to mix. Observe the test tube color and record the resulting color in table 5.1.
12. Carefully open the dialysis tubing, take four full droppers, and put two full droppers in a test tube. Record the color in table 5.1. Add 4 drops of iodine solution to one test tube. Swirl the test tube to mix and record the color in table 5.1.
13. Add one dropper of Fehling's reagent to the other test tube and place it in boiling water bath for three minutes. Remove the test tube using the test tube holder and place it in the test tube rack. Observe the color of the tube and record the resulting color in table 5.1.
14. When you finish, dispose materials as instructed by your teacher. Turn off the water bath. Solve the questions on the answer sheet provided by the teacher.

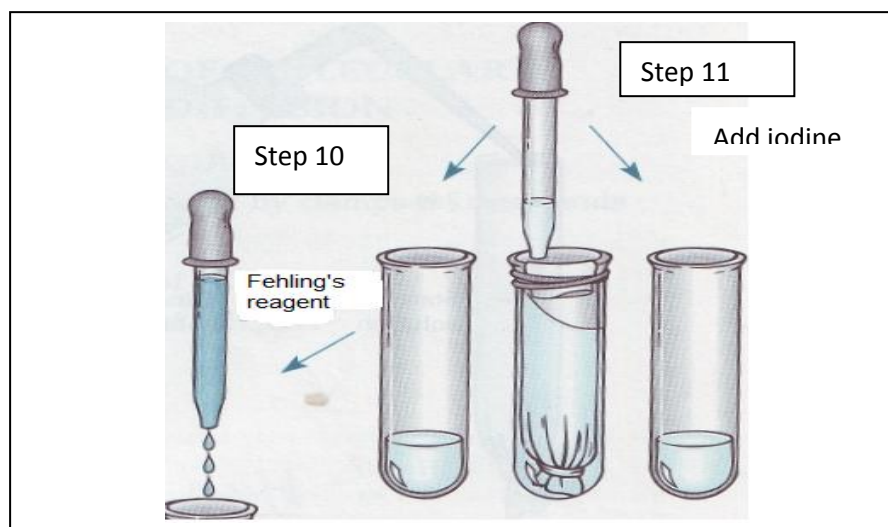


Figure "b". Continued-Procedure to detect the diffusion of starch and/or glucose.

## Results

Table 5.1

*Solutions and Color Reactions with Iodine solution and Fehling's Test*

Tested sample	Color of the tested sample	Color with Fehling's reagent	Color with Iodine solution	Conclusion
Contents surrounding the dialysis tube				
Contents of dialysis tubing				

**Questions:**

1. What molecule diffuses out of the cellophane membrane of the dialysis tubing? Support your answer with evidence.
2. What chemical substance can be used by the cell? Illustrate your answer by a scheme showing the diffusion direction of this molecule.
3. A) State, by referring to the introduction section, the characteristics of nutrients.  
B) What additional characteristic (s) is/are revealed from the experimental results?



## APPENDIX VI

### HANDS ON LABORATORY 6: STRUCTURE OF THE SMALL INTESTINE (Buckley, Miller, Padilla, Thornton, Wiggins, Wyssession, 2011; CERD, 1997; Skavaril, Finnen, Lawton, 1993)

#### **Chapter 1: Transformation of Food into Nutrients: Digestion**

#### **Activity 5: The Route of Nutrients**

#### **Laboratory Exercise 6: Structure of the Small Intestine**

**Allotted Time: 2 periods**

**Instructional Approaches: Technique (microscope) and Science Process Skills**

#### **Learning Outcomes:**

By the end of this Laboratory activity, you should be able to:

1. Name the different parts of the microscope.
2. Describe the roles of the different parts of the microscope.
3. Use the compound light microscope to get a clear focused image of the specimens.
4. Describe the villi of the small intestines.

#### **Introduction**

The microscope is an essential tool in the study of life science. It allows you to see things that are too small to be seen with the unaided eye.

#### **The compound light microscope**

Typically, a compound light microscope has one lens in the eye piece, the part you look through. The eye piece lens usually magnifies up to 10 times. Any object you view through this lens would appear 10 times larger than it is. A compound light microscope contains two other lenses called objective lenses. They are called the low power and high power lens. The lower power objective usually magnifies 10 times. The high power usually magnifies 40x. Use figure 1 to become familiar with the parts of the microscope and their functions.

#### **Observation of a Cross Section of Small Intestine**

The small intestine is 6.5 meter long and it has a diameter of 2.5 centimeters. The inner wall of the small intestine is constituted of several folds that are extremely rich in blood vessels. These folds are covered with numerous, about ten million, villi.

In this laboratory activity, you will be able to locate and observe the parts of the microscope, identify their roles, and practice using the microscope. After this, you will use the microscope to observe and identify the structures of a cross section of a rabbit's small intestine.

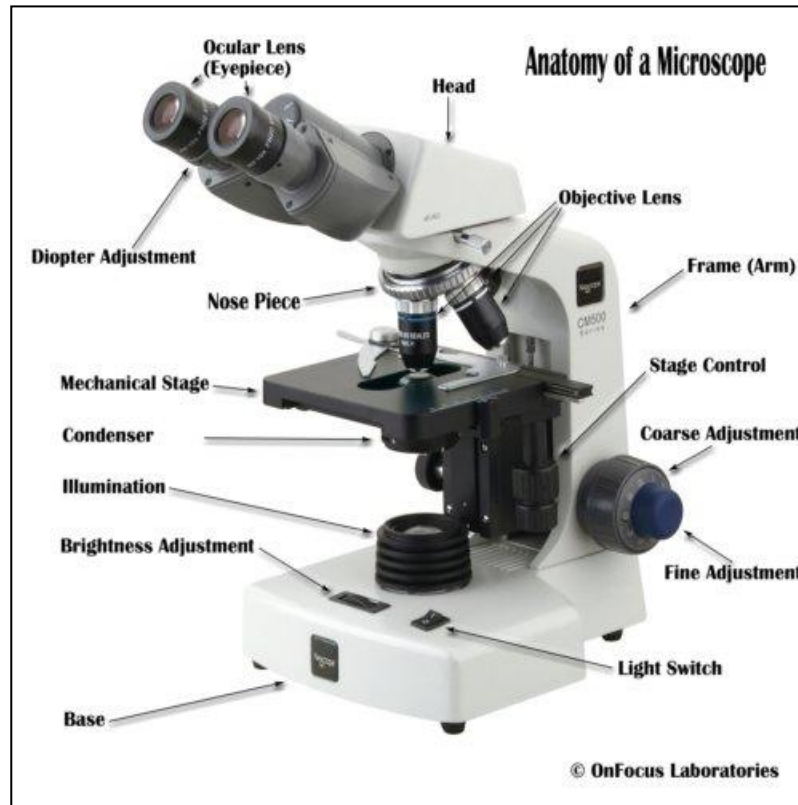


Figure 1. Anatomy of the microscope. Retrieved from <https://www.pearsonsuccessnet.com/snpapp/iText/products/0-13-366951-tr/media/b10lmaa03.doc>

### Activity 6.1: Anatomy of the Compound Light Microscope

In this activity, you will examine the main parts of a compound light microscope.

#### Materials Needed:

- Compound light microscope
- Lens cleaning solution
- Lens cleaning strips
- Calculator

#### Experimental Procedure:

1. Lift a microscope with both hands and place it gently on the table.
2. Get the material needed: lens cleaning solution, the strips, and the calculator.
3. Remove the dust cover over the microscope. Place the microscope so that eye piece is pointing toward you.

4. Use the lens cleaning strip and solution to clean the eye piece lens. Clean it with a circular motion.
5. Locate the arm of the microscope that supports the assembly of the lenses.
6. The objectives are essentially tubes that contain lenses with various magnification powers. Read what is written on each objective lens.
7. Rotate the objective lenses around the nosepiece.
8. Look at the stage which is the horizontal surface where the specimen must be positioned.
9. Locate the focusing knobs: the larger knob is the coarse knob used for general focus and the smaller knob is the fine knob used for focusing details.
10. Locate the illuminator, condenser, and the turn on/off button.
11. Answer the questions on the answer sheet provided by teacher.

### **Questions:**

1. If the ocular lens has a magnification power of 15 x and the objective magnification power is 10 x. Calculate the total magnification.
2. Name the parts of the microscope according to the following functions.
  - Lens that further magnifies the image formed by objective lens.
  - Concentrates the light before it passes through specimen.
  - Gives the microscope a firm steady support.
  - Regulates how much light goes through specimen.
  - Projects a magnified image of the specimen just beneath the ocular lens.

### **Activity 6.2: Use of the Microscope**

After having a look at the compound light microscope and identifying the role of each part, you will practice using the microscope. To facilitate this, a prepared slide showing "the e" letter is provided. You will be working with the knobs until the slide showing "e" letter comes into focus.

### **Materials Needed:**

- Compound light microscope
- Prepared slide with letter "e"

### **Experimental Procedure:**

1. Make sure that the eye piece is still pointing toward you.
2. Plug the electric cord, turn on the switch button.
3. Slowly, turn the coarse adjustment knob to move the 4x objective lens.
4. Place the slide so that "e" is positioned right up and centered over the hole. Fix it with the clips.
5. Look through the ocular lens keeping both eyes open. If you wear glasses, you may find viewing more convenient without them.
6. While focusing, turn the coarse adjustment knob carefully until your image is clear.
7. Move the lowest power objective into position and focus on letter "e". Note the brightness of the field. Answer question 1.

8. Now move to higher power. Answer questions 2 and 3.
9. Turn off the switch button.
10. Answer the questions on the answer sheet .

**Questions:**

1. The field of view is the area of slide that you can see through the ocular lens. What should you do so that you can see the entire letter within the field using the 4x power?
2. Without moving the slide, change to next high power. Describe what you see in comparison to your answer in question 1.
3. Describe the relationship existing between the magnification power and the field of view.

**Activity 6.3: Observation of a Cross Section of Small Intestine**

In the following activity, you will use the microscope to observe the structures of a cross section of a small intestine. Additionally, you will describe the observed structures.

**Materials Needed:**

- Compound light microscope
- Lens cleaning solution
- Lens cleaning strips
- Prepared slide of a across- section of small intestine of a rabbit

**Experimental Procedure:**

1. Make sure that the eye piece is still pointing toward you. Use the lens cleaning strip and solution to clean the eye piece lens. Clean it with a circular motion.
2. Turn on the switch button.
3. Slowly rotate the objective lens so you will be using the low power lens.
4. Take the prepared slide of a across- section of a small intestine. Fix it on the stage with the clips. While looking into the eyepiece rotate the coarse adjustment knob to get a clear image.
5. Use the higher power to observe the villi that are beyond the magnification of 4x . Solve questions 1 and 2.
6. When you are done, remove the slide, and use the lens cleaning strip and solution to clean the eye piece lens. Clean this is with a circular motion.
7. Turn off the switch button. Unplug the electric cord.
8. Add the dust cover over the microscope and return the microscope to its place. Dispose the used material as instructed by your teacher. Solve questions 3 and 4.

**Questions:**

1. Draw, based on your observation, a scheme showing the structures of the small intestine.

2. Label, using the information provided in the text, your scheme showing the structures of the small intestine.
3. What observed characteristics make the small intestine a place for absorption of nutrients?
4. Suggest, based on observation, a functional map showing the route of absorption of nutrients at the site of a villus, singular of villi, to blood.

## APPENDIX VII

### HANDS ON LABORATORY 7: TIDAL VOLUME AND LUNG CAPACITY (Buckley, Miller, Padilla, Thornton, Wiggins, Wyssession, 2011; CERD, 1997)

#### **Chapter 2: From Nutrients to Energy: Respiration**

#### **Activity 2: Pulmonary Ventilation**

#### **Laboratory Exercise 7: Tidal Volume and Lung Capacity**

**Allotted Time: 2 periods**

**Instructional Approaches: Science Process Skills and Problem Solving**

#### **Learning Outcomes:**

By the end of this Laboratory activity, you should be able to:

1. Measure, using a metric ruler and a balloon, the tidal volume and the lung capacity.
2. Formulate a hypothesis that helps you answer the given problem: "Would your body posture affect the tidal volume and the lung capacity?"
3. Design a procedure that you can use to test your hypothesis.

#### **Introduction**

The renewal of air in the respiratory system is brought about by altering inhalation and exhalation which constitutes a respiratory movement.

During inhalation, the dilation of the lungs caused by the movements of the rib cage and the diaphragm pulls air inside the lungs. During exhalation, the lungs become deflated and the diaphragm rises then expels air. During normal respiratory movement, the amount of air that rushes in during a normal breath is called the *tidal volume*.

Your lungs have the capacity to accept a much larger volume of air than you normally inhale. In the course of a forced inhalation followed by a forced exhalation, the amount of air mobilized is considered the maximum. For example, you might be asked to take a deep breath during a medical exam. Scientists use the term *vital capacity* to describe the largest volume of air that you can exhale after you take a deep breath.

In this activity, you will be measuring the vital capacity and the tidal volume of your own lungs; this actual number can then be compared with a number read from a

graph that relates lung volume to balloon diameter. Also, you will be answering the following question: What factors can affect lung capacity?

Remark: Do not test your vital capacity if you are ill or if you have breathing difficulty. If at any point you feel like fainting or dizzy, stop what you are doing and sit down. Ask your partner to inform your teacher of the problem. If you have an allergy to latex, do not handle the balloons. Make sure you and your partner use different balloons.

### **Activity 7.1: Measuring Tidal Volume and Vital Capacity**

In this activity you will measure the tidal volume and the vital capacity of your lungs.

#### **Materials Needed:**

- Metric ruler
- Calculator
- 2 medium size round balloons

#### **Experimental Procedure:**

##### ***Part A: Measuring Tidal Volume***

1. Working in pairs, ask your partner to bring all the materials needed.
2. Stretch a round balloon lengthwise several times.
3. Inhale and then exhale normally into the balloon. Immediately pinch the balloon shut so that no air escapes.
4. Keep pinching the balloon as you place it on a flat surface. Have your partner measure, using the metric ruler, the diameter of the balloon at its widest point as shown in Figure 1. Record the measurement in Table 7. 1.
5. Allow the balloon to deflate. Repeat Steps 2 and 3 two more times.
6. Calculate the mean for the measurements from the three trials and record your answer in the table 7.1.

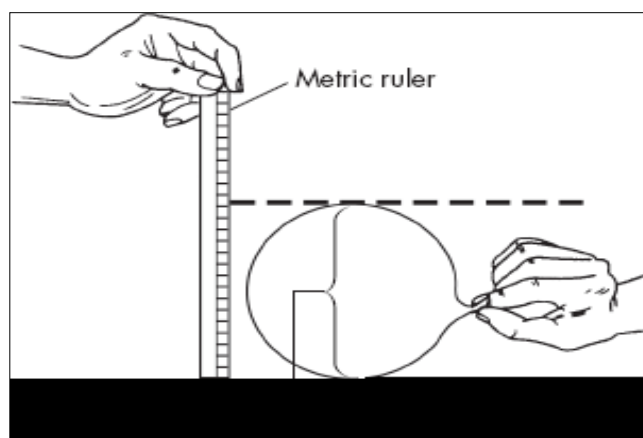


Figure 1. How to measure the diameter of the balloon.

**Part B: Measuring Vital Capacity**

7. Take as deep a breath as possible. Then, exhale as much air as you can from your lungs into the same or new balloon. Immediately pinch the balloon shut so that no air escapes.
8. Keep pinching the balloon as you place it on a flat surface. Have your partner measure, using the metric ruler, the diameter of the balloon at its widest point. Record the measurement in table 7.1.
9. Allow the balloon to deflate. Repeat Steps 7 and 8 two more times.
10. Calculate the mean for the measurements from the three trials and record your answer in the table 7.1.
11. On the graph in Figure 2, the balloon diameter in centimeters is plotted against the volume in cubic centimeters ( $\text{cm}^3$ ). Use the graph to find the volumes that correspond to your diameter measurements. Record your answers in table 7.1.

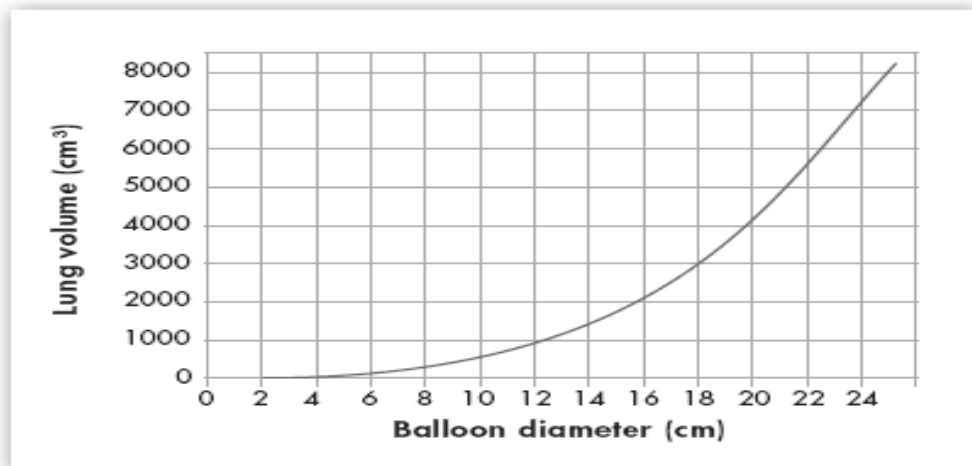


Figure 2. Lung volume versus balloon diameter

From <https://www.pearsonsuccessnet.com/snpapp/iText/products/0-13-366951-3-tr/index.ht>.



## Results

Table 7.1

*Data table*

Trial	Tidal Volume		Vital Capacity	
	Balloon Diameter	Volume (from graph)	Balloon Diameter	Volume (from graph)
1				
2				
3				
Mean				

### Questions:

1. Why is it important to measure the tidal volume and the vital capacity three times and then calculate an average?
2. How might an athlete's vital capacity compare to a non-athlete's? Explain your reasoning.
3. How would smoking cigarettes affect your lung capacity, and why?
4. You were probably standing up when you measured your vital capacity. Would the results have been different if you were seated? Would your posture when seated affect the results?
  - a-Formulate a Hypothesis: How will changing the position of your body affect your vital capacity? Record the hypothesis you will test to answer this question.
  - b-Describe Your Plan: Describe the procedure you will use to test your hypothesis. How will you modify the procedure in Part B? What variables will you need to control during your trials?

## APPENDIX VIII

### HANDS ON LABORATORY 8: DISSECTING A HEART (CERD, 1997)

#### **Chapter 3: Transport and Distribution of Nutrients and Oxygen to Organs**

#### **Activity 1: Heart and Cardiac Activity**

#### **Laboratory Exercise 8: Dissecting a Heart**

**Allotted Time: 1 period**

**Instructional Approaches: Technique (Dissection) and Science Process Skills**

#### **Learning Outcomes:**

By the end of this Laboratory activity, you should be able to:

- 1- Name the tools used in dissection activities.
- 2- Dissect, using the tools of the dissecting kit, a sheep heart.
- 3- Identify the external and the internal structures of a sheep heart.

#### **Introduction**

Dissection is the act of cutting and examining the structure of a dead animal or plant. Dissection helps us study the anatomy of a living organism. Its goal is to preserve the structures while moving through delicate layers of tissue in a living organism. For this it is a skill that develops by time and it requires patience and practice.

Also using correct tools is necessary. For this, having the correct tools and knowing when to use them will help you save time, observe structures, and find relationships with functions.

A dissecting kit, shown in figure 1, consists of the main tools needed for a dissection. A dissecting kit usually contains forceps, scalpel handles, blades, probes, and different sized scissors. Figure 2 shows the names of the main tools of the dissection kit.

With the help of dissection you can study the animal heart. The heart is one of the most vital organs because of its function, pumping the blood to all body organs. The heart contains four cavities: two auricles and two ventricles. The surface of these cavities is formed of a muscle, myocardium, irrigated by coronary vessels. The auricle and the ventricle situated on the same side communicate with each other through valves. Both sides of the heart, right and left, are separated by a septum. Veins open up in the auricles and the arteries originate from the ventricles.



Figure 1. Tool kit.



Figure 2. Dissection tools.

Figure 1. Retrieved

from <https://www.google.com.lb/search?q=dissection+tools+labeled&source>

Figure 2. Retrieved from <http://www.medical-tools.com/shop/Anatomy-Kit.html>

### Activity 8.1: Dissection of a Heart

In this activity, you will describe the external structure of a heart sheep.

#### Materials Needed:

- Laboratory coat
- Dissection kit
- Preserved sheep heart partially sectioned
- Dissecting tray
- Gloves
- About 15 small flags for labeling.

#### Experimental Procedure:

- 1- Work in pairs. Make sure all needed materials are provided. Solve question 1.
- 2- Wear your safety equipment (Laboratory coat and gloves) before starting the dissection.

- 3- Observe the heart placed on the dissecting tray, identify the external structures (ventricles, auricles, arteries, veins etc.), and use small flags to label these structures. Raise your hand so the teacher can check on the labeled small flags. Then, solve question 2.
- 4- Open the dissecting kit, get the blunt probe, and introduce it in the pulmonary artery in the direction of the right ventricle.
- 5- Cut, using a pair of scissors, the wall of the artery along its length. Cut the wall of the heart along the probe. Separate the parts that were cut.
- 6- For the left side of the heart, proceed in the same manner: Introduce the probe in the aorta in the direction of the left ventricle. Introduce the probe in the auricles and cut.
- 7- Use small flags to label the internal structures of the heart (valves, artery, vein etc.). Raise your hand so the teacher can check the labeled small flags. Then, solve part A in question 3.
- 8- When finished, return the sheep heart to its container as directed by the instructor.
- 9- Remove your gloves and clean the used material as instructed by your teacher.
- 10- Remove the Laboratory coat and wash your hands. Solve part B in question 3 and answer question 4.

**Questions:**

1. Describe, by referring to figure 1, the function of each of the tools provided in the dissection kit.
2. Describe the walls of the ventricles.
3. A- Formulate, based on your observation, a hypothesis concerning the role of the sigmoid valves.  
B- Design an experimental procedure that would help approve your hypothesis.
4. Provide, based on your observation, an argument that relates the function of the heart to its internal and external structures.

## APPENDIX IX

### HANDS ON LABORATORY 9: CHROMOSOMES

(CERD, 1997)

#### **Chapter 7: Chromosomes, Carriers of Genetic Information**

#### **Activity 3: The Carriers of Genetic Information**

#### **Laboratory Exercise 9: Chromosomes**

**Allotted Time: 1 period**

**Instructional Approaches: Inductive and Science Process Skills**

#### **Learning Outcomes:**

By the end of this Laboratory activity, you should be able to:

- 1- Extract the genetic information from the onion using everyday materials.
- 2- Describe, after the extraction, the physical appearance of the genetic information.

#### **Introduction**

The transmission of hereditary traits from parents to offspring implies the existence of certain information that passes from one generation to another and is called for this reason the genetic information.

In all organisms, the instructions for specifying the characteristics of the organism are carried in DNA (Deoxyribonucleic acid), a large polymer formed from subunits. The chemical and structural properties of a chromosome explain how the genetic information that underlies heredity is encoded in DNA.

Each DNA molecule in a cell forms a single chromosome. Thus, it is said that the chromosomes, made of DNA and present in the nucleus of the cell, are the carriers of the genetic information.

#### **Activity 9.1: Extraction of the Genetic Material**

In this activity, you will answer the following question: What do you think a chromosome will look like when you extract it from the plant cell?

#### **Materials Needed:**

- Tray
- Tap water in a squeezing bottle
- Table salt
- Dish

- One onion
- Cheese cloth
- 95 % ethanol (Alcohol) in a squeezing bottle
- 2 test tubes
- Detergent
- Table spoon
- Stirring rod
- Small beaker
- Mortar and pestle
- Knife
- Funnel

**Experimental Procedure:**

1. Work in groups of two. One member will get the material needed. Put the material on the tray.
2. Cut with a knife the onion into small pieces and mash it for about 2 minutes using the mortar and pestle. Move the mashed onion to the dish. What was the purpose of mashing up the onion?
3. Put up to 20 ml of water in a small beaker and add 1/4 table spoon of salt.
4. Add the salt water to the mashed onions. Mix them slowly using the table spoon.
5. Add 2 table spoons of detergent to the mixture (onion with salt water). Mix slowly using the spoon. What does the detergent do? Think: what do detergents do when washing your hands or dishes?
6. Insert the funnel into a test tube. Place the cheese cloth on the funnel and pour the solution over it. Observe figure 1. Wait for about ten minutes.
7. Remove the filtrate, place it in the other test tube, and slowly add to it ethanol such that the amount of added alcohol is equal to the amount of filtrate. Do not shake the tube! Gently swirl the tube once or twice. Then let the tube remain undisturbed.
8. Watch where the alcohol and extract layers come in contact with each other.
9. Place the tip of the stirring rod at the point where the two layers meet as shown in Figure 2. As you gently swirl the rod, bend down so you can observe what is happening at eye level.
10. Record your observation in the box before you dispose of the materials as instructed by your teacher, wash your hands thoroughly. Answer the questions.

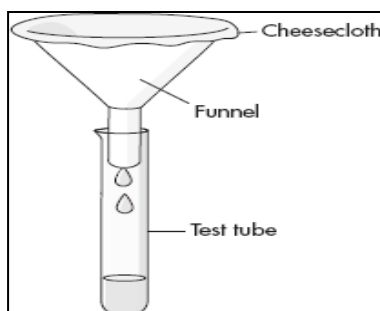


Figure 1. Filtration setup.

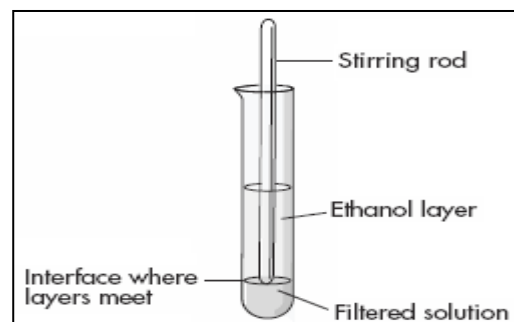


Figure 2. Placement of stirring rod.

Figure 1 retrieved from [http://ucbiotech.org/resources/display/files/dna\\_extraction\\_from\\_strawberrie.pdf](http://ucbiotech.org/resources/display/files/dna_extraction_from_strawberrie.pdf). Figure 2 retrieved from [http://ucbiotech.org/resources/display/files/dna\\_extraction\\_from\\_strawberrie.pdf](http://ucbiotech.org/resources/display/files/dna_extraction_from_strawberrie.pdf).

### **Results 9.1: Sketch Your Observation**

What do you observe? Sketch what you see in the space and note any other observations.

#### **Questions:**

1. Describe, based on your observation, how the chromosomes carrying the genetic information look like.
2. A person cannot see a single cotton thread four classrooms away. But if you wound thousands of threads together into a rope, it would be visible at the same distance. How is this statement an analogy to our extraction?
3. Are the chromosomes found in all living or once living cells? Elaborate your answer by giving examples.

## APPENDIX X

### HANDS ON LABORATORY 10: CELLS DURING DIVISION

(Skavaril, Finnen, Lawton, 1993)

#### **Chapter 8: Conformed Reproduction of Genetic Information**

#### **Activity 1: Transmission of Genetic Information**

#### **Laboratory Exercise 10: Cells during Division**

**Allotted Time: 2 periods**

**Instructional Approaches: Deductive and Science Process Skills**

#### **Learning Outcomes:**

By the end of this Laboratory activity, you should be able to:

- 1- Prepare your own specimen of onion root.
- 2- Identify the different stages of cell division.
- 3- Describe the characteristics of the chromosomes during the different stages of cell division.

#### **Introduction**

The plant cells divide and the genetic information in the nucleus is distributed equally between the two resulting cells and each functions normally. The processes that are responsible for this effect are interphase, mitosis, and cytokinesis. These stages combined form what is referred as the: cell cycle.

The cycle begins from the time a cell is formed by division and ends when it divides. The cell cycle starts with interphase. Interphase consists of the G<sub>1</sub> first gap, period of cell growth whose time is from the beginning of a new cycle to when it begins to duplicate the chromatids. This is a time of growth and normal cellular activity. The Synthesis, period is when chromatids duplicate. The G<sub>2</sub>, second gap, period of cellular growth and it lasts from end of a sister chromatid synthesis until the next cell division.

Mitosis is a cellular division which ensures the multiplication of cells and it is a continuous process that occurs in four phases: prophase, metaphase, anaphase, and telophase. In prophase, the chromatin condenses and forms the chromosomes, which are duplicated into chromatids attached to each other by a centromere. The nuclear membrane and the nucleolus disappear. In metaphase, all the double chromosomes are arranged in the center of the cell forming an equatorial plate. In anaphase the two sister chromatids separate and move away from each other toward the opposite poles of the cells. In telophase, the chromosomes of one chromatid de-condense and the nucleolus and the nuclear membrane reappear.



Cytokinesis ensures the separation of the cytoplasm leading to two daughter cells. A new cell plate is formed in the middle of the cell. This cell plate grows until it separates the cell into two.

Thus the cell cycle ensures the conservation and the transmission of the genetic information from one cellular generation to another.

### **Activity 10.1: Stages of Cell Cycle**

In this activity, you will prepare a fresh slide of onion cells. You will use the microscope to observe the stages of the cell cycle.

#### **Materials Needed:**

- Forceps
- Calculator
- Petri dish
- 2 Onion root tips
- Water bath at 60°C
- Test tube
- Scissors
- Dropper bottle of 1 N HCl
- Large beaker of distilled water
- Test tube holder
- Distilled water in a squeezing bottle
- Carmine Alume (for coloring) in a dropper bottle
- 45% Acetic acid in a dropper bottle
- Cover slip
- Slide
- Lens cleaning strips
- Lens cleaning solution
- Ruler
- Microscope

#### **Experimental Procedure:**

1. Work in pairs. One member will get the needed materials. Turn on the water bath, set it at 60°C, and fill it with distilled water from the beaker.
2. Measure, using the ruler, 1cm of the meristem region. See figure 1 to identify the meristem.
3. Using the scissors cut 2 roots meristems about 1 cm long.
4. Fill up to 2/3 of the test tube with 1N HCl. Add the cut meristems to the tube containing HCl.  
Caution: Work with the HCl carefully, it is a strong acid.
5. Place the tube in a 60°C water bath, and allow the roots to incubate for 12 minutes.
6. After the 12 minute incubation period, use the test tube holder to remove the tube from the water bath.

7. Using forceps carefully remove the meristem and use the distilled water squeezing bottle to wash them. Place the washed meristems on a petri dish.
8. Add 3 drops of carmine alum to the meristem pieces.
9. Wait for 15 -20 minutes then wash the meristem pieces with distilled water in the squeezing bottle.
10. Add 3 drops of acetic acid on a slide. Place the thin layer of meristem on the slide and cover it with a cover slip.
11. Remove the dust cover of the microscope and make sure that the eye piece is pointed toward you. Use the lens clean solution and the lens clean strips to clean the lenses.
12. Plug in the electric cord. Place the prepared slide on the stage and fix it with the clips. Turn on the switch button and examine the slide under the microscope using low-power lens. Rotate the coarse and the fine adjustment knobs to get a clear focused image.
13. Find examples of cells in each stage of the cell cycle including interphase and the stages of mitosis. In the provided space, draw each cell, label the cell according to its stage of division, and label the structures within the cell.
14. Select a random area of the slide to study using high power lens. Record the stages of each cell in the view and use the calculator to calculate the percentage of the cells in each part of the cell cycle for each sample. Record your data in Table 10.1 that shows the number of cells at each stage and their percentages. If you need more space, copy the table on a separate sheet. Repeat step 13 two more times. Record your data for the two more times in Table 10.1.
15. When you are done, dispose the material as instructed by your teacher. Turn off the switch button of the microscope, unplug it, and cover it. Put the microscope back in its place. Turn off the water bath. Solve the questions.

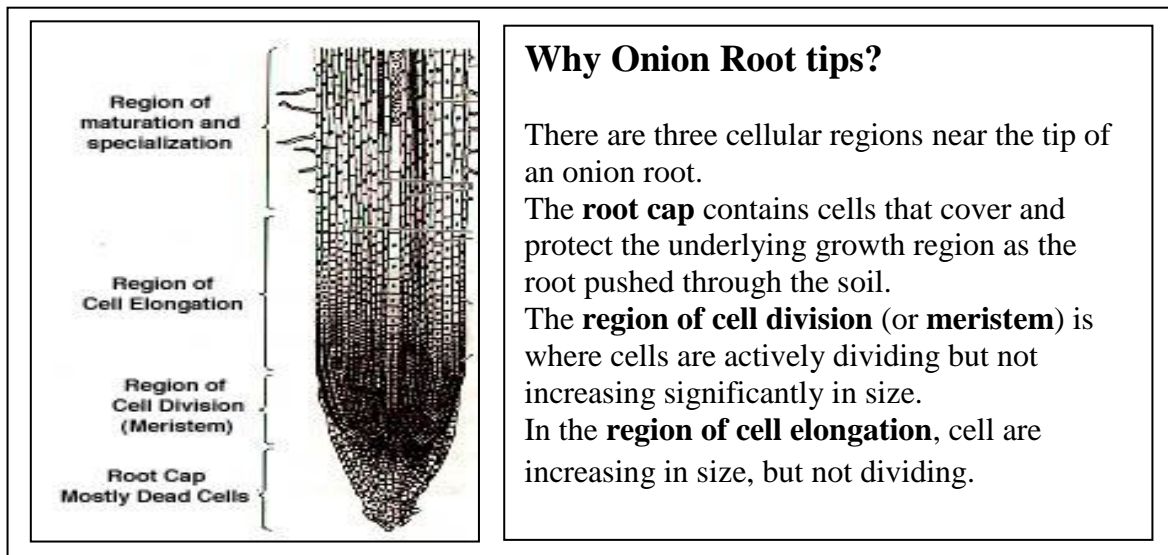


Figure 1. Showing the parts of a root tip.

From [www.marietta.edu/~biol/introlab/Onion %20root %20mitosis.pdf](http://www.marietta.edu/~biol/introlab/Onion%20root%20mitosis.pdf).

## Results

A -Sketch Your Observation

Draw and label each cell in the provided space.

B- Table 10.1

*Showing the Number of Cells at Each Stage and their Percentages.*

Sample	Total number of cells (%)	Number of cells in Interphase (%)	Number of cells in Prophase (%)	Number of cells in Metaphase (%)	Number of cells in Anaphase (%)	Number of cells in Telophase (%)
1						
2						
3						

### Questions:

1. What patterns exist in your data? In which stage of the cell cycle are the most of the cells examined? How do these data support what you know about the cell cycle?
2. Find the average percentage of cells in each stage of the cell cycle among the three samples. Assume that a cell takes 24 hours to complete one cell cycle. Calculate how much time is spent at each stage of the cell cycle.

Hint: multiply the percentage of cells in each stage as a decimal by 24 hours.

3. A chemical company is testing a new product that it believes will increase the growth rate of food plants. Suppose you are able to view the slides of onion roots tips that have been treated with the product. If the product is successful, how might the slides look different from the slides you viewed in the lab? Justify your answer.