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A Comparative Study Of Directed Laboratory And Lecture Demonstration As Methods Of Instruction In Teaching Botany To High School Students

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A COMPARATIVE STUDY OF DIRECTED LABORATORY AND LECTURE-DEMONSTRATION AS METHODS OF INSTRUCTION IN TEACHING BOTANY TO HIGH SCHOOL STUDENTS

being

A thesis presented to the Graduate Faculty of the Fort Hays Kansas State College in partial fulfillment of the requirements for the Degree of Master of Science

by

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CHAPTER I

INTRODUCTION

Although there have been many investigations concerned with methods of teaching, the field of method still presents many unsolved problems. The individual-laboratory versus the lecture-demonstration methods of teaching remain a controversial issue. Scientific investigation has not proved the superiority of either method.

The Problem

A controlled investigation of green plants as the most important food factories of the world has been made in order to contribute more information upon the issue.

Stated more specifically, the problems of this experimental study were the following:

1. To determine which of the two methods, if either, is superior as a procedure for learning.
2. To determine whether laboratory experiments are more effective than lecture-demonstration in training students to think clearly, to correlate and retain facts; and finally, to draw logical conclusions.
3. To determine, if possible, which method stimulated the greater amount of pupil interest.

Objectives

In order to arouse general interest in the pupils before beginning the project, some of the following objectives were presented:

1. To give students a greater knowledge of their environment.

In pointing out this objective, the writer presented some inspirational thoughts from Benjamin Franklin in his "Proposals for the Education of the Youth of Pennsylvania." Franklin[1] in this very interesting monograph quotes approvingly from a French contemporary as follows:

> I say that even Children are capable of Studying Nature, for they have Eyes; . . . They ask questions, and Love to be informed; and here we need only awaken and keep up in them the desire of Learning and Knowing, which is natural to all Mankind. . . It is inconceivable, how many things Children are capable of, if all the Opportunities of Instructing them were laid hold of, with which they themselves supply us. A Garden, a Country, a Plantation, are all so many Books which lie open to them; but they must have been taught and accustomed to read in them. Nothing is more common among us than the Use of Bread and Linen. How seldom do Children know how either of them are prepared, through how many Operations and Hands the Corn and Flax must pass, before they are turned into Bread and Linen? The same may be said of Cloth, which bears no resemblance to the Wool whereof it is formed, any more than Paper to the Rags which are picked up in the Streets: And why should

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1. James N. Rule. "Educational Usefulness of Science." (The Science Counselor, Vol. IV. p. 116. December, 1938).

> not children be instructed in these wonderful works of Nature and Art which they every day make Use of without reflecting upon them?

Buckham[2] also contributes some thoughts regarding the same objectives:

> It is in the laboratory that the student gets the feel of the law of nature which he is studying
> . . . .
> and if the problems are chosen as nearly as possible from students' environment, the chances of transfer to out-of-school activities are greatly increased. Thus in guiding students with important things in nature, the teacher has an exceptional opportunity to influence the character of his students.

Another important fact given to the students was that practically all man's food comes from green plants. For this purpose the writer used a large poster (Fig. 1), which illustrated the above principle. This poster was placed on the bulletin board during the entire experiment.

In order to set the stage for the actual work, the director, in charge, explained to both groups a few of the underlying factors and processes involved in the concept of photosynthesis. From another poster it was made clear to both groups that the leaves of trees are like factories where the water and mineral salts they

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2. W. B. Buckham. "An Endeavor to Contact Objectives with Methods in the Teaching of Science." (<u>School Science and Mathematics</u>, Vol. 36, p. 610. June, 1936).

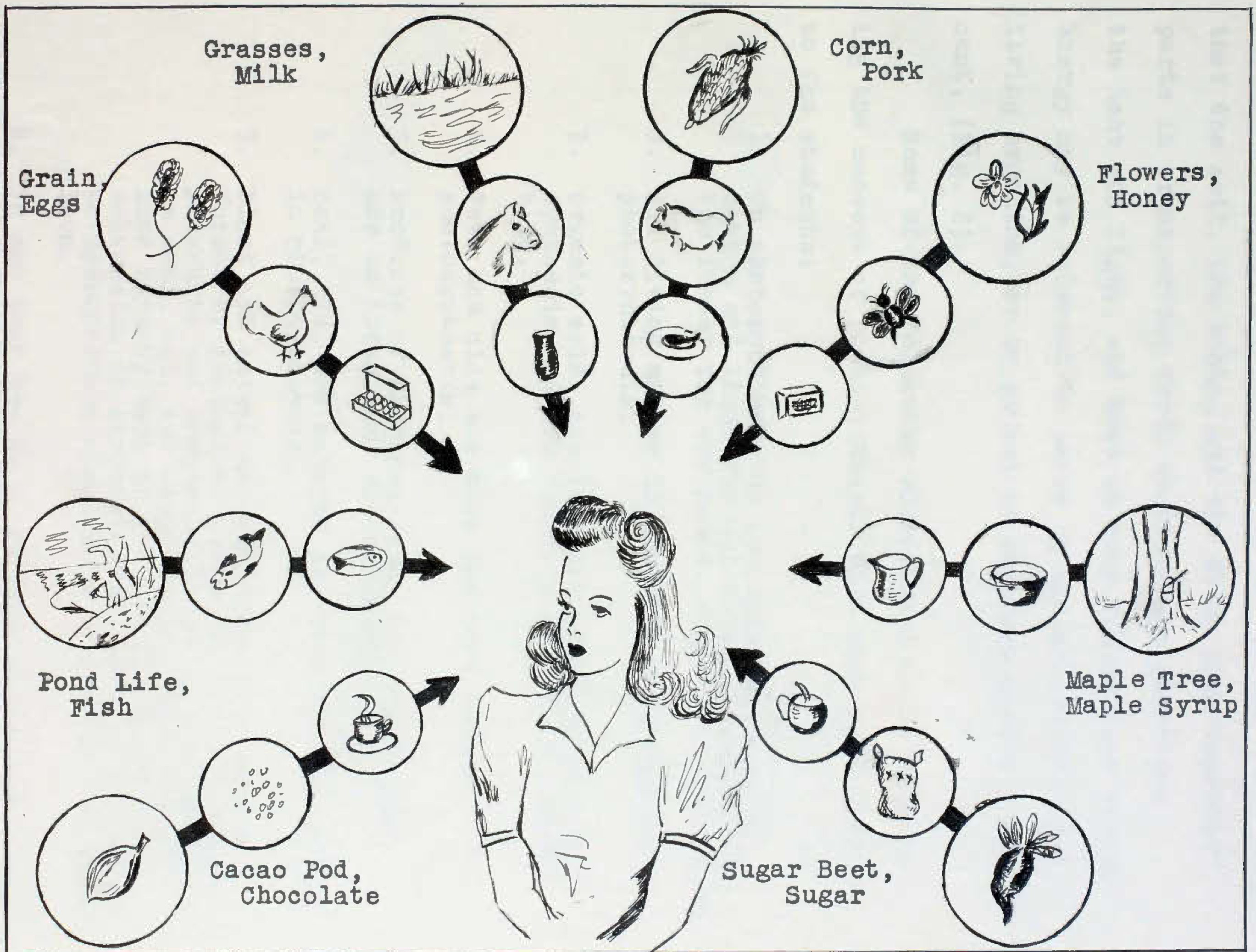

Fig. 1. Illustrating the Plant Life Source of All Food.

contain are made into food for the use of the whole tree; that the soil, the roots, and the stems play important parts in transporting food; that the sun furnishes the heat and light, and that at some future time stored energy may be released to carry on the activities of a living organism, or to propel an airplane across a continent, (Fig. 2).

Some of the following significant facts concerning the concept of photosynthesis were then made known to the students:

1. To photosynthesis we are indebted for the cotton and linen for our clothing, our foods, the lumber for our homes, as well as for fuels.

2. All living matter is probably dependent on photosynthesis.

3. Organic acids are indirect products of photosynthesis and are found in fruits and vegetables.

4. Fats and oils are also indirect products of photosynthesis.

5. Products of American farms are coming into use as industrial raw materials.

6. Coal, oil, and natural gas have their origin in photosynthesis.

7. Plant and animal material have been transformed by geological processes involving high pressures and temperatures into such compounds as coal, oil, and natural gas. That methods have already been worked out for the direct conversion of carbohydrates, such as cellulose to hydrocarbons similar to those found in petroleum.

8. In one year the E. I. de Pont de Nemours Company

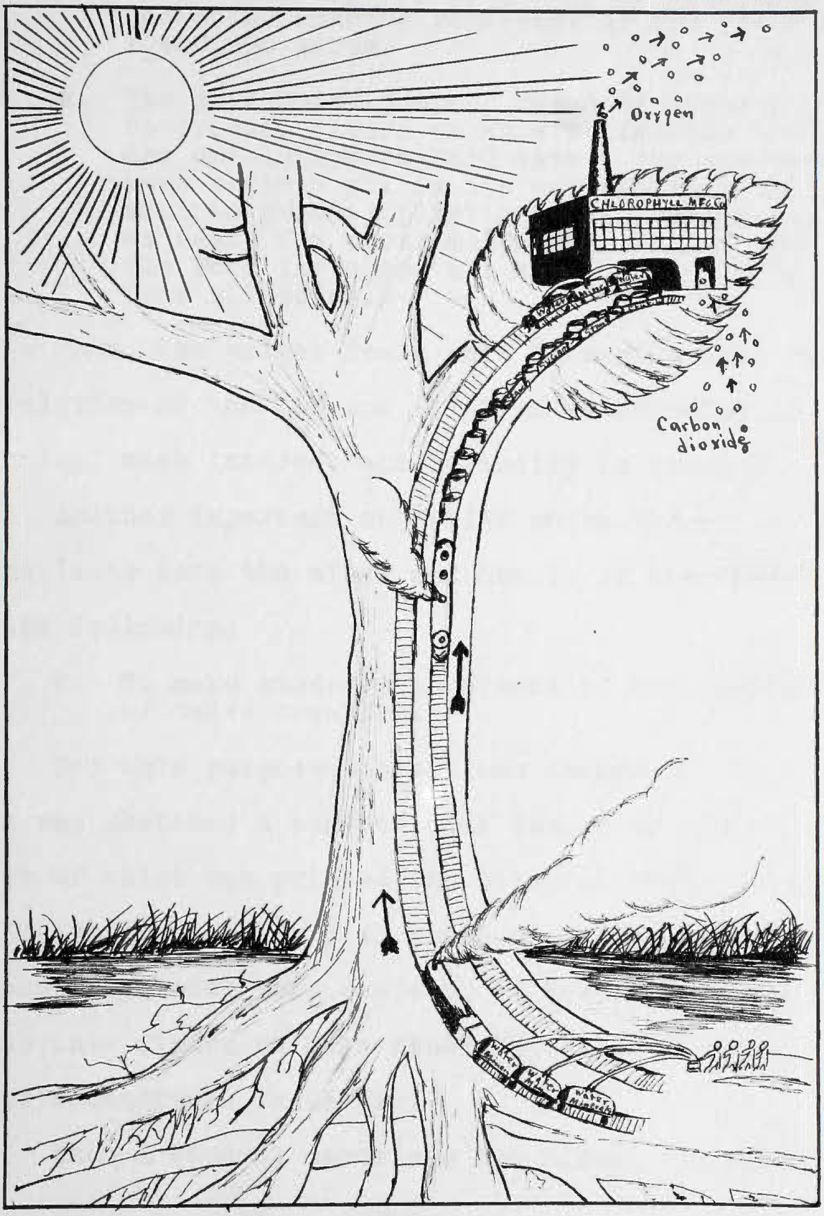

Fig. 2. A Tree is a Factory for the Manufacture of Sugar and Starch.

alone used 23,000,000 pounds of fats and oils, and corn products representing the yield from 1,400,000 acres.

9. The Ford Motor Company has used soybean protein to produce fibers on an experimental basis for the upholstery in Ford cars. The company also uses soybean oil in its car finishes and soybean meal to produce plastic molding compounds, such as cases for steel molds and foundry sand cores. The Ford factories are also painted with a soybean oil paint.[3]

Thus, the writer feels safe in saying that when a general view of the concept is given to students in the beginning, much interest and curiosity is aroused.

Another important objective which the writer wished to inculcate into the minds and hearts of the students was the following:

2. To make students cognizant of the loveliness of God's creation.

For this purpose a chart was designed. On this chart was sketched a conventional design of lilies, in the center of which was printed the biblical text, "CONSIDER THE LILIES . . . (Fig. 3). Since an Easter lily was studied in connection with this project, it seemed appropriate to use this figure to make students aware of the beauty of God's handiwork in nature.

When a student memorizes the lines, "But only

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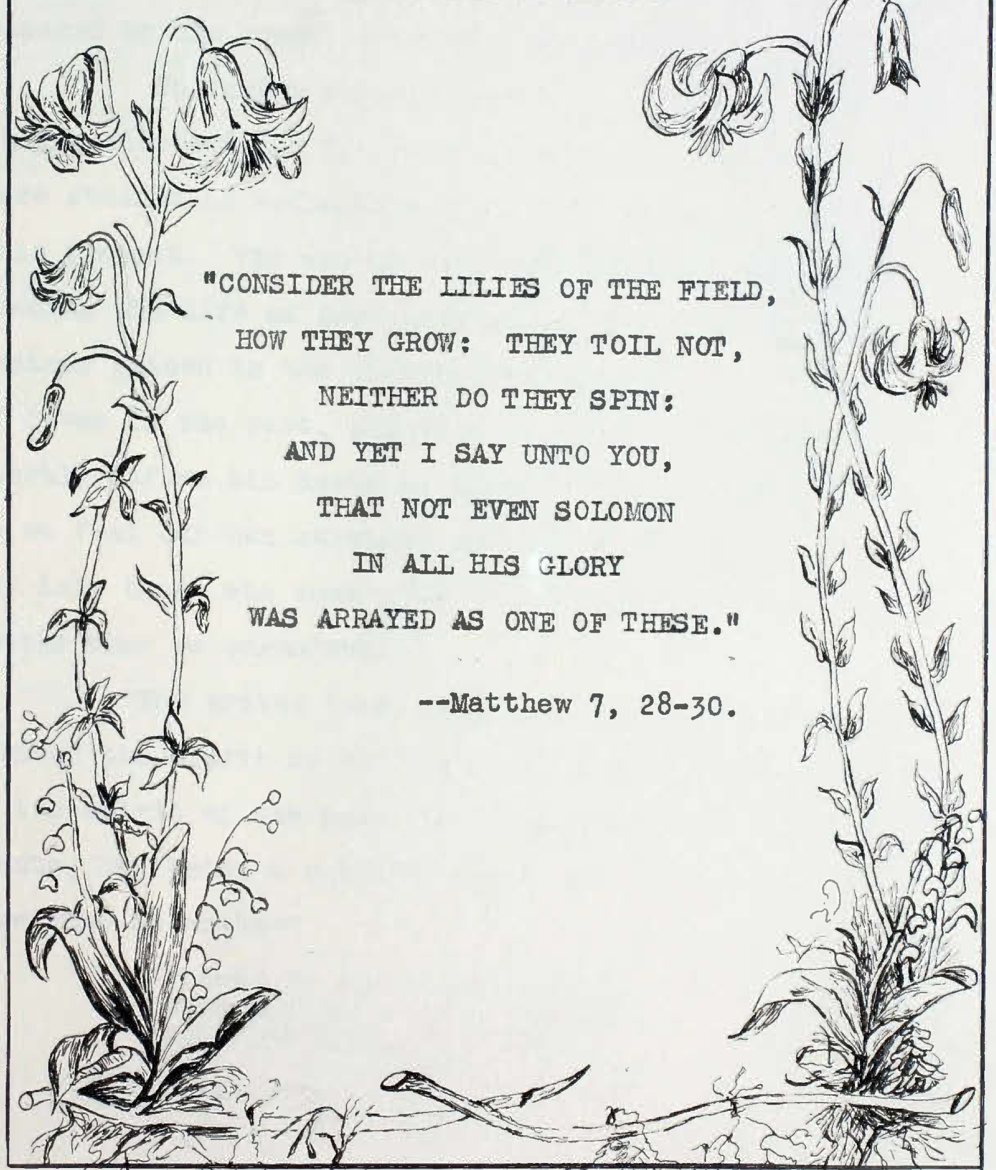
3. Arthur Talbot Bawden. Man's Physical Universe. New York, The Macmillan Company, 1943, pp. 719-724.

Figure 3.

Illustrating the Beauty of God's Handiwork in Nature



God can make a tree . . . perhaps he will be prompted to ask--How does it happen that every leaf among the thousands on a tree has its own place and grows unhampered by its neighbor leaves? And the students were made to see that it does not just happen, but that all has been planned by the great, good God for mankind.

To foster appreciation for great and noble men and their contributions to mankind, short biographies also were studied in connection with most of the problems in this project. The writer was inspired to do this after reading the life of Louis Pasteur. The knowledge that Pasteur gained in the laboratory influenced thousands of lives in the past, and will do so in future ages. Shortly before his death he said: "Our only consolation as we feel our own strength failing is to feel that we may help those who come after us to do more and do it better than we ourselves."

The writer feels that any teacher--if he has imbibed the spirit of the scientist will lead his pupils to the spirit of the poet, who apparently knew much about plants, but being a scientist knew how much he did not know when he wrote--

"Flower in the crannied wall,
I pluck you out of the crannies,
I hold you here, root and all
in my hand
Little Flower, but if I could
understand

What you are, root and all,
I should know what God and Man is."

--Tennyson

In view of some of the above objectives, interpretations, and thoughts, the writer was inspired to select, if possible, a problem that would interest students. In order to accomplish this, a set of experiments relating to photosynthesis was prepared. These problems were then taught by two methods of instruction, the individual-laboratory and the lecture-demonstration method.

CHAPTER II

SURVEY OF RELATED STUDIES

Many different opinions prevail with respect to the comparative value of the laboratory and lecture-demonstration methods of teaching. Some writers believe that the lecture-demonstration is much cheaper and makes possible the teaching of science to much larger groups. Others are confirmed in the belief that from the standpoint of learning, the lecture-demonstration method is just as concrete as the laboratory, but so far there are none who have found that the lecture-demonstration favors the development of laboratory skill or the ability to solve problems in scientific procedure. Only a relatively few experiments have tested the two methods from this point of view.

Some of the more recent writers contend that the abandonment of laboratory method would mean a degeneration in secondary school teaching.

To substantiate the above statements it was desirable to review, in general, a few of the more significant studies in this field.

Because lecture and textbook methods of teaching science are less expensive and more time-conserving than the laboratory methods, it is important to investigate their relative merits. An experiment for solving this problem was made by Mayman.[1] He taught thirty-one lessons in physics by each of the three methods to fourteen classes of boys in Grades VII and VIII.

He concluded that, on the basis of attainment, the three methods ranked from best to poorest in the order: individual laboratory, lecture, and book; but that from the standpoint of time required by the teacher, the ranking was just the reverse. This conclusion, however, was weakened by the facts that attainment was measured by essay tests and the groups were not equated.

Wiley[2] tested this conclusion with an improved technique. He used three equated groups and also the method of rotation. Unfortunately, there were only eight pupils in a group; the results were measured by essay tests; and the experiment lasted only three days. He concluded that the textbook method was superior for immediate learning, and that the laboratory method was superior for permanent learning.

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1. Homer B. Reed. Psychology and Teaching of Secondary-School Subjects. New York, Prentice-Hall, Inc., 1939. p. 599.
Quoting J. E. Mayman. An Experimental Investigation of the Book Method, Lecture Method, and Experimental Method. Doctor's Thesis. New York University, 1912.

2. Loc. cit.

A number of investigations pertaining to the relative values of the lecture-demonstration method and the individual laboratory method of instruction in secondary-school science were also reviewed by Duel.[3] He selected the studies of Johnson for biology; Carpenter and Horton, for chemistry; and Walter, for physics. Duel says that, in general, the method of conducting these investigations was as follows:

On the basis of intelligence tests and the student's previous grades in science, the students to be instructed were divided into two groups of approximately equal ability. One group was then taught by the lecture-demonstration method and the other by the individual-laboratory method. Johnson and Horton used a rotation procedure; that is, the same students were taught one exercise or set of experiments by the demonstration method and another exercise or set of experiments by the laboratory method. This method of procedure made it possible for them to compare not only the achievement of two groups taught by two different methods, but also the achievement of the same group taught by the two different methods. At the close of each study,

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3. Henry W. Duel. "Measurable Outcomes of Laboratory Work in Science; A Review of Experimental Investigations." (School Science and Mathematics. Vol. 37, pp. 795-810. October, 1937).

these two groups were given identical tests, and upon the basis of these tests, the comparative efficiency of the two methods was determined. Usually the groups were tested a second time after a considerable interval; this interval varied in the several studies. The purpose of these delayed tests was to determine the relative efficiency of the two methods in terms of the knowledge retained after the interval. In immediate results the evidence is in favor of the demonstration method. With respect to the retention of subject matter, as shown by delayed tests the evidence is not so clear.

Carpenter's study showed that the majority of students in high-school classes in laboratory chemistry taught by the demonstration method succeed as well as when they perform the experiment individually. Carpenter concluded that there is an indication that both the demonstration method and the individual-laboratory method are superior to the group-of-two method. This group-of-two method consisted of grouping several classes of several schools into one unit as the experimental group, and the several classes or several schools comprising another unit as the control group. The comparison based on intelligence showed, in general, that the mental ability of students is a more important factor than the method of instruction used.

According to Walter's[4] experiment the outcomes showed that the individual laboratory method yielded superior results in ability to manipulate apparatus. A skill of this kind can be formed only by practice, and the method which provides the most practice would be expected to yield the best results. But in understanding and knowledge--even in knowledge of experimental method, the lecture-demonstration method showed superior results which Walter attributed to the effects of drill. From experiments of others, Walter made the observation that the individual laboratory and lecture-demonstration were practically equal, but in these experiments the demonstration group used less time. In Walter's experiment the time was the same for each group, and since the time saved by the demonstration was used for drill, he concluded that the superior results obtained by the demonstration-drill method were due to the use of drill. He further contends that the use of drill introduces variables in the experimental procedure that make an exact evaluation of the several factors difficult. If there is no important difference between the two methods used, Walter believes that the saving in expense for the demonstration method is an important consideration.

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4. Reed, *op. cit.*, p. 604.

Some of the more recent studies or evaluations reveal other outcomes. At the American Chemical Society meeting in 1935, W. W. Knox as reported by Elder[5] stated the following:

> It is evident that the experimental data we possess point definitely to the superiority of the demonstration method as far as those outcomes that may be measured by the ordinary written tests are concerned.

Knox further states:

> I am convinced that the abandonment of the laboratory method at the present time would mean a degeneration of science teaching in the secondary schools.

He then added: "The question might well be raised which method stimulated pupils' interest?"

Other writers on the lecture-demonstration contend that there is too much participation on the part of the instructor and too little pupil participation, and that a continuous use of this method may lead to complete indifference and intellectual stagnation on the part of some members of the class.

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5. Albert L. Elder. "The Lecture-demonstration Method Versus Individual Laboratory Work in Chemistry. (Science Education, Vol. 23, p. 213. March, 1939).

These are substantiated by Conn[6] who pointed out some factors that are often overlooked by even the most skilled instructors. They are as follows:

1. It requires skill to command the attention of the entire class for forty minutes.

2. Pupil participation is at a minimum. The student feels that he has contributed far less than where individual laboratory work has been offered. In reality it has contributed far less. Hence there is far less interest in the class.

3. Assuming that as much subject matter may be taught by the demonstration method as by the individual laboratory method, it still fails to offer an effective program for exploration and guidance. Because it fails to provide opportunity for initiative and self-expression on part of the pupil, most of the program for the development of a scientific attitude is sacrificed.

Conn did not argue that the demonstration method is to be eliminated, but implied that the major portion should be done by students and that the demonstration method should be used mainly for certain types of work, such as the teaching of desirable skills and techniques and experiments in which there is an element of danger to the student.

Some reasons why this same author is favorably impressed with the laboratory system are:

1. It tends to develop initiative on the part of the students.

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6. Kenneth E. Conn. "The Point System of Grading as Means of Increasing Pupil Participation in High School Chemistry Classes." (School Science and Mathematics. Vol. 38, p. 818, October, 1937).

2. It promotes activity on the part of the class.

3. It motivates the class.

4. The students assume the responsibility for doing most of the work.[7]

The above point of view is further born out by Sutton[8] when he states:

> It is the job of education to prepare boys and girls to live in and be a part of democracy. Young people need to taught correct scientific principles and patriotism at home and by their teachers. The best way to teach scientific principles is through practical first-hand participation and experience.

In the studies reviewed above, the outcomes of the experiments were measured chiefly in subject matter achievement; that is, information and skills. They did not completely provide for the control of teacher-motivation and pupils' interest. It was found that one method is as effective as the other for imparting general knowledge and that time and equipment are saved by the lecture-demonstration method. Since the authors of the aforementioned studies claim that there are other outcomes involved in evaluating these methods, it is apparent that the question of relative merit should not be considered answered until these other outcomes have been measured.

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7. Loc. cit.

8. Traver C. Sutton. "Why Laboratory Science?" (School Science and Mathematics. Vol. 43, p. 401, May, 1943).

It is the general opinion of most writers that the real justification for teaching a particular science is to be found in the use made of the science. The method selected for the teaching should be evaluated solely in the terms of the objectives which it is intended to accomplish.

If the purpose is to develop pupil initiative, skills, and activity, it may be that some form of laboratory work should be selected, but if the purpose is to develop appreciation and general knowledge, it may be that the lecture demonstration method is just as good.

It was the hope of the author to verify some of the above hypotheses.

CHAPTER III

PROCEDURE AND TECHNIQUES

General Procedure

This experiment was conducted in the 10th and 12th grades of Girls Catholic High School, Hays, Kansas, during the school year 1943-1944. The enrollment in the 10th and 12th grades was, respectively 21 and 24 students. Each method was presented alternately to each group (Figures 4 and 5). This method of rotation, as discussed by Douglass[1] makes it possible to compare not only the achievement of the two groups taught by the different methods but also the achievement of the same group taught by the two different methods.

Sixteen problems dealing with the concept of photosynthesis (See Appendix) were presented to each of the two groups over a period of sixteen weeks. There were two periods of 80 minutes in each of the 16 weeks. The problems were divided into four units. The first two units consisted of six problems each, while the other two units contained two problems each.

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1. Harl R. Douglass. Modern Methods in High School Teaching. Massachusetts, Houghton Mifflin Company, [c 1926]. pp. 523-529.

Fig. 4. The Laboratory Group

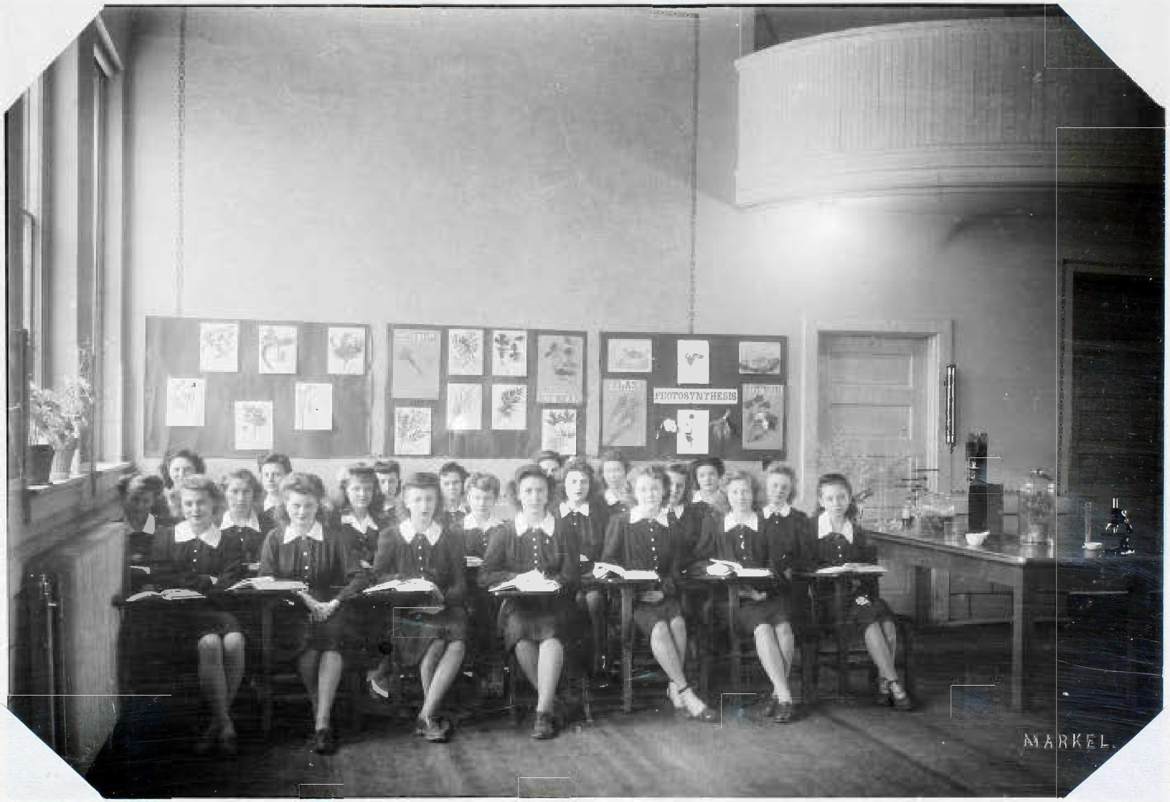

Fig. 5. The Demonstration Group

The titles for Units I, II, III, and IV are the following:

Unit I FUNCTION AND STRUCTURE OF SOIL AND ROOTS

Unit II PROCESSES AND STRUCTURES INVOLVED IN PHOTOSYNTHESIS

Unit III A STUDY OF LINEN AND COTTON

Unit IV A STUDY OF RAYON AND SOYBEANS

For problems under each of the above units, refer to pages, 46, 71, 92, 102 in the appendix.

At the completion of each unit, the two groups were given identical tests, and upon the basis of these tests the relative value of the two methods was determined. Each of the four final tests was followed by two retention tests given on an average of two and four months respectively after each of the final tests. The tests for the first two units were of the content type, while those for the last two units were a combination of the content-performance type. At the close of an experiment each group devoted the remainder of the class period to additional readings. The purpose of these suggested references was to provide a broader view of the problem. All questions based on observations and conclusions were answered immediately after the experiment was performed. The students reported their results on an extra sheet. These were then graded by the teacher and returned the following day for discussion in order to clarify doubts and to determine possible errors. This plan was to develop scientific procedure and good habits of thinking. The work was done under the direct supervision of the instructor and no outside performance or study was required.

Preliminary Steps

The first step in the procedure was to gather all the necessary materials and apparatus to be utilized in this experiment.

The students of the experimental group collected the following items:

1. Different types of soils, from different localities; such as, leaf mold, humus, clay, and sand.
2. Different types of roots; such as those of dandelions, grasses, weeds, carrots, and radishes.

Various kinds of seeds and flower pots were obtained from the College Greenhouse, Fort Hays Kansas State College. Reverend Father Terence Moffat, President of St. Joseph's College and Military Academy, Hays, gladly assisted in lending 12 microscopes for this experiment.

The students brought most of the materials from the community. Other supplies such as, chemicals, solutions, thistle tubes, glass tubing, glass slides, and cover glasses, prepared slides and sections of plants, and bell jars were at their disposal in the supply room of the science department.

Basis of Equating Groups

Since the pupils of grades 10 and 12 were available for the study, an effort was made to compare their intellectual and scholastic abilities.

The Henmon-Nelson Test of Mental Ability was given to determine the individual intelligence quotients of each student. The average scholastic achievement of each student at the end of the preceding school term was used to determine the average class standing of the students engaged in this study.

The statistical significance of difference in the mean scores between the groups was determined. The results of these tests are given in Table 1.

TABLE I. COMPARISON OF SCORES FOR GRADES TEN AND TWELVE IN THE PRELIMINARY TESTS

Group	Cases	Mean	Diff.	σDiff.	Diff/σDiff.	Reliability
			Henmon-Nelson Test			
Grade (10)	21	49.10	2.53	3.35	.75	.77
Grade (12)	24	51.63				
			General Class Average			
Grade (10)	21	87.05	2.33	2.58	.90	.82
Grade (12)	24	89.38				

From the above table it is apparent that the two groups were comparable. Since their abilities were approximately equal, it seemed reasonable to use these grades for the purpose of this study.

Plan of Instruction

Each of the two groups met in separate classes twice a week for eighty minutes. At the first meeting with each group, one week prior to the actual experiment, the instructor discussed the objectives of the experiment and the significant facts about the concept of photosynthesis (Chapter I). A mimeographed sheet, entitled, "Just a Word to the Student" was then given to each member (Appendix, page 26). The purpose of this sheet was to introduce the students to the problem, to encourage them to be attentive at all times, to follow directions carefully and accurately, and not to be satisfied with minimum accomplishment.

On the first day of the experiment, each student of both groups was given a study sheet which contained a problem and directions for solving the same. In order to stimulate interest and arouse a sense of need for the specific problem to be studied, a brief general review was given. All study sheets were of the same general arrangement (Appendix).

Description of Methods

In the laboratory method each student assumed the responsibility of performing the experiment according to directions on the study sheet. These instructions were usually given on the previous day so that the necessary materials could be ready for the experiment. Each student of this group was then assigned to a definite place in the laboratory and was directed to use the equipment required in the experiment. In order to teach desirable work habits, all were instructed how to care for the equipment and to return it to its proper place. This procedure was strictly adhered to at all times. It was made known to them that order is Heaven's first law. In this manner, much time was saved.

In the lecture-demonstration method the same technique was followed with the exception that the teacher performed all the experiments, discussed important facts, and demonstrated various phases of the problem either by sketches or by pictures and told them the outcomes. No notes were taken during the lecture demonstration. As soon as all the items were covered, students proceeded to answer the questions on the study sheet. Since the teacher performed all the work, the students of this group had a little more time for additional readings.

CHAPTER IV

ANALYSIS OF DATA ON PERIODICAL TESTING

Treatment of Data

After all the grades on the final and retention tests were computed, it was necessary to treat them statistically. The assumption was made that we were dealing with a normal group, a representative sampling.

Central Tendency and Variability

The measures calculated in this study included the mean and standard deviation. Any difference in the average scores of the two groups was assumed to be due to the experimental factor.

Reliability

It is a well-known fact that, even though two methods are equally effective, in general, a difference due to chance, would almost invariably be found in a single experiment of this kind. To show that the difference obtained was larger than could reasonably be accounted for by chance, the standard deviation of the difference between two means, also known as the standard error of that difference was calculated in this experiment.

The following formula[1] for the reliability of the difference between the two obtained means was used:

$$\sigma \text{ Diff.} = \sqrt{M_1^2 + M_2^2}$$

The degree of reliability was obtained by dividing the obtained difference by the sigma difference. Garrett's[2] table was consulted for its significance. Since the cases in this experiment were limited to 21 and 24, the value of the obtained difference had to be large.

Results

1. C. A. Gregory and O. W. Renfrow. Statistical Methods in Education and Psychology. 2nd ed. Cincinnati, C. A. Gregory Company, c 1929 , p. 114.

2. Henry E. Garrett. Statistics in Psychology and Education. Chicago, Longmans, Green and Co., 1926, p. 134.

The average achievement of each group on the final test covering Unit I is presented in Table II.

TABLE II. COMPARISON OF LABORATORY AND LECTURE-DEMONSTRATION, UNIT I

Group	Cases	Mean	Diff.	σ Diff.	Diff/σ Diff.	Reliability
			Final Test			
Lab. G. 10*	21	65.9	2.9	2.12	1.37	.91
Dem. G. 12*	24	63.0				
			Retention Test 3 Months After Final Test			
Lab. G. 10	21	61.9	2.81	2.09	1.34	.90
Dem. G. 12	22	59.09				
			Retention Test 6 Months After Final Test			
Lab. G. 10	21	59.57	3.68	2.68	1.37	.91
Dem. G. 12	18	55.89				

* G. 10 and G. 12 refer to Grades 10 and 12.

The results as shown in Table II indicate a slight superiority of the laboratory group in the final test. The chances that the difference between the two means is greater than zero are 90 in 100.

In the difference of the scores of the two methods from the standpoint of retention there is a loss of only .09 between the final test and the first retention test, and a gain of .78 between the final test and the second retention test. The result in each retention test was in favor of the laboratory group, but not by a sufficient amount to make its superiority statistically significant. The superior scores by the laboratory group on the final test and retention tests were probably due to remembering the set-up in the laboratory workroom and what happened in it.

Further light was shed on the comparative merits of the two methods by the study and testing of Unit II. The results are given in Table III.

TABLE III. COMPARISON OF LABORATORY AND LECTURE-DEMONSTRATION, UNIT II

Group	Cases	Mean	Diff.	σ Diff.	Diff/σDiff.	Reliability
			Final Test			
Lab. G.12	22	60.59	3.11	2.33	1.33	.90
Dem. G.10	21	57.48				
			Retention Test 3 Months After Final Test			
Lab. G.12	20	60.43	1.80	2.64	.68	.74
Dem. G.10	17	62.23				
			Retention Test 4 Months After Final Test			
Lab. G.12	20	56.65	3.16	2.47	1.28	.89
Dem. G.10	21	59.81				

The results in Table III show that the difference in the obtained means is in favor of the laboratory group.

Chances are 90 in 100 that the difference is greater than zero.

Since the laboratory group of Unit I became the demonstration group in Unit II, the writer concluded that the methods are about equal as far as the acquisition of knowledge is concerned.

Regarding the two tests given 3 and 4 months after the final test, the scores are slightly in favor of the demonstration group. The writer concluded that in retaining facts, the demonstration method is about as effective as the laboratory method.

The subject covered in Unit III was a study of Cotton and Linen. A new type test, a combination of content-performance type was given at the completion of this unit. The nature of the test was a completion test. Approximately one-half of the questions in this test were of the reading type, the other half, the laboratory type (Table IV). A reading type question was based on information gained by reading. A laboratory type question aimed to test information gained by actual work in the laboratory.

TABLE IV. COMPARISON OF LABORATORY AND LECTURE-DEMONSTRATION, UNIT III

Group	Cases	Mean	Diff.	σ Diff.	Diff/σDiff.	Reliability
			Final Test			
Lab. G.10	21	62.57	2.31	1.92	1.2	.88
Dem. G.12	17	64.48				
	Retention Test 2 Months After the Final Test					
Lab. G.10	19	63.58	.08	1.85	.43	.65
Dem. G.12	20	63.66				
	Retention Test 3 Months After Final Test					
Lab. G.10	21	67.48	.80	1.8	.44	.65
Dem. G.12	19	66.68				

The significant fact, though it be slight, presented in Table IV showed that the scores are in favor of the demonstration group, in both the final and the first retention test. These results seem to warrant the conclusion that the demonstration method is as good as the individual laboratory method for gaining general knowledge and operating skills. There was a gain of 1.51 in the third retention test in favor of the laboratory group which may be attributed to their experience in the laboratory.

As a final comparison of the two methods employed, a fourth unit dealing with rayon and soybeans was presented. A similar test as described in Unit III was given at the completion of this unit. This test measured both content and performance. Two identical retention tests were administered the second and third months after the final test. The comparative scores are shown in Table V.

TABLE V. COMPARISON OF LABORATORY AND LECTURE-DEMONSTRATION, UNIT IV.

Group	Cases	Mean	Diff.	σDiff.	Diff/σDiff.	Reliability
			Final Test			
Lab. G.12	21	65.90	17.11	2.5	6.84	1
Dem. G.10	19	48.79				
	Retention Test 3 Months After Final Test					
Lab. G.12	21	50.48	6.04	3.65	1.66	.94
Dem. G.10	21	56.52				
	Retention Test 3 Months After Final Test					
Lab. G.12	22	61.14	3.29	2.71	1.21	.88
Dem. G.10	20	57.85				

The study of results of Units I, II, and III, up until now, showed a very slight difference in the methods. The data presented in Table V shows that the laboratory group excelled by a large difference over the demonstration group in the final test. The large difference obtained between the two means cannot be fully accounted for at this time. Perhaps the subject matter was too difficult for the demonstration group. The added familiarity of the subject to the laboratory group in their regular biology class may have been the cause of this large gain in their favor.

With respect to the first retention test, there was a pickup in favor of the demonstration group. An earnest review on their part probably caused this result. An extraneous factor in the form of an extra-curricular school activity probably caused the decrease for the laboratory group. In the third retention test, there is little difference between the groups. Because of the inconsistencies of the scores in this unit, the writer finds it difficult to draw any definite conclusions.

As a final check on the relative merits of the two methods and the two groups, a summary table was compiled. The purpose of this table was to give a summary on all the final and retention tests for the 4 units. The mean of the raw scores of all the groups was computed. The following table provides a summary of the two groups.

TABLE VI. SUMMARY OF THE MEANS OF TOTAL GROUPS IN LABORATORY AND LECTURE-DEMONSTRATION FOR UNITS I, II, III, AND IV.

Group	Cases	Mean	Diff.	σ Diff.	Diff/σ Diff.	Reliability
			Total Final Tests			
Lab.	85	62,88	4.25	1.4	3.00	.999
Dem.	81	58.63				
			Total First Retention Tests			
Lab.	84	58.18	2.27	1.56	1.46	.93
Dem.	80	60.45				
			Total Second Retention Tests			
Lab.	84	61.27	1.26	1.46	.86	.80
Dem.	77	60.01				

The findings in this table show that the difference in the obtained mean of all laboratory groups in the final tests is 4.25. The ratio of the obtained difference to its standard deviation is 3.00, which showed that this is a significant difference in favor of the laboratory group. The inconsistency of the scores obtained in the combined retention tests casts some doubt on the certainty of this difference.

Had conditions remained normal throughout the experiment, the writer would see no evidence that either method of instruction is to be preferred in gaining general knowledge of the concept of photosynthesis.

The obtained mean of the demonstration group in the first retention tests is 2.27 in favor of that group. The difference is too slight to be of any statistical value. The results obtained in the two retention tests show that both methods are about equally effective so far as retention is concerned.

Classifying Test Questions

As a further check of probable outcomes other than factual knowledge, the test questions for Units I, II, and IV were divided into reading-type and laboratory-type questions. A reading-type question tested general knowledge gained by reading additional related references; a laboratory-type question tested initiative and skills performed in the laboratory workroom. The tabulations in Table VII give the outcomes.

TABLE VII. COMPARISON OF CORRECT RESPONSES TO THE READING AND LABORATORY-TYPE QUESTIONS ON UNITS I, II, AND IV BY THE LABORATORY (GRADE 12) AND DEMONSTRATION (GRADE 10) GROUPS

Group	No. of Cases	Reading Questions	Per Cent Correct	Laboratory Questions	Per Cent Correct
			Test, Unit I		
Lab. (G.12)	21	36	89	39	87
Dem. (G.10)	22		83		82
			Test, Unit II		
Lab. (G.12)	22	29	76	46	84
Dem. (G.10)	21		83		74
			Test, Unit IV		
Lab. (G.12)	20	38	87	37	84
Dem. (G.10)	19		61		70

Since in the Reading questions the Laboratory group was superior in 2 units and the demonstration group in one unit, there appears to be no special difference in the two methods in responding to the reading-type questions. In three tests the laboratory group was superior in the laboratory-type questions. These latter results suggest that the laboratory method is superior for giving information gained from actual work in the laboratory.

In order to find out with more certainty what type of question could be answered by each method, an analysis was made of the specific questions which showed a large difference in favor of one of the groups. Arbitrarily the writer chose those questions in which there was a difference of 15% or more of one group than of the other. After selecting the questions, they were divided into reading, laboratory, or both.

The number of questions which 15% or more of the laboratory group answered correctly than of the demonstration group was 33. It was expected that that method was best suited to the greatest percentage of questions answered correctly.

The percent of laboratory-type questions answered correctly by the laboratory group was 45% and the percent of reading-type questions were also 45%. From this it was concluded that the laboratory group can gain information equally as well from reading as from the laboratory-type questions.

The number of questions answered correctly by 15% or more of the demonstration group than of the laboratory group was 19. The percent of questions which fell in the laboratory group was only 21%, whereas the percent which fell into the reading-type was 69%. These results show that the demonstration group is superior in the reading-type questions.

In comparing the laboratory group with the demonstration group in laboratory-type questions it was found that the laboratory group answered more than twice as large a percentage of the laboratory-type questions, namely, 45 instead of 21.

These findings are in accord with Table VII which showed that the laboratory group was superior in the laboratory-type questions, and that the demonstration group is likely to be superior in the reading-type questions.

To illustrate this more clearly, we give below samples of the type of questions in which each group is superior.

Questions in which the laboratory group was superior:

1. Soil that does not retain water is 1. sand 2. clay 3. leaf mold 4. humus.

2. The growing tip of a root is called 1. root cap 2. meristem 3. root hair 4. cambium.

3. Grasses have 1. tap roots 2. aerial roots 3. fascicled roots 4. fibrous roots.

4. The response of roots to water is called 1. aquatic 2. hydrotropism 3. geotropism 4. capillarity.

Questions in which the demonstration group was superior:

1. Leaves manufacture starch in the presence of 1. moisture 2. chemicals 3. acids 4. sunlight.

2. Manufactured food is conducted in the plant by 1. xylem 2. cambium 3. phloem 3. lenticel.

3. Vascular bundles were discovered by 1. Robert Hooke 2. Grew 3. Pasteur 4. Malpighi.

4. Food is stored in 1. roots 2. leaf 3. root hair 4. stomata.

Results Other Than Tests

Little progress has been made in the measurement of the interests and attitudes of pupils with respect to science and phenomena. The task is a difficult one because as yet the interests and attitudes deemed desirable have not been clearly defined. Measurement in this field remains to be developed.

Since no reliable testing, other than teacher observation and pupil remarks, was done to test the third objective of this investigation, namely, to determine which method stimulated the greater amount of interest, no definite conclusions can be formulated. The writer has this remark to make that over 75% per cent of the groups engaged in the laboratory work at different times in this experiment preferred that method and remarked that that period was the most interesting of all their classes of the entire week in school.

From teacher observation it is noted that students who do laboratory work show more initiative in manipulative skills and laboratory techniques.

CHAPTER V

CONCLUSIONS

The information gained from this investigation leads principally to the following conclusions:

1. That the results of this study are in general agreement with those of the other investigations cited in Chapter II.

2. That as far as the outcomes of the written tests are concerned, there seems to be little significant difference in the relative efficiency of the laboratory and the lecture-demonstration in presenting the concept of photosynthesis to Grades 10 and 12, though the results suggest the probable but slight superiority of the laboratory technique.

3. That the lecture-demonstration method is nearly equal to the individual laboratory method for imparting information and developing ability to think in science, but is inferior for testing initiative, manipulative skills and laboratory techniques.

4. That the laboratory method stimulated a greater amount of interest. This would be an important finding if it could be substantiated by further experimentation, but until this is done, we can value it only as a problem for further research.

On the whole, the writer is convinced this investigation was worthwhile, and that the students gained much valuable information with respect to the indispensable part plants play in the material resources of our nation, namely as food, clothing, and shelter.

A P P E N D I X

JUST A WORD TO THE STUDENT

1. The study of green plants as the most important food factories of the world will be the special project for careful study for some time.

2. Working with living things is the most interesting way of knowing them. Your attention in class to your teacher and your laboratory work can be the most enjoyable and most profitable part of the day. Make it so.

3. A conscientious student is never satisfied with minimum accomplishment. Produce reports which indicate that you THINK.

4. In your additional problems and readings, be sure to have complete and clear answers.

5. These problems for special study will fit you to use and to enjoy the things around you. Make them pay dividends.

6. Your teacher will demonstrate and help you; your laboratory directions will guide you. They are effective plans of attack. Follow them accurately.

UNIT I

FUNCTION AND STRUCTURE OF SOIL AND ROOTS

Problems

Problem 1. How various soils differ in their ability to hold water.

Problem 2. Effect of soil on growing plants.

Problem 3. In which direction do roots and stems grow?

Problem 4. Do roots grow toward water?

Problem 5. Structure of the root.

Problem 6. Structure and function of root hairs.

STUDY SHEET

References:	Hunter	Problems in Biology, pp.137-140.
	Snyder	General Science, pp. 327-332; pp. 335-340.
	Coulter	Plant Life and Plant Uses, pp. 98-104.
	Sr. M.Defrose	Biology for High Schools, pp. 557-558.
	Carroll, F.B.	Understanding our Environment, Bk. I, p. 149.

Problem 1: HOW VARIOUS SOILS DIFFER IN THEIR ABILITY TO HOLD WATER

Materials Required: Four small flower pots (4-in.); four different kinds of soil. Collect sand, clay soil, loam, and leaf mold.

Experiment: Place equal amounts of various types of soil in each flower pot. Measure a quantity of water, 300 c.c. Add slowly the same quantity to each pot. Measure the water which runs through and calculate how much the soil retained.

Observation:

Sample	Water Poured in	Water Recovered	Water Retained
Sand	300 c.c.	214 c.c.	86 c.c.
Clay	300 c.c.	19 c.c.	281 c.c.
Loam	300 c.c.	139 c.c.	161 c.c.
Leaf Mold	300 c.c.	115 c.c.	185 c.c.

Conclusions: Write a list of soils in the order of their ability to hold water.

Additional Problems:

1. List various types of soils.
2. What type of soils holds the most water? the least?
3. What type of soil would you find in the desert? in the river valley? in a prairie?

QUESTIONS GIVEN TO STUDENTS AT CLOSE OF PRESENTATION

Question	Answer
1. Write a list of soils in the order of their ability to hold water.	1. Sand holds the least water, then rich soil, leaf mold, and clay holds the most.
2. List various types of soils.	2. Sand, clay, loam, and humus are various types of soils.
3. What type of soil would one find in a desert, river valley, prairie, forest floor?	3. Sand is found in a desert, rich soil in a river valley and also prairie land, and humus or leaf mold in the forest floor.

STUDY SHEET

References:

Carroll, F. *Understanding our Environment*, Bk. I., pp. 149-150.

Hunter, Problems in Biology, pp. 137-140.

Sr.M.Defrose *Biology for High Schools*, pp. 557-558.

Weaver, Clements *Plant Ecology*, pp. 173-233.

Problem: EFFECT OF SOIL ON GROWING PLANTS

Materials Required: Five small jars or flower pots; five different kinds of soil; seeds of various kinds.

Experiment: Place an equal amount of the various types of soil in each of the five flower pots. Place several seeds, such as radish or bean seeds in each pot. Set the flower pots in selected place in the laboratory and control factors of moisture, temperature, and light. Note signs of growth each day over a period of several days.

Conclusions: From observations on the laboratory experiment, record the following:

1. Compostition of the soil in which seeds showed the first signs of growth.

2. Make a list of the chemicals you would judge each soil to possess because of the growth of the seedlings.

3. From experience, could you reasonably conclude that the soil in your locality is rich or poor?

4. Is there any way by which a farmer can improve soil depleted or mineral content?

Additional Problems:

1. What is soil?
2. How would you make up a good soil for growing flowers in pots?
3. What are some of the materials which make up a rich soil?
4. List the most important chemicals found in soil.

5. How can a farmer improve soil depleted of mineral content?

6. How is nitrogen added to the soil?

7. How does soil obtain phosphorus? Give its importance in the soil?

8. Why is potassium necessary in soil?

Vacabulary:

organic	rotation of crops
cultivation	capillarity
loam	water table
alkali	bacteria
humus	

Suggested Biographies (Brief): Eugene W. Hilgard.

Questions	Answers
1. What is soil?	1. The upper portion of mantle rock which is very finely weathered and mixed with organic material is known as soil.
2. How would you make up a good soil for growing flowers in pots?	2. Soil for potting should be light, well supplied with humus, and sand, moderately fertile, well sifted, uniformly mixed and damp but not wet.
3. What are some of the materials which make up a rich soil?	3. Rich soil is a complex mixture. It is composed of particles of rocks, decaying organic matter, water, soil, air, and living organisms.
4. List the most important chemicals found in soil.	4. The most important chemicals found in soil are: nitrogen, potassium, phosphorus, magnesium, calcium, iron, and sulphur.
5. How can a farmer improve soil depleted of mineral content?	5. By rotation of crops.
6. How is nitrogen added to the soil?	6. By means of sodium nitrate, ammonium sulphate, and tankage (dried ground animal refuse of all kinds).
7. How does soil obtain phosphorus? Give its importance.	7. The soil obtains phosphorus in the form of bone and wood or ash, and phosphate rock Phosphorus is necessary for making plants mature more quickly and helps them resist disease.
8. Why is potassium necessary?	8. Potassium is necessary for chlorophyll formation.

Vocabulary:

organic	Pertaining to living things.
cultivation	Plowing, harrowing, and otherwise breaking up the soil is called cultivation.
loam	A variety of sand and clay is called loam.
alkali	Originally a soluble salt obtained from ashes of plants.
rotation of crops	The practice of alternating various crops on a given area to improve soil fertility.
humus	Dead organic material usually present in soil.
capillarity	A phenomenon shown by liquids rising in fine tubes.
water table	Upper limit of the ground wholly saturated with water.
bacteria	Microscopic plants.

Biography:

Eugene W. Hilgard (1833-1916) was a soil expert.

STUDY SHEET

References:	Carroll,	Understanding our Universe, Bk. III pp. 372-377.
	Holmes and Robbins,	General Botany, p. 39.
	Hunter,	Problems in Biology, pp. 140-141.
	Bergen,	Foundations of Botany, pp. 36-50.
	Atkinson,	Botany for Schools, pp. 26-30; 30-32.
	Bergen & Caldwell,	Practical Botany, pp. 5-11; 24-38.
	Smith, E. T.	Exploring Biology, pp. 582-585.

Problem 3: IN WHICH DIRECTIONS DO ROOTS AND STEMS GROW?

Materials Required: Two pieces of glass four or five inches square; a piece of heavy blotting paper the same size as the glass; radish seeds for sprouting; adhesive tape, or rubber bands.

Experiment:

1. Lay one of the pieces of glass on your desk. Place on it the blotting paper. Place several seeds of about the same thickness about 1½" apart on the blotter. Lay a second piece of glass over the seeds. With a piece of string or rubber bands fasten the pieces of glass tightly enough to hold the seeds in place. You have made a pocket garden Fig. 6.

2. Stand the pocket garden edgewise in a pan containing about an inch of water. The water will wet the blotter which will in turn moisten the seeds.

3. After a few days you will be able to see the sprouting seeds develop their roots and stems.

4. When you are sure of the direction of growth of the roots and stems, turn the pocket garden so that one of the side edges is in the water. Watch it for several days.

Diagrams:

1. Pocket garden as first built.
2. Pocket garden, after seedlings show direction of growth.
3. Pocket garden showing direction of growth after turning.

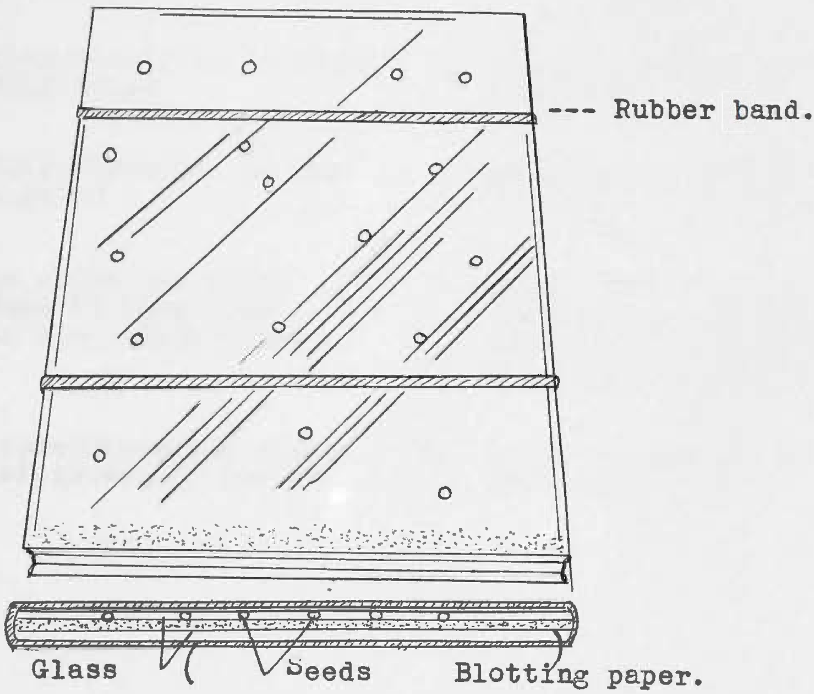

Fig. 6. A Pocket Garden.

Conclusions:
1. In which directions do the roots grow?
2. In which direction do the stems grow?
3. Do the roots and stems continue to keep growing in a straight line toward the edges of the glass they originally started for?
4. What seems to determine the direction of growth?

Questions	Answers
1. In which direction do roots normally grow?	1. Roots normally grow downward.
2. In which direction do the stems grow?	2. Stems grow upward.
3. Do the roots and stems continue to keep growing in a straight line?	3. Roots can be made to grow sideways or upwards if water is available only to the side or above them.
4. What determines the direction of growth of roots?	4. Roots respond to gravity and water.

STUDY SHEET

References:	Hunter, *Problems in Biology*, pp. 141-143. Carroll, F.B. *Understanding the Universe*, Bk. III pp. 372-377. Sr. Defrose *Biology for High Schools*, pp. 541-544; pp. 751-752.
Problem 4:	DO ROOTS GROW TOWARDS WATER?
Materials Required:	A shallow box (wooden) beans, sawdust. or A box, wire screen, seeds or beans, wet sawdust.
Experiment:	Divide the interior of a shallow wooden box with glass slide into two parts by a partition with an opening in it. Fill the box with sawdust. Plant beans in the sawdust on one side of the partition, and water them very slightly, but keep the other side of the box well soaked. After two weeks, take up some of the seedlings and note the position of roots. or Replace the bottom of a box with wire screen. Put in an inch of wet sawdust. Support it so that you can see the bottom from below. Plant beans at one edge (Fig. 7).
Conclusion:	Do roots grow down or do they follow the wet sawdust?
Vocabulary:	geotropism, heliotropism or phototropism, hydrotropism.
Suggested Biographies:	Jacques Loeb, Julius Sachs.

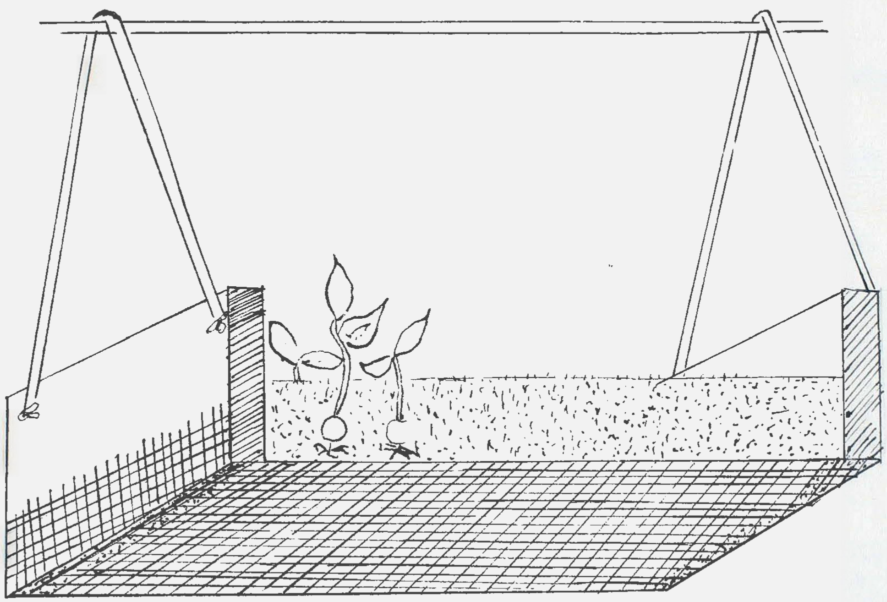

Fig. 7. To Show That Roots Seek Water.

Questions	Answers
1. Do roots grow down or do they follow the wet sawdust?	1. Roots may grow sideways or upwards if water is available to the side or above them. Roots follow the wet sawdust.

Vocabulary:

geotropism	Response of plants to gravity.
heliotropism or phototropism	Response of plants to light.
hydrotropism	Response of roots to water.

Biographies:

1. Jacques Loeb (1859-1924) University of California ascribed many of the phenomena of growth to tropisms.

2. Julius Sachs (1832-1897) A German botanist, experimented on tropisms and showed the effect of sunlight, moisture, and gravity on plants.

STUDY SHEET

References:	Bergen & Caldwell,	Practical Botany, pp. 24-38.
	Charles, B.	Biology, pp. 64-68.
	Cowles and Coulter,	Practical Course in Botany, pp.63-65; pp.72-78.
	Sr.Defrose	Biology for High Schools, pp.563-565; pp.557-565.
	Hunter,	Problems in Biology, pp. 143-144.
	Holmes and Robbins,	Textbook in General Botany, pp.161-162.
	Kinsey,	An Introduction to Biology,
	Menge,	Laws of Living Things, pp.154-160.
	Smallwood, Reveley & Bailey,	New Biology, pp. 485-495.
	Smith, E. T.	Exploring Biology, pp. 127-131.

Problem 5: STRUCTURE OF THE ROOT

Materials Required: Microscope; prepared slides; hand section of bean roots previously grown and stained with iodine or eosine.

Experiment: Examine a slide of the cross section of a root, under the microscope; compare findings with sketches in references; study very carefully the structure, draw and label.

Conclusions: From the sketches and your reading, define, locate and give the function of the following:

central cylinder, epidermis, root hairs, cambium, root cap, cortex, xylem, phloem, endodermis.

Additional Problems: Name various types of roots, give description of each, and examples.

1. Adventitious, air roots, aquatic, parasitic, taproots, fascicled, and fibrous roots.
2. Give seven functions of roots.

Suggested things to do:

1. Dig out, wash, and mount three different kinds of fibrous roots.
2. Make a collection of three types of tap roots, wash them and put them in clean boxes, correctly

labeled for a classroom exhibit.

3. Sketch fibrous and tap roots, aerial and water roots, adventitious, fleshy and fascicled roots.

Vocabulary:

Mitosis, meristem

Biographies: N. de Saussure and J. B. Boussingault.

Questions | Answers

Types of Roots	Description	Example
Adventitious	Roots growing from the stem or leaves	Ivy, Strawberry
Aerial Roots	Roots growing into the air to absorb water.	Orchid
Aquatic	Short root of aquatic plant growing into water.	Hyacinth, Pond Lily
Fascicled	Fleshy roots produced in clusters.	Dahlia
Parasitic	Adventitious roots which grow into another plant to absorb its food.	Mistletoe
Fibrous	Differ from tap roots in developing several independent branches of a thread-like form instead of one main strong root.	Grasses, Grains, Cereals, Corn
Taproots	Are primary roots that grow straight down into the soil as a single stout structure. Stores food, therefore, also called fleshy roots.	Carrots, Beets, Dandelions, Turnips

Questions Answers

ROOT STRUCTURE

Part or Region	Description and Location	Function
Central Cylinder	Central portion of root. Consists of xylem cells. Some are fibrous, others are tubular.	Sends liquids up the plant. Stores food; stiffens root.
Epidermis	Brick-shaped cells outside of root.	Protects cells within.
Root hairs	Elongated epidermal cells of root.	Absorb soil water and salts.
Cambium	Region of growth between xylem and phloem in fibrovascular bundles.	Produce new cells. Growing layer.
Root cap	Dead cells on the end of the root.	Protects the growing tip.
Endodermis	Circle of cells separating cells of the cortex from those of central cylinder.	
Cortex	Thin-walled spherical cells inside of the epidermis.	Stores food.
Phloem	Phloem cells occupy spaces between xylem and cambium and continue in stems.	Carry manufactured food from leaves to all parts of the plant.
Xylem	Region of woody cells and water conducting tubes.	Conduct sap upwards in plants.

Vocabulary:

Meristem — Growing tip. Small irregular cells at the tip of a live root. Increases length of root.

Mitosis — Change in chromosomes in cell division.

Biographies:

Nicholas de Saussure (1767-1845) a Swiss botanist, proved that the mineral matter in plants came from the soil.

Jean B. Boussingault (1802-1887) French agricultural chemist, proved that nitrates in soil are necessary for plant growth.

Seven funtions of roots:

1. Most roots anchor the plant to the ground.
2. Absorb moisture and minerals from the soil.
3. Convert atmospheric nitrogen into nitrates by means of nitrogen-fixing bacteria. (Alfalfa, clover).
4. Store food as carrot.
5. Reproduce the plant. (Dahlia).
6. Secure food for the plant. (Mistletoe, dodder).
7. Aid the plant in climbing. (Ivy).

References: Use the same as in Problem 5.

Problem 6: STRUCTURE AND FUNCTION OF ROOT HAIRS

Materials Required: Microscope, portion of the root hairs, radish seedlings, longitudinal sections of roots showing epidermal outgrowths.

Experiment: Detach several of the fine hair-like structures growing from the root; place on a slide with a few drops of water; examine under the microscope; also examine the longitudinal section of the root on the prepared slides.

Conclusions: From the above experiment and from your study of sketches in your textbooks and references determine the following:

1. The nature of a root hair.
2. Function of a root hair.
3. The structure found in a root hair.
4. Where are the longest root hairs found?
5. Of what value are the large number of root hairs?

Additional Problems: Name six roots and give their economic value to man. Examples: tapioca, potash and sugar beets, ginseng, ipecac and others.

Questions	Answers
1. The nature of a root hair.	1. A root hair is an outgrowth of the epidermis.
2. Give function of a root hair.	2. Function of a root hair is to absorb water containing dissolved minerals.
3. Name structures found in a root hair.	3. a. The cell wall is flexible and thin and is made up of cellulose. b. Cell membrane is very delicate. c. Protoplasm is found in root hairs. d. Interior of root hair contains many vacuoles or spaces filled with fluid celled sap. e. Each root hair has a nucleus.
4. Where are the longest root hairs found?	4. The longest root hairs are found some distance back from the tip.
5. Of what value are the large number of root hairs?	5. Root hairs increase the surface of absorption.

Additional Problems:

Economic value of six roots:

1. Carrots are used as vegetable food.
2. Tapioca is manufactured from the root of the tropical cassava plant.
3. The sugar beet furnishes more than half of the world's sugar supply.
4. Potash for glassmaking and waste for fertilizer are also by-products of sugar beets.

5. Root of grasses and trees are valuable agents of great economic importance in preventing soil erosion.

6. Ginseng and ipecac are products from the roots whose medicinal qualities are beneficial to man.

Vocabulary:

Ginseng	Chinese herb, red berries, quinquefolio leaves.
Cassava	Fleshy rootstalk, nutritious starch or tapioca.
Ipecac	Dried rhizome, roots known as Rio or Brazilian ipecac.

Final Test for Unit I

Time: 40 Minutes Possible Score:

(2) 1. Soil that retains water best contains 1. seed 2. humus 3. gravel 4. sand.

(2) 2. Bacteria nodules on the clover make 1. sulphates 2. nitrates 3. phosphates 4. potassium.

(2) 3. Name a soil expert 1. Pasteur 2. Hilgard 3. Audubon 4. Sachs.

(4) 4. Sand is found in 1. forest floor 2. river valley 3. prairieland 4. desert.

(2) 5. Leaf mold or humus is found in 1. desert 2. forest floor 3. prairie 4. river valley.

(4) 6. A good soil for growing flowers in pots is 1. well supplied with mineral 2. wet and very rich 3. wet and well sifted 4. proportions of sand and humus.

(5) 7. In clay soils the water penetrates 1. very slowly 2. rapidly 3. moderately 4. not at all.

(3) 8. Planting beans and clover and plowing the roots under restores 1. calcium 2. phosphorus 3. nitrogen 4. oxygen.

(3) 9. A farmer can improve soil depleted of mineral content by 1. irrigation 2. cultivation 3. rotation of crops 4. plowing.

(3) 10. Potassium is necessary for 1. osmosis 2. transpiration 3. chlorophyll formation 4. absorption.

(2) 11. Organic pertains to 1. non-living things 2. living things 3. minerals 4. gases.

(1) 12. Soils containing both organic and mineral matter are 1. humus 2. clay 3. alkaline 4. sand.

(2) 13. A great amount of soluble salts are found in 1. clay soils 2. alkaline soils 3. sandy soils 4. humus.

(1) 14. Bacteria are 1. microscopic organisms 2. elements 3. compounds 4. minerals.

(1) 15. The process of plowing and breaking up the soil is called 1. cultivation 2. rotation of crops 3. irrigation 4. contouring.

(3) 16. The rising of liquids in fine tubes is called 1. osmosis 2. circulation 3. capillarity 4. absorption.

(3) 17. Ground bone or rock phosphates restores 1. nitrogen 2. potassium and nitrogen 3. calcium and phosphorus 4. carbon dioxide.

(1) 18. Soil that does not retain water is 1. sand 2. clay 3. leaf mold 4. humus.

(1) 19. Plants grow best in 1. rich soil 2. clay soil 3. gravel 4. poor soil.

(3) 20. Photosynthesis takes place in the 1. stem 2. root 3. leaf. 4. root hair.

(1) 21. Root hairs grow from the 1. epidermis 2. cortex 3. central cylinder 4. root cap.

(3) 22. A root used for medicine is the 1. parsnip 2. wild carrot 3. licorice 4. peppermint.

(2) 23. Sugar is made from the roots of the 1. sweet clover 2. beet 3. red maple 4. Canadian Thistle.

(2) 24. The influence of light on the direction of stems is called 1. geotropism 2. heliotropism 3. hydrotropism 4. gravitation.

(2) 25. Soil that retains water the best contains 1. limestone 2. humus 3. gravel 4. sand.

(2) 26. Bacteria nodules on the clover roots make 1. sulphate 2. nitrates 3. phosphates 4. carbohydrates.

(2) 27. Fleshy roots store food in the 1. epidermis 2. cortex 3. xylem 4. phloem.

(2) 28. The direction of roots is influenced by 1. photosynthesis 2. gravity 3. capillarity 4. heliotropism.

(4) 29. The growing point of the root is protected by 1. epidermis 2. central cylinder 3. xylem 4. root cap.

(1) 30. The absorbing surface of a root is often increased by 1. root hairs 2. epidermis 3. cambium 4. xylem.

(4) 31. The type of root that best prevents soil erosion is 1. tap root 2. fascicled root 3. adventitious root 4. fibrous root.

(4) 32. A plant that has no root cap is 1. carrot 2. flax 3. wheat 4. water lily.

(1) 33. A response of roots to the pull of gravity is called 1. geotropism 2. hydrotropism 3. heliotropism 4. phototropism.

(1) 34. The chief function of the root hairs is to 1. absorb water 2. anchor the plant 3. performs photosynthesis 4. transpiration.

(3) 35. A plant having nitrogen-fixing nodules on its roots is 1. wheat 2. beets 3. alfalfa 4. corn.

(2) 36. Rich soil contains large proportions of 1. humerous 2. humus 3. clay 4. sand.

(4) 37. In the nitrogen cycle the nitrates are formed by the action of 1. sunlight 2. acids 3. electricity 4. bacteria.

(2) 38. What causes the direction of roots 1. sunlight and rainfall 2. moisture and gravity 3. soil and humus 4. moisture and capillarity.

(2) 39. The growing tip of a root is called 1. root cap 2. meristem 4 3. root hairs 4. cambium.

(1) 40. An example of a parasitic root is 1. mistletoe 2. water lily 3. ivy 4. orchid.

(1) 41. Conducts sap upwards in plant 1. xylem 2. phloem 3. epidermis 4. endodermis.

(3) 42. Humus in soil comes from 1. rock 2. minerals 3. decayed matter 4. moisture.

(3) 43. The structure protecting the growing area of the root is 1. root hair 2. meristem 3. root cap 4.epidermis.

(1) 44. Proved that mineral matter came from the soil was 1. Nicholas de Saussure 2. Hilgard 3. Jacques Loeb 4. Julius Sachs.

(4) 45. Proved that nitrates in soil are necessary for plant growth 1. Jacque Loeb 2. Hilgard 3. Julius Sachs 4. Jean B. Boussingault.

(2) 46. Roots growing from the stem or leaves in an unusual way are called 1. fibrous 2. adventitious 3. aerial roots 4. aquatic.

(3) 47. Roots growing into the water are called 1. adventitious 2. fascicled 3. aquatic 4. taproot.

(4) 48. Roots growing into another plant to absorb its food are called 1. aerial 2. adventitious 3. fascicled 4. parasitic.

(1) 49. A fleshy root produced in clusters is the 1. dahlia 2. orchid 3. strawberry 4. ivy.

(3) 50. A plant having one main strong root is 1. corn 2. hyacinth 3. dandelion 4. wheat.

(3) 51. A root growing in air to absorb moisture is 1. dahlia 2. ivy 3. orchid 4. hyacinth.

(4) 52. Fleshy roots produced in clusters are found in 1. pond lily 2. strawberry 3. hyacinth 4. dahlia.

(4) 53. Grasses have 1. tap roots 2. aerial roots 3. fascicled roots 4. fibrous roots.

(1) 54. Roots that aid in climbing are found in the 1. ivy 2. strawberry 3. mistletoe 4. grass.

(3) 55. A root used as food is 1. alfalfa 2. clover 3. carrot 4. beans.

(2) 56. The response of roots to water is called 1. aquatic 2. hydrotropism 3. geotropism 4. capillarity.

(3) 57. The symbol for carbon dioxide is 1. CHO 2. H_2O 3. CO_2 4. O.

(4) 58. The symbol for water is 1. CO_2 2. O 3. CHO 4. H_2O.

(3) 59. A circle of cells separating the cortex from central cylinder in root is called 1. epidermis 2. fibrovascular bundles 3. endodermis 4. cortex.

(4) 60. Region of growth between xylem and phloem is called 1. cortex 2. endodermis 3. central cylinder 4. cambium.

(2) 61. Co_2 is an 1. element 2. compound 3. mixture 4. solid.

(1) 62. Oxygen is 1. gas 2. solid 3. liquid 4. compound.

(2) 63. Cell division is called 1. osmosis 2. mitosis 3. respiration 4. expansion.

(1) 64. Direction of roots is caused by 1. moisture and gravity 2. sunlight and rainfall 3. soil and humus 4. soil and minerals.

(4) 65. An example of a tap root is 1. corn 2. bean 3. buffalo grass 4. carrot.

(2) 66. The cortex of roots 1. conducts sap upwards 2. stores food 3. absorbs soil water 4. protects the growing tip.

(2) 67. Epidermal cells of roots are 1. round 2. brick-shaped 3. square 4. irregular.

(2) 68. Root hairs are 1. dead cells 2. elongated epidermal cells 3. consists of xylem cells 4. growing region.

(2) 69. Carry manufactured food from leaves down to all parts of the plant 1. cortex 2. phloem 3. xylem 4. endodermis.

(1) 70. Region of root that reproduces new cells is 1. cambium 2. epidermis 3. phloem 4. endodermis.

(4) 71. Julius Sachs is a 1. Swiss botanist 2. French botanist 3. Norwegian botanist 4. German botanist.

(2) 72. An example of fibrous root is 1. carrot 2. grass 3. dahlia 4. sugar beet.

(1) 73. Jean B. Boussingault is a 1. French agriculturist 2. German chemist 3. Dutch soil expert 4. English botanist.

(1) 74. Most of the world's sugar supply comes from 1. beets 2. sweet potatoes 3. parsnips 3. sorghum.

(3) 75. The upper limit of the ground wholly saturated with water is called 1. rock 2. loam 3. water table 4. aquatic.

UNIT II

PROCESSES AND STRUCTURES INVOLVED IN PHOTOSYNTHESIS

Problems

Problem 7. Diffusion and Osmosis

Problem 8. The structure of stems and to show the upward movement of liquids through a stem.

Problem 9. Study of the leaf.

Problem 10. Effect of light on leaves.

Problem 11. Transpiration in leaves.

Problem 12. Photosynthesis.

STUDY SHEET

References:

Bergen and Caldwell,	Practical Botany, pp. 79-80.
Carroll, F.B.	Understanding our Universe, Bk.III pp. 374-375.
Charles, Bro.	Biology, pp. 26-27.
Defrose,Sr.M.	Biology for High Schools. p. 168 and p. 566.
Hunter,	Problems in Biology, pp. 147-151.
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Smith, E. T.	Exploring Biology, pp. 131-132.

Problem 7: DIFFUSION AND OSMOSIS

Preliminary Study: Diffusion Pressure is a tendency of two liquids of unequal concentration to seek equilibrium when brought into contact.

Osmosis is the flow of two liquids or gases separated by a semi-permeable membrane through that membrane into each other, the greater flow is toward the denser liquid or gas.

Note: The flow at first is always from the less dense to the more dense substance.

Materials Required: Egg, animal membrane, lima bean membrane (testa) potato, sugar, salt, hydrochloric acid, beaker, tumbler, thistle tube, glass tubing, sealing wax, eosine, porcelain dishes, fresh water.

Experiment: (1) Remove a small area of shell from the blunt end of an egg without breaking the membrane. This can be done by setting the egg in a dish of concentrated hydrochloric acid until the shell is dissolved off leaving the skin that lines the shell exposed. Pierce the membrane at pointed end of egg. Insert a capillary tube in the broken part of membrane and fasten it with sealing wax. Set the egg in a glass or tumbler filled with fresh water. Let stand for about 24 hours (Fig. 8).

Observation: What was forced up into the glass tube?

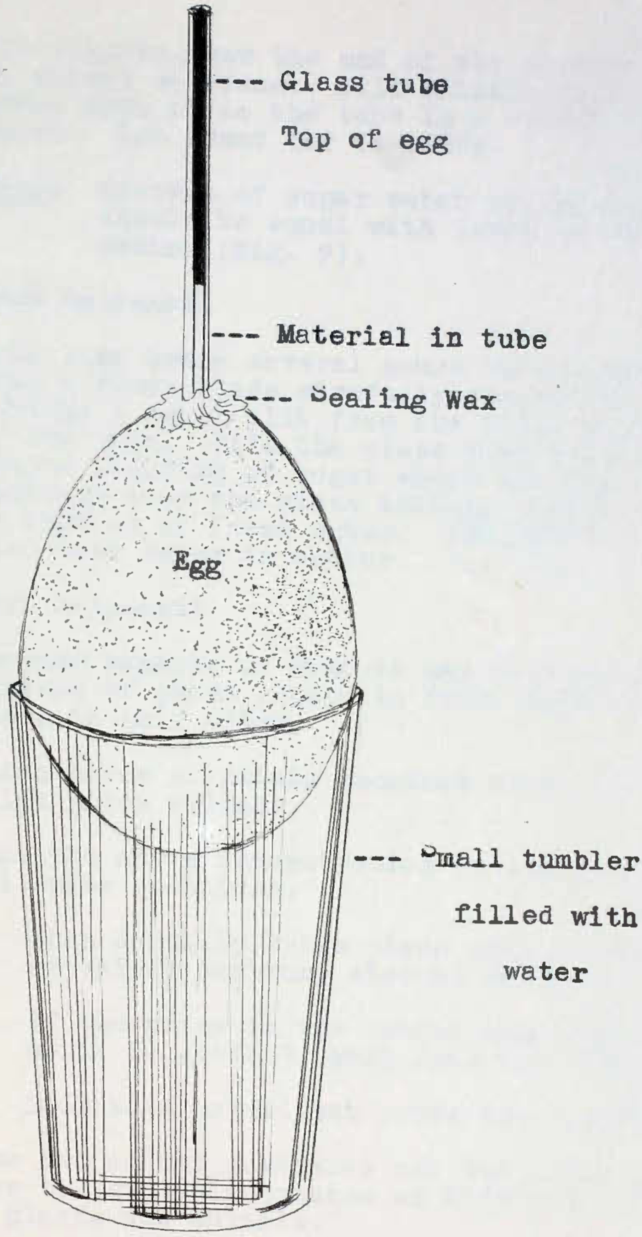

Fig. 8. To Show Osmosis

Experiment: (2) Tie tightly over the end of the thistle tube an animal membrane. Fill thistle tube with sugar water then place the tube in a beaker of frehs water. Let stand for 24 hours.

Note: Leavels of sugar water in the thistle tube should be equal with level of water in beaker (Fig. 9).

Observation: What happened:

Experiment: (3) Soak lima beans several hours before experiment. With a razor blade carefully remove the testa by cutting a small slit from the hilum on one side of the bean. Fill the glass tube with a concentrated solution of sugar water and tie a bean membrane over the glass tubing. Set in a beaker or tumbler of fresh water. Let stand for 24 hours. Then test water in beaker.

Observation: What happened?

Experiment: (4) Another example of osmosis may be seen by soaking a piece of pared potato in frehs water and another piece in salt water.

Observation: Which piece of potato remained crisp and firm? Which piece wilted?

Conclusions: From the above demonstration on osmosis, answer the following questions.

1. What actually takes place when a plant root or animal membrane absorbs water?

2. If the water in the beaker were tested, what would be gotten? What does this show?

3. Does this experiment prove the law of osmosis?

Additional Problems: Name two animal membranes and two plant membranes. Give the great importance of diffusion and osmosis in plants and animals.

Vocabulary: semi-permeable membrane, diffusion, osmosis.

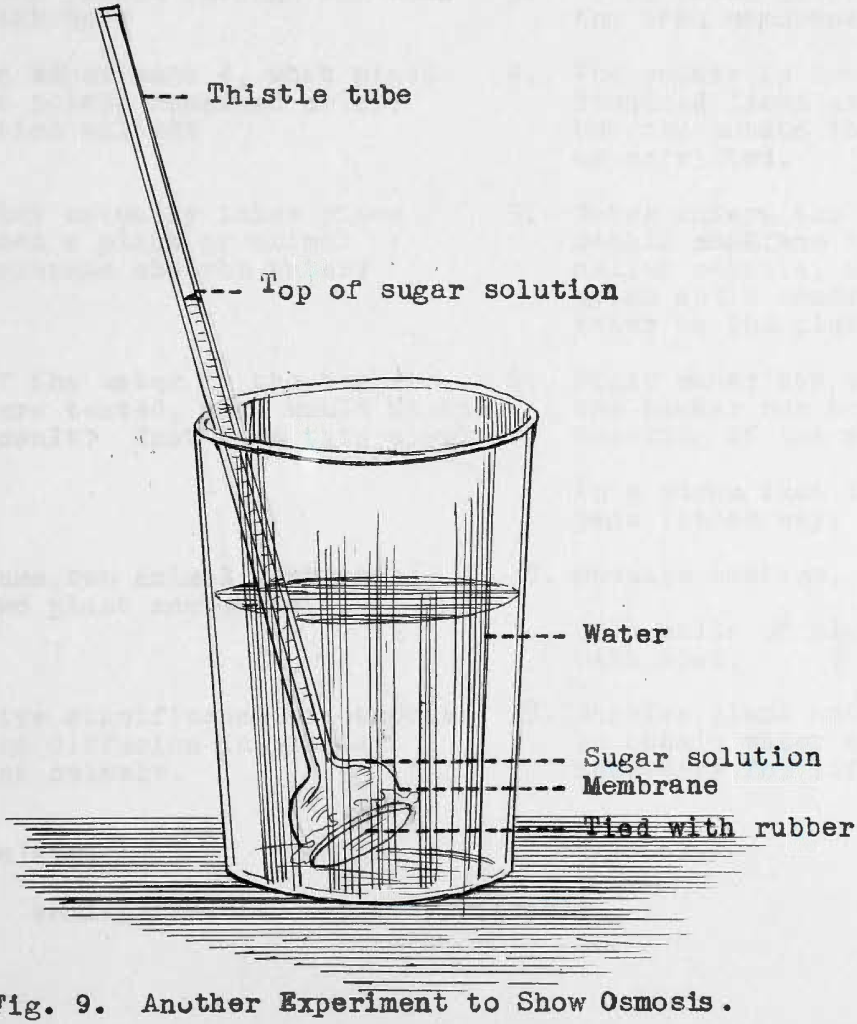

Fig. 9. Another Experiment to Show Osmosis.

Questions		Answers	
1.	In expeŕiment 1, what passed through the membrane of the egg?	1.	In experiment 1, fresh water passed through the membrane of the egg.
2.	In experiment 2, what passed through the animal membrane?	2.	In experiment 2, water also passed through the animal membrane.
3.	What passed through the bean membrane?	3.	Fresh water passed through the bean membrane.
4.	In experiment 4, what piece of potato remained crisp? which wilted?	4.	The potato in fresh water remained fresh and crisp, but the potato in salt warer wilted.
5.	What actually takes place when a plant or animal membrane absorbs water?	5.	Water enters the semi-per meable membrane by a process called osmosis, then the xylem cells conduct the water to the plant.
6.	If the water in the beaker were tested, what would be the result? What does this show?	6.	Sugar water has entered the beaker due to the breaking of the membrane. This showx that liquids pass iether way.
7.	Name two animal membranes; two plant membranes.	7.	Sausage casings, egg membrane. Cell walls of plants, and bean coat.
8.	Give significance of osmosis and diffusion in plants and naimals.	8.	Enables plant and animal to obtain water and food necessary for life.

Vocabulary:

semi-permeable   partly passable.

osmosis: The flow of two liquids or gases separated by a semi-permeable membrane through that membrane into each other, the greater flow is toward the denser liquid or gas.

diffusion: The tendency of two liquids of unequal concentrations to seek equilibrium when brought into contact.

STUDY SHEET

References:

Atkinson, *Botany for Schools*, pp. 57-67
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Bergen, *Practical Botany*, pp. 11-13.
Carroll, B.F., *Understanding the Universe*, pp.385 389.
Charles, Bro. *Biology*, pp. 15-55
Coulter, *Elementary Studies in Botany*, pp. 224-253.
Defrose, Sr.M. *Biology for High Schools*, pp.532-555.
Hunter, *Problems in Biology*, p. 154; and pp. 166-173.
Kinsey, *An Introduction to Biology*, pp.98-101.
Menge, *The Laws of Living Things*, pp.160-169.
Smith, E.T. *Exploring Biology*, pp.132-136.

Problem 8: THE STRUCTURE OF STEMS AND TO SHOW THE UPWARD MOVEMENT OF LIQUIDS THROUGH A STEM

Experiment: Observe the appearance of the stalks which have been previously placed in red ink or eosine water; with a scapel, make a cross section of the stalk, and note the areas which are red; examine a monocot and dicot stem under the microscope.

Observation: What part of the stem was colored red?

Conclusion: What part of the stem conducts liquids upward in plant?

Additional Problems:

1. What functions are common to all stems and how are they fitted for these functions?
2. What causes stems to become modified? Give examples.
3. Give economic uses of stems to man.
4. What is a monocot? dicot? Give examples.
5. Show in tabular form the principal differences between monocotyledonous and dicotyledonous stems.

Vocabulary: pith, xylem, pith rays, cortex, annual rays, excurrent, lenticel, cambium, deliquescent, pjloem.

Questions	Answers
1. What part of the stem was colored red?	1. The xylem cells were colored red.
2. Through what does liquid pass up the stems?	2. Liquids pass up thestems through the xylem cells.
3. What are the functions of stems and how are they fitted for these functions?	3. The functions of stems are: 1. Serve as a paasageway from leaves to the stem and roots, and back. 2. Hold leaves up to the sun. 3. Breathe through lenticels. 4. Store food (sugar cane; potato). 5. Help in climbing (tendrils of grapes. 6. Reproduces the plant (potato, sugar cane). 7. Have thorn for protection.
4. What causes stems to become modified?	4. Since stems or branches usually bear foliage, any stem which does not is spoken of as "modified" (thorns).
5. Give economic uses of stems to man.	5. Economic importance of stems to man: 1. Used as food. 2. Medicine is derived (elm, cinnamon, cascara). 3. Obtain beverage (sassafras 4. Rubber, camphor, gum. 5. Timber is used in various ways. 6. Paper comes from spruce and the poplar. 7. Fibers as flax, jute, hemp 8. Sugar from sugar cane and sugar maple. 9. Cork (cork oak).
6. What is a monocot? Give examples.	6. A monocot is a subclass of flowering plant having one cotyledon in the seed, parallel-veined leaves, and scattered fibrovascular bundles in the stem; includes grains, grasses, and lilies; called monocots.

Questions	Answers
7. What is a dicot? Give examples.	7. A dicot is a subclass of flowering plants having two cotyledons in the seed, netted-veined leaves, and one or more rings of wood in the stem, they include most of our common flowering plants, such as beans, gernaiums, hardwood trees, commonly called dicots.

8. Show in tabular form the principal differences between monocotyledonous and dicotyledonous stems.

Monocot	Dicot
1. Has rind as outer covering.	1. Has covering of epidermis and bark.
2. Cambium is present only in each fibrovascular bundle.	2. Cambium is in the form of a ring when seen in cross-section.
3. The fibrovascular bundles are scattered throughout the pith.	3. The fibrovascular bundles are arranged in cylinders having distinct layers.
4. The stem is mostly made of pith.	4. The stem is mostly made of wood.
5. Supported by rind.	5. Supported by wood.
6. Grows in height and not in thickness.	6. Grows in thickness as well as in height.

Vocabulary:

pith	A short spongy substance in the center of plants.
xylem	Wood cells which serve as passageways for water in the roots, stems, and leaves of ferns and seed plants
pith rays	Thin wedges of pith running from the cambium towards the center of the stem.
annual rings	Concentric rings in the wood parallel to the cambium.
cortex	The tissue in a root or stem that lies between the fibrovascular tissue and the epidermis; the outer layers of an organ.
excurrent	Running out from the main trunk or stem as in the spruce and other conifers.
cambium	A layer of living cells from which new xylem and phloem cells are found and formed in the stems of naked-seeded plants and dicot trees and shrubs.
phloem	Food-conducting cells in the roots, stems and leaves of ferns and seed plants.
lenticel	Breathing pore in the bark of trees.

STUDY SHEET

References:	Bergen and Caldwell	Practical Botany, pp.13-15; 55-71.
	Carroll, F.B.,	Understanding the Universe, pp.378-383.
	Defrose, Sr.M.	Biology for High Schools, pp.503-531.
	Hunter,	Problems in Biology, p. 151
	Kinsey,	An Inttoduction to Biology, pp.94-97.
	Smith, E.T.	Exploring Biology, pp.138-141.

Problem 9: STUDY OF THE LEAF

Materials Required: Leaf, prepared cross sections of leaves, microscope.

Experiment: Examine a leaf and note the petiole, blade, and venation. With a scapel or razor blade, gently remove the surface layer of the under side of the leaf; examine this section under the microscope; note the surface layer of the upper side of the leaf and examine under the microscope, noting the cell structure.

Conclusions: From the experiment and readings answer the following questions:

1. What is a leaf? Give its functions.

2. What is the difference between a leaf and blade?

Biographies: Marcello Malpighi (1628-1694); Nehemiah Grew (1628-1712); Jan Ingenhousz (1739-1799).

Vocabulary:

blade, chlorophyll, heliotropism, netted veins, parallel veins, palisade layer, spongy layer, stomata, transpiration, guard cells, petiole, chloroplasts.

Questions	Answer
1. What is a leaf? Give its function.	1. A leaf is a so-called factory where all food is manufactured, CO_2 taken in and H_2 O and O are liberated.
2. What is the difference between a leaf and a blade?	2. A leaf is the development from the plumule of a seed. The blade is only a part of the leaf, the broad, flattened part.

Biographies:

Marcello Malpighi (1628-1694) was an Italian scientist who discovered stomata and vascular bundles.

Nehemiah Grew (1628-1712) was an English scientist, discovered stomata independently.

Jan Ingenhousz (1730-1799) A Dutch botanist was an authority on plant physiology. He discovered that oxygen is absorbed and carbon dioxide given off by leaves during respiration and that carbon dioxide is absorbed and oxygen released in the process of photosynthesis.

Vocabulary:

blade	The broad, flattened part of the leaf containing the working parts.
chlorophyll	The green coloring matter in plants.
heliotropism	Response to light.
netted veins	Veins that do not run parallel and found in dicots.
parallel-veins	Veins that run parallel and found in monocots.
palisade-layer	A layer of green cells just under the upper epidermis of a leaf.
spongy layer	A layer of loosely fitted cells in a leaf.
stomata	Openings through which air enters leaves.
transpiration	The loss of water by evaporation through the stomata of a leaf or a plant.
guard cells	Two cells on either side of a leaf's stomata. These guard cells regulate the size of the opening.
petiole	Stalk connecting leaf with stem and holds blade up in the light.
chloroplasts	Small body containing chlorophyll found in the cells of green plants.

STUDY SHEET

References:	Bergen,	Practical Botany, pp. 15-18.
	Charles, Bro.	Biology, pp. 61-62.
	Coulter,	Elementary Studies in Botany, pp.32-
	Defrose, Sr.M.	Biology for High Schools, p. 523.37.
	Hunter,	Problems in Biology, pp. 154-160.
	Hunter,	Problems in General Science, p. 80.
	Smith, E. T.	Exploring Biology, p. 139.

Problem 10: EFFECT OF LIGHT ON LEAVES

Materials Required: Tumblers, bean seeds or seedlings.

Experiment: Prepare three tumbler gardens. Place two of them in the dark. Place the third one in the light. To see if the plants develop normally--when leaves are developed, place one tumbler from the dark in the light and record the time that elapses before the first green color appears in the leaves. Let the other tumbler of plants grow in the dark.

Observation: What happened to the plants in the dark? In the light?

Conclusion: Is light necessary for chlorophyll manufacture?

Questions	Answers
1. What happened to the plant in the dark?	1. The plant in the dark turned yellow.
2. What happened to plants in the light?	2. Plants in the light remained normal and green.
3. Is light necessary for chlorophyll manufacture?	3. Light is necessary for the manufacture of chlorophyll.

STUDY SHEET

Problem 11: TRANSPIRATION IN LEAVES

Materials Required: Potted geraniums. Bell hjars, sheet rubber.

Experiment: Water the soil of a flower pot containing a geranium. Cover the entire pot with sheet rubber to prevent any evapotation of water from the soil. Place the plant under the bell jar.

Observation: After a few hours what was seen on the inside of the bell jar?

Conclusion: Do leaves give off water?

Additional Problems:

1. Name two ways in which plants benefit by transpiration.
2. Why do plants droop and wilt on ahot day?
3. From what part of the plant is oxygen released?

Vocabulary: Transpiration, stomata.

Note: Immediately after this experiment pin small discs of cork to a portion of upper and lower epidermis of geranium leaves. This experiment is necessary to work out Experiment 12.

Questions		Answers
1.	What was seen on the inside of the bell jar?	1. At first the jar looked foggy then drops of water appeared.
2.	Do leaves give off water?	2. Yes, leaves give off water.
3.	Name thre ways in which plants are benefitted by transpiration?	3. Threeways in which plants are benefitted by transpiration are:

1. It produces a steady flow of water from roots to cells of leaves supplying with water necessary for photosynthesis and with other substances necessary for food manufacture.

2. It produces a cooling effect on the leaves, preventing shrivelling from too much heat.

3. Another beneficial effect is prevention of erosion and floods because of constant absorption and gradual release of large amounts of water by trees.

4.	Why do plants droop and wilt on a hot and dry day?	4. Plants droop and wilt on a hot and dry day because of the amount of water released.
5.	From what part of the plant is oxygen released?	5. Oxygen is released from the leaf.

Vocabulary:

transpiration — Loss of water by evaporation through the stomata which is an openeing through which air enters the leaves.

STUDY SHEET

PHOTOSYNTHESIS

Problem 12: TO SHOW THE NECESSITY OF CHLOROPHYLL AND SUNLIGHT FOR STARCH MAKING

Materials7 Required: Plants (green) bean plants geranium grown in the laboratory, iodine, alcohol.

Experiment: Boil a green leaf (A portion of which was covered for several days with discs of cork) in alcohol. This will remove the chlorophyll. Then apply the iodine.

Observation: What part of the leaf turned blue? Which did not?

Conclusion: Is chlorophyll necessary for starch making?
Is sunlight necessary for the manufacture of starch?

Additional Problems:

1. Name two functions of photosynthesis.

2. Give five economic uses of leaves.

Vocabulary:

photosynthesis, chloroplasts, chlorophyll.

Questions	Answers
1. What part of the leaf turned blue?	1. The part that was exposed to the sunlight turned blue.
2. Which part did not turn blue?	2. The part that was not exposed to sunlight and was covered wit[h] a disc of cork.
3. Is light and chlorophyll necessary for the manufacture of starch in a plant.	3. Light and chlorophyll are necessary for the manufacture of starch in a plant.

4. Name two functions of photosynthesis.	4. a) It supplies plants, animals, and man with food. b) It purifies the air by removing carbon dioxide formed during oxidation, combustion, and decay. It adds to the oxygen content of the air by releasing oxygen not needed for the manufacture of carbohydrates.
5. Give five economic uses of leaves:	5. Leaves are used for food by animals. Both domestic and wild animals eat leaves of grasses and other plants in summer, and feed on hay or dried grasses in winter. Leaves are eaten by man, many containing vitamin as spinach, lettuce, celery, Swiss chard, parsley, watercress, cabbage, Brussels sprouts. Leaves are essential for silkworm industry.

Tea is an important beverage. Medicinal substances are obtained from leaves, such as spearmint, peppermint, sage, tansy, camphor, wintergreen, senna, horehound and digitalis. Cocaine is obtained from cocoa leaves. Tobacco is made into cigars and cigarettes from tobacco leaves. Fans are fashioned from palm leaves. From the strong vascular bundles of pineapple leaves, a fine cloth is woven.

Vocabulary:	photosynthesis	The manufacture of starch and sugar from water and carbon dioxide by green plants in sunlight.
	chloroplasts	Small bodies containing chlorophyll found in the cells of green plants.
	chlorophyll	Green pigment found in plants.

FINAL TEST FOR UNIT II

Time: 40 Minutes — Possible Score: 75

(3) 1. Manufactured food is conducted in the plant by the 1. xylem 2. cambium 3. phloem 4. lenticel.

(2) 2. The chief function of a stem is to 1. absorb water 2. support leaves 3. anchor the plant 4. perform photosynthesis.

(3) 3. The food factory of a plant is 1. root 2. stem 3. leaf 4. stomata.

(1) 4. Moisture is absorbed chiefly through the 1. root hairs 2. roots 3. xylem cells 4. epidermal cells.

(2) 5. The green coloring matter needed by plants in making food is called 1. chloroplasts 2. chlorophyll 3. chromosomes 4. cambium.

(3) 6. A breathing pore found in stems is called 1. stomata 2. guard cell 3. lenticel 4. scar.

(2) 7. The process of making food in green plants is 1. metamorphosis 2. photosynthesis 3. metabolism 4. digestion.

(1) 8. A substance used to test for starch is 1. iodine 2. lime water 3. Fehling's solution 4. nitric acid.

(3) 9. One difference between a monocot stem and a dicot stem is that the monocot lacks 1. xylem 2. phloem 3. cambium 4. pith.

(3) 10. Openings in the leaf epidermis are 1. lenticels 2. pores 3. stomata 4. guard cells.

(2) 11. Plant tissue consisting of actively growing cells is called 1. mitosis 2. meristem 3. fission 4. reproduction.

(2) 12. Fehling's solution is a test for 1. cellulose 2. glucose 3. starch 4. protein.

(2) 13. The portion of dicotyledonous plant stems where growth occurs is called 1 cortex 2. cambium 3. xylem 4. pith.

(4) 14. Leaves manufacture starch in the presence of 1. moisture 2. chemicals 3. acids 4. sunlight.

(5) 15. A by-product of photosynthesis is 1. O 2. CO_2 3. H. 4. N.

(1) 16. The most important value of photosynthesis to man is 1. the manufacture of food 2. aids digestion 3. absorbs moisture 4. conducts food to the plant.

(2) 17. Spinach is what part of a plant? 1. stem 2. leaf 3. roots 4. cortex.

(1) 18. Leaves purify the air by 1. taking in CO_2 and giving off O. 2. taking in nitrogen and forming nitrates 3. giving off H_2O and absorbing moisture 4. by giving off CO_2 and taking in O.

(3) 19. A monocotyledonous stem is mostly 1. xylem 2. phloem 3. pith 4. cambium.

(2) 20. The annual rings 1. store food 2. indicate the age of a tree 3. convey food 4. protect the stem.

(2) 21. A dicotyledonous stem is 1. mostly pith 2. xylem (wood) 3. has rinds 4. fibrovascular bundles scattered in pith.
(4) 22. Quinine comes from 1. leaf 2. root 3. root hair 4. stem.

(1) 23. Flax comes from 1. stem 2. leaf 3. root 4. cambium.
(1) 24. The process in which light-energy causes carbon dioxide and water to combine into sugar is called 1. osmosis 2. respiration 3. transpiration 4. photosynthesis.
(1) 25. Stomata are most abundant in 1. lower surface of leaves 2. on stems 3 roots.
(4) 26. The passage of water through a semi-permeable membrane is called 1. transpiration 2. capillarity 3. respiration 4 osmosis.
(1) 27. The outer covering of a leaf, on both the upper and lower surface is called 1. epidermis 2. palisade layer 3. spongy layer 4. guard cells.

(1) 28. Water rises in the stem through 1. xylem 2. phloem 3. cambium 4. bark.
(4) 29. Starch is manufactured in leaves 1. at night 2. on a cloudy day 3. when it rains 4. while the sun shines.
(1) 30. Transpiration takes place 1. day and night 2. daytime only 3.at night 4. on a cloudy day.
(2) 31. The turning of leaves toward the light is called 1. photosynthesis 2. phototropism 3. hydrotropism 4. geotropism.
(3) 32. Autumnal change in leaves is due to 1. frost 2. humidity of atmosphere 3. the breaking up of chlorophyll 4. respiration.
(2) 33. A leaf used as a beverage is 1. celery 2. tea 3. spinach 4. peppermint.
(1) 34. Palisade cells in a leaf are located 1. under the upper epidermis 4. chloroplasts. 2. in stomata.
(1) 35. Chlorophyll bodies are 1. round green bodies 2. oblong green bodies 3. kidney-shaped bodies 4. brick-shaped bodies.
(3) 36. Leaves liberate oxygen through 1. lenticel 2. vein 3. stomata 4. blade.
(4) 37. The leaf gives off CO_2 through 1. blade 2. vein 3.lenticel 4. stomata.
(2) 38. Starch is composed of three elements 1. carbonm nitrogen and oxygen 2. carbon, hydrogen, and oxygen 3. carbon nitrogen and sulphur 4. carbon, hydrogen and potassium.

(3) 39. Leaf stalks are called 1. stems 2. blades 3. petioles 4. tendrils.

(1) 40. The outside of a leaf is 1. colorless 2. green 3. opaque 4. translucent.

(2) 41. The most important part of a leaf to use sunlight in making starch is 1. chloroplasts 2. chlorophyll 3. stomata 4. guard cells.

(4) 42. The cells just below the palisade layer in the leaf is called 1. stomata 2. lower epidermis 3. veins 4. spongy layer.

(1) 43. All stomata are surrounded by 1. two guard cells 2. veins 3. epidermis 4. spongy layer.

(4) 44. Food is stored in 1. leaf 2. roothairs 3. stomata 4. roots.

(2) 45. While photosynthesis is going on there is no surplus of 1. O 2. CO_2 3. H. 4. C.

(4) 46. A compound passed from leaves at night in excess is 1. O 2. N. 3. C. 4. CO_2.

(2) 47. Green leaves make 1. wood for the world 2. food for the the world also oxygen. 3. beautify the forests 4. provide nests for birds.

(1) 48. Xylem cells in stems are 1. woody cells 2. spongy cells 3. pith cells 4. chloroplasts.

(2) 49. The cambium of a stem provides 1. for conducting sap 2. for growth 3. for supporting leaves 4. for storage of food.

(2) 50. Radiating lines through xylem and phloem cells called 1. conducting tubes 2. pith rays 3. vascular bundles 4. cambium cells.

(1) 51. The purpose of the bark is to 1. protect the delicate tissues from drying out 2. aid in transpiration 3. to conduct food material 4. to help growth.

(2) 52. The outer layer of a cornstalk is called 1. cork 2. rind 3. cambium 4. phloem.

(2) 53. Grasses have 1. netted-veined leaves 2. parallel-veined leaves 3. palmately-veined leaves 4. pinnately-veined leaves.

(4) 54. Vascular bundles were discovered by 1. Robert Hooke 2. Grew 3. Pasteur 4. Malpighi.

(1) 55. Stomata were studied independent by 1. Grew 2. Hilgard 3. Marcello Malpighi 4. Jean Boussingault.

(1) 56. A bean leaf has 1. netted-veined leaves 2. parallel-veined leaves 3. palmately-netted leaves.

(2) 57. Jan Ingenhousz was an 1. English botanist 2. Dutch botanist 3. French scientist 4. German agriculturist.

(2) 58. Linen comes from 1. leaves 2. stems 3. roots 4. root hairs

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(4) 59. Deliquescent, an example is 1. fir 2. pine 3. magnolia 4. maple tree.

(3) 60. An example of an excurrent tree is 1. maple tree 2. oak tree 3. pine tree 4. apple tree.

(4) 61. An acid that will dissolve an egg shell is 1. nitric 2. acetic 3. sulphuric 4. hydrochloric.

(1) 62. Exchange of liquids of different densities when separated by a membrane is 1. osmosis 2. assimination 3. photosynthesis 4. capillarity.

(2) 63. A study of plants is called 1. ecology 2. botany 3. agriculture 4. biology.

(3) 64. Modified leaves on roses arel. tendrils 2. spines 3. thorns.

(3) 65. Modified leaves on sweet peas are 1. spines 2. hairs 3. tendrils.

(2) 66. Leaves purify the air 1. by adding hydrogen to the air during photosynthesis 2. by removing carbon dioxide from air 3. by removing nitrogen from the air.

(2) 67. Tobacco is made from 1. dried stems 2. dry leaves 3. fibrovascular bundles.

(1) 68. Silkworm industry depends on 1. mulberry leaves 2. oak leaves 3. milkweed leaves 4. cottonwood leaves.

(4) 69. Fans are made from 1. linden leaves 2. hackberry leaves 3. locust leaves 4. palm leaves.

(2) 70. Cocaine is obtained from 1. coffee leaf 2. coca leaf 3. peppermint leaf 4. colea leaf.

(2) 71. During photosynthesis leaves add to the air 1. CO_2 2. O 3. N. 4. H.

(4) 72. Pith rays are found in 1. corn stems 2. lily stems 3. grass stems 4. woody stems.

(1) 73. Liquids flow down the part of the vascular bundles known as 1. phloem 2. xylem 3. cortex 4. cambium.

(1) 74. Leaves used for seasoning are 1. celery 2. lettuce 3. spinach.

(1) 75. Hemp comes from 1. stem 2. leaf 3. root 4. root hairs.

UNIT III

A STUDY OF COTTON AND LINEN

PROBLEMS

Problem 13: How can fibers of cotton be identified?

Problem 14: How can linen fibers be identified?

STUDY SHEET

References: Carroll, F. B. *Understanding the Universe*, Bk. III
Reich, *Consumer Goods*, pp. 37-61.
Pieper and Beauchamp *Everyday Problems in Science*.
The World Book, Vol 8., pp. 1708-1718.

Note: For further references use any modern encyclopedias, dictionaries, and biologies.

Problem 13: HOW CAN FIBERS OF COTTON BE IDENTIFIED?

Materials Required: Cotton cloth, cotton plant, cotton thread, litmus paper, test tubes, lye or 5% solution of sodium hydroxide, forceps, hydrochloric acid, olive oil, microscope, slides, cover glasses, procelain dishes, beaker, water, alcohol lamps, sulphuric acid.

Experiments: 1. Burning test.

Obtain a piece of cotton cloth. Light a small piece with a match. Observe the odor, the color of the flame, and the rapidity of burning.

2. Litmus test.

Moisten a strip of blue litmus paper. Heat a piece of cotton goods in a dry test tube and hold the litmus paper in the smoke which comes from the tube. Note the color change. Repeat, using a strip of red litmus paper, and not any color change.

3. Sulphuric acid test also lye test.

Make a solution of two teaspoonfuls of lye to a cup of water or use a five per cent solution of sodium hydroxide. Place a piece of cotton in a test tube. Add about a half-inch of the solution out into a small dish. Remove the cotton from the lye with a pair of forceps, and rinse it in water.

Test the strength of the cloth.

Place a piece of cotton in a solution of sulphuric acid. What happens?

4. To distinguish cotton from linen.

Obtain a piece of mixed cotton and linen fabric. Place it in a beaker of water to which have been added two or three drops of hydrochloric acid, and heat. This will remove the starch and other materials which have been added to the cloth to make it stiffer.

Allow the fabric to dry and then place a drop of olive oil on it.

Observation: Which threads absorb the oil more rapidly?

5. How are plant fibers prepared?

Pick out some cotton seeds from their hairy costs. Spim the fibers between your fingers, twisting and pulling until you have spun an inch or two of thread.

Observation: Why do cotton fibers spin? Examine fibers under the microscope and sketch and describe them.

Additional Problems:

1. Ehat is the length of a cotton hair?
2. If you went into a cotton field, how could you tell which blossoms just opemed and which had come out the day before?

Note: Southern children hwe a pretty little song that well describes their appearance and aharacter:

" First day white, next day red,
Third day from my birth I'm dead;
Though I am of short duration,
Yet withal I clothe the nation?

3. Discuss the boll weevil, the harm it does to the cotton crop, and the measures to control it.

4. Which states rank in the production of cotton?

5. Who invented the cotton gin? Eli Whitney.

6. Name products and by-products of cotton.

   a. From cotton fiber:

      calico, cambric, canvas, etc.

   b. From cotton linters:

      absorbent cotton, artificial leather, etc.
      cellulose
      coating for airplane wings, etc.

   c. From Cotton seed:

      Oil
      Butter substitutes, candles, oleomargerine, cosmetics, etc.

Vocabulary: mercerizing, cotton boll, cotton gin, linters, lint, cellulose.

Questions	Answers
Burning Test	
1. Observe the odor, color of flame and rapidity of burning cotton.	1. There was no odor; a yellow flame was produced and cotton burns very rapidly.
Litmus Test	
2. Note the color change of blue litmus paper; red litmus paper.	2. Blue litmus paper turned red while red litmus paper remained unchanged.
Lye and Sulphuric Acid Test	
3. Give effect of sodium hydroxide on cotton; sulphuric acid?	3. Sodium hydroxide does not effect the strength of cotton, whereas sulphuric acid dissolves it.
Distinguish cotton from linen	
4. What kind of spot is formed on linen? Which takes up more water evenly and quickly, cotton or linen?	4. A translucent spot is formed. Linen absorbs water more evenly than does cotton.

5. Give description of cotton fibers as viewed under the microscope.	5. Cotton fibers viewed under the microscope have the appearance of twisted, flat tubes.
6. Why do cotton fibers spin so easily?	6. Because fibers stick together more easily and readily than other fibers.
7. What is the length of a cotton hair?	7. The average length of a cotton hair is 3/4" .
8. What is the color of the blossom the first day? the next?	8. The color of the blossom that opems first is white. The next day it turns pink.
9. What harm does the boll weevil do to the cotton crop?	9. During the larva stáge the boll weevil attackes cotton crop.
10. Give measures to control this insect pest, (boll weevil).	10. Cotton plants are dusted and sprayed with arsenate of lead.
11. Which states rank in the production of cotton?	11. Texas, Mississippi, Arkansas rank highest in the production of cotton.

Vocabulary:

Mercerizing	Treating cotton with a solution of potash to give it a silk luster.
cotton boll	The part of the cotton plant containing the fiber and seed.
cotton gin	A machine for separating the seeds from cotton fiber.
linters	The cotton "fuzz" next to the seed.
cellulose	Cell walls of plants.

STUDY SHEET

References: Same as for Problem 13, except Consumer Goods, pp. 61--83.

Problem 14: A STUDY OF LINEN AND HOW ITS FIBERS CAN BE IDENTIFIED.

Materials Required: Microscope, flax plant, linen thread, match, litmus paper, lye, 5% solution of sodium hydroxide, forceps, hydrochloric acid, nitric acid, sulphuric acid, olive oil, slides, cover glasses, porcelain dishes, water, beaker, alcohol. lamps.

Experiment: 1. Burning test.

Moisten a piece of linen cloth. Light a small piece with a match. Observe the odor, the color of the flame, and the rapidity of burning.

2. Litmus test.

Moisten a strip of blue litmus paper. Heat a piece of cotton in a dry test tube and hold the litmus paper in the smoke which comes from the tube. Note the color change.

3. Lye test.

Make a solution of two teaspoonfuls of lye to a cup of sodium hydroxide. Place a piece of linen in a test tube. Add about a half inch of the solution and boil for about five minutes. Pour the solution out into a small dish. Remove the linen from the lye with a pair of forceps and rinse it in water. Test the strength of the cloth. Place a piece in sulphuric acid. What happens?

4. To distinguish cotton from linen.

Obtain a piece of mixed cotton and linen fabric. Place it in a beaker of water to which have been added two or three drops of hydrochloric acid, and heat. This will remove the starch and other materials which have been added to the cloth to make it stiffer.

Allow the fabric to dry and then place a drop of olive oil on it. Test also with water.

Observation: What kind of a spot formed on linen by the olive oil?

Which takes up water more evenly and quickly, cotton or linen?

5. Soak some flax stems in a glass of water for two or thee days. Then strip or scrape the threads from the stems. Examine under the microscope. Make sketches of linen fibers in your notebook.

Give shape of the flax fibers. What are their uses?

Additional Problems:

1. Which states lead in the production of flax?
2. For what purposes is flax chiefly cultivated in the United States?
3. Name the most important flax manufactureing countries.
4. Name some linen products.

Vocabulary:

pectin, blue-flowered flax, linseed oil.

Questions	Answers
Burning Test	
1. Give the odor, color of flame, and rapidity of burning linen.	1. Linen burns rapidly and without an odor. It produces a yellow flame.
Litmus Test	
2. Note the color change of the blue litmus paper.	2. Blue litmus paper turned red.
Lye and Sulphuric Acid Test	
3. What effect did lye water have on linen, sulphuric acid?	3. The linen boiled in lye water remained firm. Sulphuric acid dissolved linen.
4. Which takes up olive oil more, cotton or linen?	4. Linen absorbs olive oil and water rapidly.
5. What kind of a spot is formed on linen by the olive oil?	5. A round, translucent spot is formed.
6. Give the shape of linen fibers as viewed under the microscope.	6. Linen fibers are shaped like bamboo sticks.
7. Which states lead in the production of flax?	7. North Dakota, S. Dakota and temperate regions lead in the production of flax.
8. For what purposes is flax chiefly cultivated in the United States?	8. It is chiefly cultivated for its seed.
9. Name the most important flax manufacturing countries.	9. Belgium, Ireland, Germany, Japan, Switerzerland.
10. Name some linen products.	10. Lace, damaks, sheeting, twine.

FINAL TEST FOR UNIT III

Time: 40 Minutes Possible Score: 75

COTTON

Burning test

Obtain a piece of 1. cotton cloth. Light a small 2. piece with a 3. match. The color of the flame is 4. yellow. It has 5. no odor. It burns 6. rapidly.

Litmus test.

7. Moisten a strip of 8. blue litmus paper. 9, Place a piece of 10. cotton in a 11. dry test tube and hold the 12 blue paper in the smoke which comes from the tube. Blue litmus paper changes to 13 red. Red litmus paper remains 15. red.

Acid test.

Concentrated sulphuric acid dissolves cotton 16. slowly. A five percent solution of 17. sodium hydroxide does 18 not injure the 19. strength of the cloth.

To distinguish cotton from linen. Other items also .

Place a drop of 20. olive oil on cotton. An 21. opaque spot forms. Cotton absorbs water 22. slowly. The very short fibers that are attached to the cotton seeds after ginning are called 23. linters. Treating cotton fibers with caustic soda is called 24. mercerizing. An insect that destoys the cotton boll is the 25. weevil. A cotton boll contains from 26. 25 27. 50 seeds. The cotton fibers are also called 28. lint. The machine used to separate the seeds from the cotton fibers is called 29. cotton 30 gin. 31. Eli32 Whitney invented the 33. cotton 34. gin. in 35. 1793. Cotton is used to make 37. cloth. Under the microscope the cotton a fibers appear like a flattened 38. twisted tube. Linen 39. products come from 40. flax. The ma; cotton raw materials are: 41. fiber 42. linters 43. hulls 44 oil 45. meal. The oil of cotton seeds is used in (butter substitutes) as 46. oleomargarine.

The length of a cotton hair is 47. 3/4". When a cotton blossom appears the first day the color is 48. white. The next day it is 49. red. Two states ranking in cotton production are: 50 Texas

51. Georgia. Products from cotton linters are 52. plastics
Calico is a product of cotton 53. lint. Lard substitutes are products of the 54 oil of the cotton seed. Fertilizer is a product of 56. hulls of cotton seed. Cosmetics are prepared from the 56 oil of cotton seed. Crackers are made from 57 meal of cotton seeds. Seersucker is a product of cotton 58 lint. Paints are prepared from the 59 oil of cotton seeds. Paper pulp is a product of cotton 60 hulls. Cotton linters make wartime 61. rayons. Oleomargarine comes from 62 oil of cotton seed. Cheesecloth is a product of cotton 63 lint. Every automobile contains about 65. 54 lbs. of cotton. Parachutes have cotton 65. cords and 66. harnesses. Linen absorbs water 67 quickly. Olive oil makes a 68 translucent spot on linen. Linen burns with a 69 yellow flame. Linen threads look like 70. bamboo sticks. Sulphuric acid 71. dissolves linen cloth. The gummy substance that holds together the fibers of flax is called 72. pectin. The oil obtained from seeds of flax is called 73. linseed oil. Decompostion of woody tissues of flax stems is called 74. retting. Linen is a 75. flax fiber.

UNIT IV

A STUDY OF RAYON AND SOYBEANS

Problem 15: STUDY OF RAYON

Problem 16: ORGANIC NUTRIENTS FOUND IN SOYBEANS

STUDY SHEET

Study of Rayon

References: Same as for Problem 13 except --
Reich, Singer — Consumer Goods, pp. 131-145
The Chemistry Leaflet, Sept. 1943
Vol. 18, pp. 7-40.

Problem 15: STUDY OF RAYON

Materials Required: Rayon fibers, rayon goods, litmus paper (blue and red), test tubes, sulphuric acid, burners, pieces of silk.

Experiments:

1. Burning test.

   Take a small piece of rayon, hold it over a trough and burn it. If it is real silk, it burns slowly and emits a strong odor, similar to the odor of burning hair. The remains will be small, black crispy beads.

2. Moisture test.

   Moisten threads of rayon and silk.
   Observe what happens.

3. Red litmus paper.

   Dampen the litmus paper. Burn a piece of rayon to be tested and hold the paper over the smoke of the burning material. If the material is silk, the paper will turn blue.

4. Blue litmus paper.

   Dampen the paper. Burn a piece of the material in a dry test tube and hold the litmus paper over the smoke of the burning material. Note the color change.

5. Drop a 2% sulphuric acid on a piece of rayon. Place it between two oieces of paper, and apply a hot iron. Note what happens to the rayon fibers.

Additional Problems: What is cellulose?

How is rayon made?

Name the various chemical processes in converting cellulose into a liquid.

Discuss briefly the cupramonium process.

What is the Viscose process?

Discuss in short the acetate process.

What country leads in the production of rayon?

Biography: Count Chardonnet.

Vocabulary: rayon

Questions	Answers
Rayon	
Burning Test	
1. Give the odor, color of flame and rapidity of burning of rayon fibers.	1. Rayon burns rapidly with a yellow flame and it has no odor.
Moisture Test	
2. Observe wha happens when rayon is moistened?	2. Rayon shrinks when moistened.
Red Litmus Paper	
3. Give color of the red litmus paper.	3. There was no change in color. Red litmus paper remained red.
Blue Litmus paper	
4. Note the color change.	4. Blue litmus paper turned red.
5. What effect did the 2% sulphuric acid and a hot iron have on rayon?	5. Rayon charred and fell apart.

6. What is cellulose?	6. Cellulose is the substance resembling and allied to starch which forms cellular plant tissue.
7. Give uses of cellulose acetate.	7. Plastics--adding machines, bottle stoppers, buttons, cigarette cases, costume jewelry, fountain pens, hair ornaments, and handbags.
8. How is rayon made?	8. Rayon is made from the cellulose of spruce wood and cotton linters or from a combination of the cellulose from these sources.
9. What is the chief problem in making rayon?	9. The chief problem in making rayon is getting the cellulose into solution and then getting it out of solution and into a continuous yarn.
10. Name the various processes (chemical) in converting cellulose into a liquid.	10. Various chemical processes are employed to convert the cellulose into a liquid, which is about as thick as castor oil. The cellulose in solution is forced through a spinerett which contains many tiny holes. The outcoming filaments combine to form yarn. (rayon).
11. What is the cupraamonium process?	11. The cellulose is dissolved in an ammoniacal oxide solution.
12. What is the Viscose process?	12. The bulk of the world's rayon is made by the Viscose process, wherein the pulp is treated with caustic soda, and then withcarbon-bisulphate to form cellulose xanthate. A weak solution of caustic soda is added and after thorough mixing the viscose solution is formed. All these methods are regenerated cellulose rayons.

13. Discuss the acetate process.	13. In this method the pulp is treated chemically to make cellulose acetate from which the yarn is made. Acetates are not yellowed by age or exposure to light.
14. What country leads in the production of rayon?	14. The United States leads in the production of rayon.
15. Give a brief account of Count Chardonnet.	15. Count Chardonnet was the first to dissolve the nitro-cellulose process of treating the raw material with nitric and sulphuric acid, forming nitrocellulose.
16. Define rayon.	16. Rayon comes from the English word "ray" meaning beam of light.

STUDY SHEET

References: Hunter, *Problems in Biology*, pp. 117-120
Smith, E.T. *Exploring Biology*, pp. 259-264.
Current Science, Vol. 27, April 13-17, 1942. Soy--The Wonder Bean.

Problem 16: ORGANIC NUTRIENTS FOUND IN SOYBEANS

Materials Required: Soybean plants in laboratory, seeds from soybean plants, iodine, burners, test tubes.

Experiments: 1. Test for Starch in Soybeans

Mash a small piece of the bean cotyledon which has previously been soaked in water. Heat and test with iodine solution. Note the color of the material. Mount the material on a glass slide and examine under the microscope. Give the shape of the starch grains.

Conclusion: Is starch present in soybeans?

2. Proteins in soybeans?

Same as above but heat slowly and add nitric acid and then add a few drops of ammonium hydrate. What color appears when nitric acid is added? When ammonium hydrate is added?

Conclusion: Do soybeans contain proteins?

3. Fats and oils in soybeans.

Mash soybeans with ether. This will extract the oil. Place a few drops of the oil on brown paper and heat over a warm radiator. What kind of a spot appears?

Conclsusion: Do soybeans contain fats and oils?

Additional Problems: Give importance of soybean during World War No. 1.

When did the real boom in planting soybeans begin in the United States?

Give the results of the investigation in the Ford laboratories regarding soybeans.

How many bushels of soybeans were grown in the United States in 1925? in 1940?

Name minerals found in soybeans.

Give uses of soybean oil.

What is the newest use for soybeans?

Soybean meal contains how much %protein? % starch? % fiber? %fats?

Questions		Answers
1. Is starch present in soybeans?	1.	About 29% starch is present in soybeans.
2. Do soybeans contain protein?	2.	Soybeans contain about 44% of protein.
3. What kind of spot occurs on paper after rubbing it with a soybean?	3.	A translucent spot occurs on paper.
4. Do soybeans contain oils and fats?	4.	Soybeans contain oil and fats.
Additional Problems:		
5. Give importance of soybeans during World War No. 1.	5.	Soybeans were used for margarines and oils during World War No. 1.
6. When did the real boom in planting soybeans begin?	6.	In the year 1935.
7. Give the results of the investigations of the Ford laboratories regarding soybeans.	7.	Scientists in the Ford laboratories had developed methods of using the protein of soybean meal as a source of plastics for many small gadgets on the car. A few months ago Mr. Ford had made a plastic auto containing metal only in its engine, frame and running gear.

8. How many bushels of soybeans were grown in the United States in 1925? in 1940?	8. In 1935, 5,000,000 bushels were produced. In 1940, 80,000,000 bushels were grown.
9. Name minerals found in soybeans.	9. The minerals found in soybeans are calcium, phosphorus, and iron.
10. Give uses of soybean oil?	10. Soybean oil is used for lacquers, for cars, printing inks, lubricating oils, soaps, and linoleum.
11. Give newest uses for soybeans.	11. The newest uses for soybeans are now being used for clothing, upholstery, seat covers, and rugs for autos.

FINAL TEST FOR UNIT IV

Time: 40 Minutes Possible Score: 75

Rayon

Burning test

Take a small piece of rayon, hold it over a trough and 1. burn it. If it is real silk it will burn 2. slowly and emit a strong odor similar to the odor of burning 3. hair. The remains will be small, black, crispy 4. beads. Rayon burns 5. rapidly. The color of the flame is 6. yellow andit has 7. no odor.

Red Litmus paper

8. Moisten the red litmus paper. 9. Burn a piece of 10 rayon to be tested and hold the paper over the smoke of the burning material. If the material is silk, the red litmus paper will turn 11. blue.

Blue Litmus Paper

12. Moisten the paper. Burn a piece of rayon in a 13. dry test tube andhold the blue litmus paper over the 14. smoke of the burning material. The paper over the smoke turned to a 15. red color.

The sources of cellulose for rayon are 16. spruce 17. trees and 18. cotton 19. linters. One of the main uses of cellulose acetate is 20 plastics. Various chemical processes are employed to convert the cellulose into a liquid which is about as thick as 21. castor oil. The cellulose in solution is forced through a 22. spinnerette which contains many tiny holes.

The outcoming 23. filament combines to form rayon yarn. The bulk of the world's rayon is made by the 24. Viscose process, wherein the 25 pulp is treated with sodium hydroxide and 27. carb bisulphide to form cellulose 28. xanthate. A weak solution of caustic soda is added and after thorough mixing, the 29. viscose solution is formed. A country that leads in the production of rayon is 30. U. S. 31. Count Chardonnet was the first one to treat the raw material with 32. nitric acid and 33 sulphuric acid forming 34. nitro-cellulose. Rayon comes from the

35. English word 36. "ray" meaning 37. beam of light. When a drop of 38. sulphuric acid is placed on a piece of rayon and placed between two pieces of 39. paper, rayon 40 chars.

Test for Starch in Soybeans

Mash some soybeans previously soaked in 41. water and 42 heat in a test tube. Add a few drops of 43. iodine . About how much starch is there in soybeans 44. 29%.

Proteins in Soybeans

Mash some soybeans previously soaked in water and 45. heat in a test tube. Add 46. nitric acid. A 47. yellow color appears. Then add a few drops of 48. ammonium 49. hydrate. A 50 deep orange color appears. Soybeans, therefore, contain 51. proteins About what %? 52. 44%.

Fats and Oils in Soybeans

Mash some dry soybeans in a mortar with 53. ether. This will 54. extract the 55 oil. Place a few drops of the oil on brown paper and heat over the radiator. A 56 translucent spot appears. Soybeans, therefore, contain 57. oil.

The real boom in the planting of the soybeans was in 58. 1935 when 59 Henry Ford used it for 60 automobiles. In the investigation of Ford's laboratories he made a 61 plastic automobile out of soybeans. Five uses of soybean oil are:
62. margarines, 63. lacquers, 64. paint, 65. varnishes 66. printin inks.

The newest use for soybean is 67. clothing. The external membrane of a bean is called 68. testa. The 69 hilum is the scar at the point of attachment. In 1940, 70. 80,000,000 bushels of soybeans were grown. The minerals in soybeans are 1. calcium 72. phosphorus and 73. iron. The tiny opening in the hilum of the bean is called 74. micropyle. The structure bearing both root and seed is called the 75 hypocotyl.

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