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A MODIFIED UNIT ON PLANT BIOLOGY FOR STUDENTS IN 40 MINUTE CLASSES

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A MODIFIED UNIT ON PLANT BIOLOGY FOR STUDENTS IN 40 MINUTE CLASSES

By

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ABSTRACT

A unit on photosynthesis and cellular respiration was developed for a required high school general biology course. Due to the short class periods, neither plant anatomy/physiology nor labs related to photosynthesis and cellular respiration had been taught to these students at this level. To compound the problems with the shortened classes, the students come from over fifteen different feeder schools with very diverse backgrounds in science. Students in previous years seemed to struggle with these topics. Therefore, the focus of the unit is to give all students a consistent foundation in plant anatomy and physiology and have students involved in at least one demonstration, observation or laboratory activity each day of the unit. The hands on activities will help the students to grasp the general concepts of what takes place in photosynthesis and cellular respiration.

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INTRODUCTION

The phenomenon of photosynthesis always has been most difficult for my freshmen biology students to comprehend. Moreover, there had never been any plant anatomy taught in previous years. The goal of my plant biology unit was to provide the students with a basic background knowledge of these topics, because a learner must possess a working or basic knowledge base for interpreting new or novel experiences (Lumpe and Staver, 1995). When students have that solid foundation of knowledge, they can understand the new material with a better comprehension of why it may be important, how it works and/or how it was developed or discovered. Without that base to start from, full understanding may not be achieved. The goal of this study was to: 1)incorporate some basic plant anatomy and physiology into a basic biology course so all students would be starting out with the same foundation, 2) add labs and activities to a plant biology unit that will work in a 40 minute class period, 3) try new note taking methods and include group work to help reduce lecturing in class.

Previously, laboratory activities had not been incorporated in the curriculum. Therefore, any activities or experiments completed would be beneficial to the students. The biggest obstacle with adding the labs/activities is that the class time is at most, forty minutes per day. The school day is divided into nine equal periods with one of these periods being lunch. The students have an option of including one or two study halls into their schedule. The schedule is set up this way so that students can include additional electives to their core curriculum. Many students elect choir and/or band, art classes or physical education. Students who are college bound often choose two math, science or foreign language classes in a given year to enhance their preparation. A major drawback to this scheduling is that the science department is unable to offer any of the Advanced Placement courses due to unavailable lab time. The study encompassed sixty-one ninth grade students, fifteen tenth grade students, four eleventh grade students, and one twelfth grade student in a suburban parochial high school. The students were divided into four different classes; fifth hour had twenty-one students and was taught in the biology room, sixth hour had sixteen students and was taught in the chemistry room, eighth hour had twenty-four students and was taught in the biology room, and ninth hour had twenty students and was taught in the chemistry room. The student body is made up of approximately four hundred and thirty students. The school is a Class C parochial school, with a student body of over ninety percent Caucasian, which mirrors the population of the feeder schools. The students are products of over fifteen different elementary schools and/or middle schools which span up to a fifty mile radius from the high school. There is no consistency within these schools with respect to their science curriculum. Some students come in with little to no science background, while others come with extensive training in all areas of science.

The high school has forty minute class periods, dictating that many modifications be made to most laboratory experiences and/or activities which are typically designed for a fifty to fifty-five minute class period. The 40 minute time constraint does not always allow time for the instructor to assist all students who need extra help. One solution is to assign small groups to work on various tasks. I find that this enables those students who grasp concepts quickly a chance to help others. Researchers recommend peer collaboration be used to help students overcome scientific misconceptions (Lumpe and Staver, 1995). Lumpe and Staver also say that students working in peer collaborative groups developed more scientifically correct conceptions. According to Pizzini and Shepardson (1992), students helping students (giving explanations) correlates positively with achievement. Such assisting is also reported to raise self esteem. Students who feel good about themselves tend to be more motivated to do well in school.

Historically, when students begin studying photosynthesis, they have been less than enthusiastic because they do not like plants. According to research, students revealed that they prefer animal study over plant study. (Wandersee, 1986). Although major biological concepts may be applied to all living systems, examples are most often drawn from animal studies (Uno, 1994). Through informal discussion in my own classes, students explained that they prefer animals because they move and are more readily observable than plants. For balance, incorporating plants into the curriculum wherever possible became important. Since nomenclature is of value (Wandersee, 1995) and most students have poor understanding of plant classification (Tull, 1994), these were the two areas where I elected to incorporate plant examples.

For students in biology, there is no adequate substitute for the first-hand experience of living material. “What is a biology room without something that lives, moves, makes noise and is interesting to look at?” (Saunders and Young, 1985) Prior to the unit under discussion, there were two iguanas in the biology room and no living material in the chemistry room. Perhaps the mere presence of attractively displayed, living materials in the classroom serves to arouse student curiosity and interest, and thus stimulates learning beyond that which would normally be expected in a barren classroom (Saunders and Young, 1985). Studies by Saunders and Young suggest that living displays in the classroom serve to stimulate interest and curiosity which in turn influences attitude and achievement.

According to Eichinger, students favored science classes that offered laboratory work, teacher demonstrations, projects, and audiovisual materials. Students prefer science teaching and learning in which they take an active and responsible part (Ebenezer and Zoller, 1993). Students are more interested when they actually get to do something instead of just sitting and watching. They are more likely to learn something when actively engaged, in part because they take ownership for the completed product. This is supported by recommendations by the National Research Council (1996) which states that science should be an active, inquiry-based process (Chan, 1996). Not only is social interaction essential as learners internalize new or difficult understandings, problems, and processes (Glasson and Lalik, 1993) but with hands on experience students begin to feel connected to the process of scientific discovery rather than simply being passive recipients of previously discovered knowledge (Fail, 1995).

One method of teaching freshman biology is to begin with simple facts and to progress rapidly to sophisticated conclusions and questions (Slobodikin, 1996). Following that idea, the information presented with this unit began with general plant anatomy and physiology and proceeded to the topic of photosynthesis. During this time, students were presented with what is necessary for the reaction of photosynthesis to take place, what the products of the reaction are, and general ideas of what takes place in between. With respect to cellular respiration, aerobic and anaerobic aspects were covered which included the lab activity on fermentation of cabbage.

IMPLEMENTATION

In conducting my research at Michigan State, photosynthesis was the topic selected because I judged students at my school needed some type of activity/laboratory experience with this topic. Also, by incorporating some basic plant anatomy into the course, I would ensure that all students were starting out with the same foundation of plant knowledge. The challenge was to develop activities that could somehow be completed in 40 minute class periods. I also wanted to include new teaching strategies incorporating plant anatomy but not increasing the teaching time of the unit on plant biology. To procure the needed time for these activities/labs, less time was spent using traditional lecture and students worked at taking their own notes from the book and in small groups.

The unit was eighteen class periods long with special schedules, which translates to 600 minutes of class time. The topics covered in this unit were: basic plant classification, plant anatomy and physiology, photosynthesis, respiration and fermentation. At the completion of this unit, students would have an understanding of why and how plants are classified; would be able to identify the parts of a seed and plant and their respective functions; would be able to identify the requirements for photosynthesis; describe what happens during glycolysis and respiration; and identify what happens during fermentation and how that is related to glycolysis.

Parents were notified through a student-delivered letter (Appendix A-1) that students took home with them. A few weeks later at a Parent Open House, the letter was discussed and parents had the opportunity to ask questions about anything with respect to the research or how it would affect their child. They were very receptive to new activities being tried, especially since their children would be getting to do hands-on activities in science and it was not simply new teaching techniques that were being tried.

The following outline is a brief overview of the new materials that were developed through my research at Michigan State and is referenced as Table 1. Information is provided for three areas: preunit which is anything completed before information on this unit was presented, the unit itself including all information provided and activities done during the three week time period, and the evaluation tools which includes a quiz, post test, and class discussion.

Table 1

Unit Outline

Preunit - Topic	Activities
A. Parent Consent Letter	
B. Nomenclature	Leaf Collection Project
C. Plant Life Cycle	"Private Life of Plants" video
D. Biology/Science Survey (Appendix A-2)	
E. Pretest	
F. Plants displayed in the biology room	

Unit - Topic	Activities
A. Plant Classification	Classification Outline - fill in blanks
B. Plant Anatomy/Physiology	1. Fit To Be Dyed
	2. Bubbling Leaves
	3. Seed Dissection and Starch Test
	4. Plant Tropism
C. Photosynthesis	1. Observing Relationships Between Photosynthesis and Respiration
	2. Plant Pigments
D. Cellular Respiration	1. Energy Release in Respiration
	2. Fermentation Lab

Evaluation Tools

A. Plant Anatomy Quiz

B. Post Test

C. Class Discussion

Because students are not normally intrigued by the study of plants, incorporating plant biology into other aspects of the curriculum was a means to increase interest. During the first quarter of the year, the students were assigned a leaf collection project in which they identified and classified leaves. This project of collecting leaves helped them to see the differences between a tree, shrub, and herb. A hands-on exposure to plants encouraged students to be more open to plants during the unit on plant biology. They worked on their own for five weeks to complete this project and there were two days in class where books were available for classification purposes. The information they were to include was the date of collection, location of collection (as specific as possible), scientific name (genus and species), and common name.

Another way of introducing students to plant biology was with a video called "The Private Life of Plants" that was shown prior to teaching this unit. It was an interesting video that held the student's attention. The video used time-lapsed photography and showed many aspects of plant life from seed dispersal to fruit consumption.

Creating an environment where plants were a regular part of daily activities helped students become more receptive to plant study. The weekend before the unit began, several small house plants, along with some geraniums, were added to the biology room with an artificial light source. Bean seeds were planted in foam cups so that they would have a good start when the week began. Throughout the unit this set up prompted many questions that were not necessarily related to the plants directly. One student asked "How did people figure out to eat the root of a plant instead of the green stuff on top?" . Only two of the four classes (fifth and eighth hours) were exposed to this set up because they were taught in the biology room while sixth and ninth hours were taught in the chemistry room. Due to the basic nature and space available in the chemistry room, there was no plant display set up.

Before the students began any work on this unit on plant biology, a biology survey (Appendix A-2) was given to each of the students. They did not put their names on this but did write at the top if they were male or female. This was given as an attitudinal measurement, as to how they perceived biology/science and especially plants. A pretest (Appendix D-1) covering basic plant anatomy and photosynthesis was also given to gauge their prior knowledge. Students were extremely concerned when they completed the pretest, realizing that they knew absolutely nothing about plant anatomy or photosynthesis. It was somewhat reassuring for them to know that the questions addressed topics/concepts that they were supposed to know at the completion of this unit.

To begin the unit, students were given group assignments in order to develop a short class presentation defining a given group of terms. The terms were randomly divided and could include plant anatomy and photosynthesis topics. They were given five to ten minutes, depending on the class and how quickly they worked, to figure out what the meaning of the terms and how they tied together and then how the group would present this to the class. This was done to help them become familiar with the upcoming unit.

Incorporating basic plant anatomy and photosynthesis was a major step to completing the expansion of this unit. The students were given a skeleton outline (Appendix C) of the background information that included classification, plant anatomy, and photosynthesis terms. They were given time to work in groups during a class period and then instructed to complete the outline over a weekend at home. This was done so that traditional lecture style teaching could be partially eliminated with this unit. The day the classification outline was due, the class was given a slide presentation that included examples of the different phyla of plants following the outline. Information was covered that students should write down as each slide was presented. Working into the photosynthesis and respiration part of the unit, another way of presenting the information to students was used. Typically, students would simply read the assigned sections in the text, come to class and take notes. This information would usually not make sense to them when gone over by the instructor. With this unit, I routinely had them read a section of the chapter the night before, and take their own notes on the material. At first they would complain that they did not understand their own notes, but after the material was explained in class, the information made more sense than if they simply would have read over it. When the students already have written a large portion of the notes and are just adding bits and pieces, time is saved in waiting for students to copy information. This is something of great importance when working within a forty minute time frame.

Student note taking saved sufficient time so that several activities/labs were incorporated into the curriculum. I began with activities related to plant anatomy since these took up minimal class time and required small amounts of guidance. Progressing into the labs that were related to photosynthesis, more time was needed as well as more analytical thought processes on the part of the students.

The following are activities and laboratories that students completed during this unit. There is a description of each activity, what students were suppose to do and find, and where in the appendix each can be found.

1. Fit To Be Dyed (Appendix B-1)

Students worked through this activity in order to see how water is transported throughout a plant. A stalk of celery is placed in a glass/jar of colored water for a period of 24 hours. Students worked with a partner to slice off a portion of the stalk that was under water and discard it. Then, they examined the stalk's cross section with their naked eye to locate the xylem and phloem. The students answered some questions on the handout and responded to a survey a week later with respect to their understanding of how water is transported in plants.

2. Bubbling Leaves (Appendix B-2)

Students were assigned to groups of three or four and asked to place three different types of leaves (geranium, bean, and *Ficus*) into hot water. The hot water caused the stomata to open, which would produce a bubble at the point of the opening. This activity gave students the opportunity to see characteristic differences between different types of leaves with respect to their stomata. The students needed to respond to analytical questions on a handout and took part in a class discussion at the end of this activity.

3. Seed Dissection and Starch Test (Appendix B-3)

Students were to discover that a seed has specific parts which are important to its development from seed into a plant. Students acquired bean or corn seeds that the instructor had soaked in water for two days. They cut them open and examined the various embryonic parts. Then, they tested for the presence of starch using an iodine solution. If starch is present, the iodine would stain black. The students responded to survey questions a few days after the activity.

4. Understanding Plant Tropism (Appendix B-4)

These were set ups of bean and corn seeds put together by the students. The seeds had been soaked in water for 24 hours and were placed in a row, in four different directions at right angles to each other, in a petri dish with a damp paper towel. There were stands made for the petri dishes out of index cards and then these set-ups were placed in the dark. This activity was to show the students that the presence of light did not affect the directional growth of the roots and stems. The students answered many analytical questions on the lab handout along with survey questions at a later time.

5. Plant Pigments (Appendix B-5)

In this laboratory exercise students attempted to determine what type of pigments such as carotenes or xanthophylls are found in leaves of different colors using paper chromatography. They used an ethyl alcohol solution to separate the pigments from each other. The leaves were spinach and a red leafed spider plant. With this lab, students were required to make drawings of their lab set up developed with their partners. Students were asked to answer application questions upon completion of this lab.

6. Observing the Relationship Between Photosynthesis and Respiration (Appendix B-6)

This activity was done as a demonstration. A student volunteer would blow through a straw into an Erlenmeyer flask of Bromthymol Blue solution. This was done with two flasks: one was placed in the dark, and one was placed in the light for 24 hours. Both flasks had a sprig of *Elodea* added to it. When the class met the following day, the analysis questions in the lab handout were used as the basis for a discussion on what had happened to the Bromthymol Blue solution in the flasks.

7. Fermentation (Appendix B-7)

This long-term laboratory activity was set up early in the second week of this unit to allow for ten days of observations. The students worked with a partner and set up a container with cabbage covered by a ten percent salt solution. Each day students would come into class and immediately check their set ups for enough liquid covering, texture, smell, and pH. Students answered questions and completed graphs to be handed in at the completion of this activity. There was also a class discussion with respect to some of the analytical questions at the end of the activity. The purpose of this lab was to document the transformation of cabbage to sauerkraut and study fermentation in the process.

8. Energy Release in Respiration (Appendix B-8)

Seeds were sterilized to see if such treatment affected the amount of heat energy produced in respiration. The seeds used had not been treated with a fungicide and were therefore susceptible to mold growth. This activity was done as a demonstration to conserve class time and because of equipment constraints. The students were asked to predict what they thought would happen before the experimental data were collected. The purpose in this activity was for the students to see that energy (heat) is produced when seeds "breath" or respire during germination.

Students were assigned to groups in various ways. The basic function of these groups was to save on time, supplies, and facilitate discussion and other inquiries among the students. The peer collaborative groups were set up in various ways. Most of the anatomy activities (Fit To Be Dyed, Seed Dissection and Plant Tropism) were done in groups of two and the students were allowed to choose who their partner would be. This gave them opportunities to take part in the experiments. With some of the activities that involved more equipment (Bubbling Leaves and Plant Pigments), I assigned groups, making an attempt to get a good academic mix within each group. The size of these groups varied from three to five students. The fermentation lab was an extended (ten class periods) activity so students were allowed to choose their partner but to choose with the thought that they would be working with this person for two weeks. Generally, students were more productive in their work with the groups of two that they got to choose.

A quiz (Appendix D-2) was given after the point that the classification and plant anatomy had been completed. The quiz covered the labs/activities up to that point and the classification outline that had been assigned and then covered in class. The results of this quiz are presented in the evaluation section of this document. A post test (Appendix D-4) was given at the completion of the unit. This covered plant anatomy/physiology, photosynthesis, a cellular respiration; much of this overlapped with the questions on the pretest. It consisted of both objective and subjective questions. There were also some opinion questions at the end and students were told that they could include any constructive comments that they would like to add regarding the unit.

EVALUATION

The major goal of this unit was to add lab activities that could be completed in a 40 minute time frame to a plant biology unit. The restrictions also included a unit that could not be lengthened. Since the expansion of their learning opportunities was involved, the students and their parents, were very receptive to this being done.

By introducing the students to plants through several activities before this unit formally was initiated, the students were more receptive to the topic than at the beginning of the year. I observed that they looked forward to doing another activity each time one was completed because they would ask what they would be doing next and wondered how soon they would get to do it. As the year progressed, students were a little disappointed that not as many labs were done in other units as were done with the photosynthesis unit.

Students responded to a biology survey before the unit began to determine their attitude with respect to science and plants in general. The first question revealed their past attitude toward science. 56 students responded that they liked science as a subject last year while 20 did not like it. The second question probed whether or not their attitude toward science had changed since last year. In the responses, 47 said their appreciation for the subject was about the same, 11 said it was better, and 19 said it was worse. The next question asked if they enjoyed working with plants in the yard, farm, or garden; 37 said yes and 40 said no. There was a distinct difference in how males and females answered two questions; 12 males responded yes, they enjoyed working with plants and 24 said no, while females said 25 of them enjoyed working with plants and 16 said no. That would translate to 61% of the females preferred to work with plants verses only 33% of males. The next question showed similar results between males and females as did the previous question. The question was "Have you enjoyed the topic of plants in the classroom in the past?" Males responded with 13 yes and 24 no, while females responded with 22 saying yes and 19 no. This gives 35% of the males enjoying the topic of plants compared to 54% of the females enjoying the topic. The last question asked "would you like to learn more about plants"; 26 said yes while 50 said no they did not. The percentages of males and females on this question was closer to each other than the previous two questions: 31% of males said they would like to learn more about plants while 38% of females responded that they would like to learn more. This survey showed that students had an overall negative/apprehensive attitude toward plants going into this unit. At the end of this survey, the students had the opportunity to make any additional comments on the topic of plants. One male's response was "I like to learn about plants, but it can be boring depending on how it is presented. That video was good." Another said "I like learning about plants but only if we do activities and not just go along with the book". Finding that the students in general had a negative attitude toward plants, I tried to at some point in each class give them some practical aspect of what we were talking about. For example, without the sun, the food chain would have a tough time surviving and in that process, trying to elicit answers from them. In the end, the students attitudes in general were not as negative as in years past when the unit was completed.

Since students are incredibly concerned with their grades, they were allowed to respond to survey questions that were built into some lab activities. They could express their opinions on topics, questions related to the lab activities, and other areas regarding the unit. Although not graded, it was understood that these responses were to be constructive and valid. Responses also reflect input students gave during class discussions and group conversations. These survey questions/comments are included in each of the following activity/laboratory evaluations. There are also results that they acquired during the activity.

Evaluation of Activities

1. Fit to Be Dyed

The students were able to set up this mini lab up very quickly and the results were fairly dramatic. At the completion of this activity, approximately two-thirds of the class commented that they knew how water was taken up before this activity. However, those students who did not understand how the water moved did benefit from this activity. One student said, " It was kind of neat how the red dye left the trails so we could see how the water was soaked up." Another said "It showed the route of the liquid more clearly". Because this was a quick activity, the lab was able to be set up at the end of one class and discussed at the beginning of the next.

2. Bubbling Leaves

The leaves that the students used in this activity provided a wide variety of observable results. The bean leaf showed the best results because students were able to see the most bubbles with this leaf. Frustrations set in if the students began with the other two leaves which did not produce noticeable results. However, when they had to compare their results with other students, they found that others obtained similar results from the same types of leaves. Some questions the lab handout included were related to what had they observed and why did they think it happened. One student's response read "There were bubbles on the leaf; the plant is breathing in air when it is under water". Another student's response to why it happens was "the leaves are releasing oxygen".

3. Seed Dissection and Starch Test

The students enjoyed the hands-on work that was associated with this activity. They were very focused and very diligent about locating the parts to be found. Nearly all the students found the necessary structures without any help. In the survey conducted at the end of this activity, one-third responded that they did not know that a dry seed could grow and when asked if the activity helped, some of the responses included, "yes, because I could see the actual growth" and another said "when they were in water they started to grow".

4. Understanding Plant Tropism

The students took strong ownership with this laboratory activity. One student came into class the second day and wanted to know how her "little ones" were doing. Overall they were very curious to see what was happening with the seeds. The corn seeds produced more reliable results than the bean seeds, most likely because it was easier to hold the corn seeds in place as the petri dish was secured. On survey questions, students were asked what two structures appeared after a few days in the dark. Most responded with roots and stems but some put down just roots or roots and leaves. They were also asked what direction did these structures grow and why. Two-thirds of the students had the response that roots grew down with responses such as "roots grow down towards the source of gravity and leaves grow away from gravity" and another student said "up and down like they do in the ground".

5. Plant Pigments

As individuals worked through this laboratory, they thought logically by questions asked during the process of completing the lab and by participating in a class discussion on photosynthesis and the pigments involved in the process. Students executed the procedures very self conscious and took the activity seriously, asking valid procedural questions along the way. They appeared to be as precise as possible with their lab set ups. Unfortunately, the desired results did not occur. The line of green moved up the filter paper without any separation of pigments.

6. Observing Relationships Between Photosynthesis and Respiration

This lab/demonstration failed to produce desired results in all of the classes. The bromthymol blue solution that had been exhaled into and having a sprig of *Elodea* added to it did not perform photosynthesis. The Elodea may have not been fresh enough to photosynthesize. Before any testing could be completed on the bromthymol blue solution, it had been disposed of by the lab assistant.

7. Fermentation

This extended laboratory was most likely the one that the students will remember most. From their responses on the post test questions relating to this activity, the part that had the biggest impact was the pH changes over the 10 class periods. This lab took part of one class period to set up. Once started, it developed into an independent project. The students would come in at the beginning of each class, and one of the partners would do the tests for pH, texture and smell before class would begin. During the first few days, it would take approximately five minutes for the students to get in the room and check their set up and record their results. By the end of the two weeks, the daily procedures would be finished in the first one to two minutes of class.

8. Energy Release in Respiration

In this demonstration, the students followed the instructor at each step. The seeds were sterilized before class started. It was difficult for the students to piece the procedures together without explaining why and/or how each step connected to the next. For some reason unknown to the instructor, this activity was difficult for students to connect one step/part of the set up and data collection to the next. In the future, more predemonstration explanation/discussion will be included.

The first tool of evaluation used during the unit was the plant anatomy quiz. The results produced by this are presented in Table 2 and include the mean, median, and mode for all four classes. Compared to the pretest, which included considerably more information, scores improved roughly forty percent. The scores of these quizzes are arranged from highest percent to lowest in each class.

Table 2

Plant Anatomy Quiz
(scores given in percentage)

	5th hour	6th hour	8th hour	9th hour
	94	100	87	87
	94	94	87	80
	94	87	87	73
	87	87	80	73
	87	80	80	73
	87	80	80	73
	80	73	73	73
	80	73	73	73
	73	67	67	73
	67	60	67	67
	60	47	60	67
	60	40	60	60
	60	33	53	53
	60	33	53	53
	47	27	47	53
	40	20	40	53
	40		40	53
	33		33	53
	33		20	47
	33		7	40
	20			33
Number of students	21	16	20	21
Mean	63	63	60	62
Median	60	70	64	67
Mode	60	33, 73 80, 87	80, 87	73

Overall Mean = 62

The primary tools of evaluation for this unit were a pre and post test as well as the quiz (Table 2) given after completion of the plant anatomy section. In comparing pretest to the post test scores, students improved anywhere from thirty-two to forty five percent. The means for all four classes that were part of the study improved from the pretest to the post test. Tables 3-6 show the comparison of pretest and post test scores ranked from highest percentage to lowest percentage for the four sections involved in the study. The same number of students took the post test as the pretest except for the 9th hour class (Table 6) where there were two students frequently absent. They were not in school consistently enough to ever makeup the pretest but were there the day the post test was given. These students did not finish the semester at this school. From the t-test assessment, the difference of the means between the pre and post test scores for each class is significant beyond the 0.001 level. Therefore it is more than 99.9% certain that there was real learning that took place during the teaching of this unit. The data tables include the mean, median, mode and t-test results for each class. The scores are arranged from highest to lowest percentage and do not necessarily reflect the same person's scores in each column. The data comparison shows that the first two classes did better and this could be attributed to the fact that they have the class earlier in the day when the students are more alert than the last two classes which are held during the last two periods of the day.

Table 3

5^{th} hour Biology - Biology Room
(scores given in percentage)

	Pretest	Posttest
	53	93
	47	92
	38	88
	38	84
	31	81
	31	78
	31	76
	28	69
	28	67
	28	67
	25	67
	25	64
	24	61
	22	58
	19	57
	19	56
	16	56
	16	54
	16	39
	13	35
	3	21
Number of students	21	21
Mean	26	65
Median	25	67
Mode	28, 31	67

T-Test Result = 8.18, significant at 0.001 level

Table 4

6th hour Biology - Chemistry Room
(scores given in percentage)

	Pretest	Posttest
	50	94
	44	92
	41	89
	31	86
	30	83
	28	79
	28	76
	28	61
	26	58
	25	57
	19	54
	19	51
	16	46
	16	44
	13	32
	6	29
Number of students	16	16
Mean	26	64
Median	27	60
Mode	28	na

T-Test Result = 6.23, significant at 0.001 level

Table 5

8^{th} hour Biology - Biology Room
(scores given in percentage)

	Pretest	Posttest
	34	79
	31	78
	28	76
	28	71
	28	71
	25	69
	25	68
	25	67
	25	67
	25	61
	23	61
	22	61
	22	51
	22	47
	19	46
	19	43
	19	42
	16	39
	16	36
	16	33
	13	29
	13	15
Number of students	22	22
Mean	23	55
Median	23	61
Mode	25	61

T-Test Result = 8.02, significant at 0.001 level

Table 6

9th hour Biology - Chemistry Room
(scores given in percentage)

	Pretest	Posttest
	34	85
	34	83
	31	82
	31	81
	31	81
	25	78
	25	76
	25	75
	22	74
	22	71
	19	65
	16	65
	13	63
	13	58
	13	58
	13	51
	9	51
		38
		33
Number of students	17	19
Mean	22	67
Median	22	71
Mode	13	51, 58, 65, 81

T-Test Result = 11.11, significant at 0.001 level

The survey questions that the students responded to on the post test produced results that reflect positively the goal of the unit. Over half of the students felt that the labs/activities helped them to understand the overall concepts studied in this unit. The second question resulted in over two-thirds stating that the labs were what they liked best about the unit. When students get involved with hands-on activities, they enjoy the class and are more likely to learn. The third and final question showed that approximately half of the students liked the homework/study guide/notes portion of the unit the least. Perhaps by breaking the study guide up into smaller parts instead of one big assignment, the students would not have felt so overwhelmed by it.

DISCUSSION AND CONCLUSIONS

Since this was the first year that laboratory activities were incorporated into the plant biology unit, new information was acquired by both the students and instructor. From an in-class discussion and results on post test survey questions, students enjoyed the many activities and labs they were asked to complete during this unit. As each group worked through many of the simple plant anatomy activities, such as "Fit to Be Dyed" and "Seed Dissection", the instructor was able to assess that roughly two-thirds of the class had been through similar activities. Since these activities tended to be less time consuming, they were easily worked into the forty minute time frame. Students who had previously done something similar did not mind the repetition. These activities were good tools to make sure everyone started at the same point in their learning. Finding out that many students had completed similar activities helped the instructor to determine that in future years, combining these activities on the same day will free up additional days for more extensive laboratories.

Students in these general biology classes were willing to give informal feedback. Through discussion in class, I learned that the students felt a lot of pressure from the amount of information they were required to know for one test. They thought that it would be better to make the plant anatomy quiz longer, turning it into a test. Finally, they said it would be easier to learn the information if it were given in two smaller sections: plant anatomy and photosynthesis. I feel that this was a very valid statement and for next year, I will try to work that out as part of the curriculum.

Typically, students in the biology classes work in small groups. Having the opportunity to work through several activities in a short period of time gave the instructor a good look at different group sizes. For the activities that were completed in this unit, a group of two was ideal. This gives the student the best chance at seeing and doing all there is to see and do.

With only forty minute classes, any deviation from the normal schedule creates problems. Assembly schedules, late starts and a North Central Accreditation (NCA) team visit contributed to lost time during this unit. The assembly schedules and late starts cut class time to thirty-five minutes. The NCA team visit required that the instructor be prepared to potentially have a substitute instructor for two days throughout these classes. None of the above were conducive to the teaching of this unit. Furthermore, some labs, "Observing the Relationship Between Photosynthesis and Respiration" and "Energy Release in Respiration", were changed to demonstrations due to time and supplies/equipment restrictions.

The note taking method that was tried with this unit seemed to work out really well. The students asked if they could do that in future units that we covered as the year progressed. This showed the instructor that they were concerned about understanding the material and with this in mind, an attempt will be made to continue and refine this for next year.

Looking at the post test that the students had taken, there were parts that they did well on as well as some areas that they did not do so well. The areas that they did not do so well on is the objective type of questions and even though I discuss how to take the different parts of tests, perhaps more discussion and reemphasis as the year progresses is necessary. Also, if the student did not study for the test, they found it difficult to answer many of the short answer questions. For these types of questions, if they paid attention in class and wrote down information during the review, they did fine. They especially did well on the questions that related directly to activities or labs that were done in class, such as the types of indicators used and what they detected and the function of stomata. The students seemed to be able to express their thoughts better with the short answer types of questions and part of what I would like to do for next year is to incorporate more short answer questions and eliminate some of the objective questions.

Overall, the unit was successful. Students will never forget the smell of fermenting cabbage as they left for Christmas vacation. Having taught the unit once has given me significant insight. The student's suggestions to break the unit up into two parts is valid. Combining the simple activities to create more time for more challenging labs and modifying some activities to accommodate equipment shortage will be planned for next year.

APPENDIX A

Beverly K. Baldwin
Valley Lutheran High School
3560 McCarty Road
Saginaw, Michigan 48603
(517) 790-1676

To Whom It May Concern:

I would like to introduce myself as your daughter/son's Biology teacher. During the first semester, your child will complete a unit on Photosynthesis and Cellular Respiration. This unit has been modified from last year as part of my Master's degree program through Michigan State University. During this unit, students will be required to complete some typical work such as written homework, quizzes, and tests. The major change comes with the addition of several demonstrations and laboratory based activities. It is my opinion that these labs will significantly increase the student's understanding of the topic.

Your child's participation in my research will be in the form of collection of his/her test scores, as well as observations that I make of his/her general understanding. In no way will your child's name be attached to any data included in my research. Participation in this study will not affect your child's grade.

If you have any questions, concerns, or objections to your child's scores being included in my research, please contact me by September 10, 1997. If you are unable to reach me either at school (517) 790-1676 or home (517) 871-3154, please leave a message and I will get back to you as soon as possible.

Sincerely,

Beverly K. Baldwin

Biology Survey

1. What hour do you have Biology? 5 6 8 9

2. Did you like Science as a subject last year? Yes No

3. Compared to last year, is your appreciation for the subject:

   Better Worse About the same

4. Do you enjoy working with plants in the yard, farm, garden, etc? Yes No

5. Have you enjoyed the topic of plants in the classroom in the past? Yes No

6. Would you like to learn more about plants? Yes No

7. If you have any comments as to things you have liked or disliked about the topic of plants in the past, please feel free to share them. Also, if there is anything specifically that you would like to learn about them, you may write that here. If there is anything in general you have to comment about at this time, now is the opportunity.

APPENDIX B

Fit to Be Dyed

PROCEDURE

1. Fill a medium-sized jar one-fourth full of water. Then add a few drops of food coloring and stir. Note: Be careful when using dyes, as they can stain.

2. Place a stalk of celery in the jar so that its leaves are at the top and its base is at the bottom. Only the base should be submerged in the colored water.

3. Place the jar where it will not be disturbed. After 24 hours, examine your stalk of celery. What do you observe?

4. Remove the stalk of celery from the jar. Using a knife, cut off the portion of the stalk that was under water . Be very careful when using a knife. Discard this portion.

5. Examine the base of the stalk.

OBSERVATIONS & CONCLUSIONS

1. What do you observe?_____________________________________.

2. Why does this occur? _____________________________________

____.

Bubbling Leaves

Photosynthesis uses the gas carbon dioxide and produces the gas oxygen. Tiny openings in the leaves called stomata allow carbon dioxide to get in and oxygen to get out. Where are stomata located? Are they in the same position in all leaves? Discover for yourself by doing this activity.

Procedure and Observations

1. Obtain a variety of fresh leaves and glass container of hot water.
2. Pinch the stalk of a leaf. Then dip the flat part of the leaf in hot water.

   What do you observe?______________________________

   ____

   Why do you think this happens?________________________

   ____

3. Repeat step 2 with some different kinds of leaves. How do your

   results differ from one another?________________________

   ____

Analysis and conclusion

1. What can you infer about the structure of the leaves?____________

   ____

2. Share your findings with your classmates. Compare your results. Are

   they similar? Why or why not?__________________________

   ____

3. What are some possible sources of error in this activity?__________

   ____

SEED DISSECTION AND STARCH TEST

Problem - Question -Are seeds alive?
-How can you tell if something is alive?
-If something is alive what does it have to do

Materials-
- bean seeds (soaked in water for 2 days)
-corn seeds (soaked in water for 2 days)
-scalpel
-petri dish
-iodine solution
-pipet (medicine dropper)

1. Acquire bean and corn seeds that have been soaked in the water for 2 days.
2. Using the scalpel - and a been seed, make a small cut around the center of the seed.
3. Carefully peel back and remove the seed coat.
4. At this point you should be able to see the center, where the 2 halves meet. Slowly separate the 2 parts, make sure you have the embryo attached to one of the halves.
5. Using the scalpel, make some cuts in the cotyledons.
6. Using a dropper pipet, drop several drops of iodine solution onto the seeds.
7. The visibility of starch will be shown by the dark staining.

UNDERSTANDING PLANT TROPISMS

Problem

- How do roots find water and how do leaves find light?
- Does it matter which way seeds are planted?

Materials

-aluminum foil
-2 150 ml beakers or 1/2 pint milk cartons
-transparent tape
-15 corn seeds
-cotton- absorbent
-filter paper
-2 index cards
- medicine dropper - pipet
-milk carton or box
-petri dish
-scissors
-potting soil

PROCEDURE

See page 528 in your textbook.

OBSERVATIONS

1. In which directions are the leaves of the corn seeds in the petri dish growing? The roots?

____

____

2. In which direction are the leaves of the covered corn plants in the beaker growing?

____

3. In which direction are the leaves of the uncovered plants in the beaker growing?

____

____

ANALYSIS AND CONCLUSIONS

1. Why were the seeds in the petri dish grown in the dark?

____

____

2. What was the main influence on the direction of growth of the leaves and the roots of the corn plants in the petri dish?

____

____

3. How did the aluminum caps influence the direction of leaf growth in the corn plants?

____

____

4. What influenced the direction of growth of the leaves of the corn plants in the beaker?

____

____

PLANT PIGMENTS

PRE-LAB DISCUSSION

Photosynthesis begins when light is absorbed by pigments in the plant cell. One technique for separating and identifying these pigments is paper chromatography. In paper chromatography, solvent moves up the paper carrying with it dissolved substances - in this case plant pigments. The pigments are carried along at different rates because they are equally soluble in the solvent and are attracted in degrees to the paper.

Many green leaves contain pigments colors that are not seen until autumn because they are hidden by the chlorophyll. A few plants have leaves that are red, orange, or yellow all year long.

In this investigation, you will use paper chromatography to determine what differences exist in the plant pigments of various colors of leaves. You will also determine which leaves or which parts of the leaves contain the chlorophyll necessary to carry out photosynthesis.

PROBLEM

What plant pigments can be found in Spinach leaves?

MATERIALS

1 piece of filter paper
1 150-ml beaker
1 glass plates (cover for beakers)
coin
70% isopropyl alcohol or Ethyl alcohol
Fresh Spinach leaf/Red leaf
Scissors
Stapler
Metric ruler
Pencil

SAFETY

Put on a laboratory apron if one is available. Put on safety goggles. Handle all glassware carefully. Alcohol is flammable. Do not expose it to heat or flames. Do this laboratory investigation in a well-ventilated room. Be careful when handling sharp instruments. Note all safety alert symbols next to the steps in the procedure and review the meanings of each symbol by referring to the symbol guide on page 10.

PROCEDURE

1. Make two filter-paper rectangles that are each approximately 12 cm by 7 cm. Using a pencil, draw a base line 1.5 cm from the bottom of the long side of each rectangle.

2. Place a spinach leaf over the pencil line on one of the rectangles. Roll the coin over the leaf so that a horizontal green line is transferred to the pencil line. Repeat this step with the red leaf and the second filter- paper rectangle.

3. Add just enough isopropyl alcohol to the beakers to cover the bottom. Do not add more than 1 cm to ensure that the pigment line will not be submerged when the paper is lowered into the beaker. CAUTION: Avoid inhaling the alcohol.

4. Make a cylinder of each piece of filter paper by stapling it end to end. Lower each paper cylinder into a beaker contain alcohol. The solvent will begin to move up the paper and cause the pigments to move as well. Draw a diagram of your set up.

5. Cover the beaker with a glass plate. Do not disturb the beaker for approximately 15 minutes, or until the solvent is about 1 cm from the top of the paper.

6. When the solvent is about 1 cm from the top of the paper, remove the paper and mark the farthest point of the solvent's progress (front line) with your pencil before the line evaporates.

7. Allow the filter-paper cylinders to dry, and then make a sketch of the chromatogram. Some possible colors and the pigments they represent are: faint yellow-carotenes; yellow-xanthophyll; bright green-chlorophyll a; yellow-green-chlorophyll b; red-anthocyanin.

Observations
Data Table

1. How many pigments were separated in each type of leaf?

____

____

2. How did the pigments in the spinach leaf compare with the pigments in the red leaf?

____

____

3. Which of these leaves can carry on photosynthesis? Explain your answer.

____

____

Critical Thinking and Application

1. Photosynthesis requires the green pigment chlorophyll. Explain how a Japanese tree, having only red leaves, can carry on photosynthesis.

____

____

____

____

2. Many trees have leaves that are green in the summer and red, yellow, or orange in autumn. Where were these colors during the summer? How can they suddenly appear in autumn?

____

____

____

3. In addition to separating plant pigments, what are some other possible applications for paper chromatography?

____

____

____

Observing The Relationship Between Photosynthesis and Respiration

PROBLEM

What is the relationship between the processes of photosynthesis and respiration?

DEMONSTRATION: Draw a diagram of the set up.

OBSERVATIONS

1. What was the color of the BTB solution before you exhaled into it? After you exhaled into it?

2. What was the color of the BTB solution in the flask that was placed in the dark for 24 hours? In the flask that was placed in the light for 24 hours?

ANALYSIS AND CONCLUSIONS

1. What substance was released into the BTB solution when you exhaled into it? How is this substance produced?

2. Explain why the color of the BTB solution changed after you exhaled into it.

3. Why was Elodea placed in both flasks?

4. Which flask is the control? Describe additional controls that you might use for this experiment.

5. Why are the results for the two flasks different?

6. How are photosynthesis and respiration related?

FERMENTATION

INTRODUCTION

Have you ever seen what happens when bread rises or when apple cider “goes hard”? These actions are the result of fermentation, the process by which an organism breaks down glucose in the absence of oxygen. During this process, 2 molecules of adenosine triphosphate (ATP) are made from a glucose molecule (instead of 36 made in the presence of oxygen), and a variety of byproducts are produced. Fermentation is important in making many foods; it produces the alcohol found in beer and wine. In this lab, you will create conditions in which cabbage will become fermented in the presence of certain bacteria and will turn into sauerkraut.

1. When does the human body produce lactic acid?

2. Why is the CO_2 given off during alcoholic fermentation important for making bread?

PROCEDURE

Part 1

A. Pack a plastic container with shredded cabbage.
B. Cover with 2.5% NaCl (salt) solution until the container is full.
C. Cover the container tightly. For the next 2 weeks, make sure the container remains full. Replenish with more NaCl solution as needed.

3. For Day 0 in the chart, record the color and texture of the cabbage, the odor , whether any gases are produced (check for bubbles), and the pH of that solution (use pH paper). Repeat these observations and recordings every school day. On the first day (day 0) and the last day of the experiment, check for the presence of the bacteria and the condition of the cabbage cell.

Since the day you set up the experiment is designated Day 0, Day1 occurs after the cabbage has been incubating for one day. These observations should take just a few minutes at the beginning of each class.

D. To check the condition of the cabbage cell, make a wet mount of a few cells peeled from the lower epidermis. Stain these cells using methylene blue. Examine under a microscope using low and high power. Look carefully to see if the cell membrane has separated from the cell wall.

4. Why would 2.5% NaCl solution cause such separation?

E. To check for the presence of bacteria, make a wet mount by gently scraping the bottom of the cabbage with a toothpick and putting it on a slide with a drop of brine. Stain with methylene blue and examine under high power.

Part 2

F. Make daily observations and recordings until no more gas bubbles are produced. This should take 2 weeks. Remember to replenish with more NaCl solution as needed. On the last day prepare slides for microscopic observation by repeating steps D and E.

5. Describe any changes over the course of the experiment in the odor, color, and texture of the cabbage and in the pH of the brine.

6. Does the number of bacteria increase between the first and last days of the experiment?

7. Sketch any bacteria you see. Estimate how many you see.

G. You and your teammate should each make your own graph showing the pH from Day 0 to Day 10 (last day).

8. Make your graph on separate paper.

9. Describe any changes in the appearance of the cabbage cells. How might the hypertonic brine and the enzyme activity of the bacteria explain these changes.

POSTLAB ANALYSIS

The bacteria growing anaerobically (without air) in the brine will convert glucose to lactic acid, carbon dioxide, acetic acid, ethyl alcohol, mannitol, dextran, and esters. These combine to produce the characteristics odor and flavor of sauerkraut.

10. Why do you think you soaked the cabbage in brine (2.5% NaCl) instead of water? What do you think would have happened if you had used water instead of brine?
11. What do you think caused the gas production?
12. What happened to the pH over the course of the experiment? What do you think caused this change in pH?
13. Which equation in the Prelab Preparation section could account for the odors produced during this experiment?
14. Why did you keep the container tightly covered at all times?

FURTHER INVESTIGATIONS

1. Yogurt is made by different bacteria from those in the sauerkraut. You may make yogurt using commercial yogurt cultures and fresh milk. Look for changes in pH, odor, texture, and the number of bacteria.
2. Observe how yeast makes bread rise. Look for changes in odor, texture, and the number of yeast for CO_2 production and for changes in pH.

FERMENTATION DATA SHEET

1. ____

____

____

2. ____

____

3. Enter your answers on the data chart.

4. ______________________________

____

5. ______________________________

____

____

____

____

6. ______________________________

7.

8. Make a graph on a separate sheet of paper.

9. ______________________________

____

10. ______________________________

____

11. ______________________________

____

12. ______________________________

____

13. ______________________________

14. ______________________________

ENERGY RELEASE IN RESPIRATION

Burning a peanut or any other food indicates the presence of potential energy in foods. But we do not see visible flames burning in living things. If living organisms produce energy, they must do so at a slower rate than the burning peanut. Slow, controlled energy production in an organism is called respiration. Germination of seeds is one of the many activities of organisms that requires energy from respiration.

MATERIALS

- 4 wide mouth bottles
- 4 thermometers
- cotton
- cardboard boxes - large enough to hold 4 bottles
- masking tape
- saw dust, vermiculite, or any other good insulator
- 100 ml 20% bleach solution
- seeds of oats, barley, **wheat,** or milo, untreated

PROCEDURE

1. Use masking tape to label four wide-mouthed bottles, A, B, C, and D.
2. Fill bottles A, B, and C one-third full of seeds that have not been treated with a fungicide.
3. Cover the seeds in bottle B with the bleach solution for about an hour. Then pour out the bleach and rinse the seeds five times with tap water.
4. Fill bottles A and B with water. DO NOT add any water to bottles C and D. After 24 hours pour out the water.
5. Plug all four bottles with cotton. Insert a thermometer through the cotton of each bottle. The tip should be about 2 cm from the bottom of the bottle. You may need to put a wad of cotton in the bottom of bottle D to keep the thermometer bulb from touching the bottom of the bottle. Add a tag at the top of each thermometer with the letter corresponding to the letter on the bottle. (i.e. bottle A -- thermometer A)
6. Pour sawdust or insulating material into a cardboard box to a depth of about 3 cm. Set the four bottles in the box. Pour sawdust or other insulating material into the box until each bottle is completely surrounded and covered. Sawdust can even cover the cotton plugs loosely.
7. Observe the temperature of the room and the bottles as soon as the experiment is set up, and then two times daily for four days. Record your observations in Table 1.

8. After 4 days, open each bottle and examine its contents.
9. Plot the data in Table 1 on the graph provided, using a different color or kind of line for each bottle. The key should include the treatment as well as the letter of each bottle. Room temperature should also be graphed.

DISCUSSION QUESTIONS

1. What did you notice about the contents of bottle A? ____________________

____

2. Did germination occur in any of the bottles? ________________________

3. If germination occurred in some bottles but not in others, can you think of any

explanation?____

____

____

____

4. Did you notice any relationship between temperature change and amount of

germination? ____

____

5. What was the purpose of bottle D? _______________________________

____

APPENDIX C

PLANT OUTLINE

Kingdom Plantae

- Eukaryotic
- multicellular
- nonmotile
- photosynthetic autotrophs
- chlorophylls a, b & other pigments
- scientists use term division rather than phylum

Phylum Chlorophyta

-
-
-

Phylum Phaophyta

-
-
-
-
-

Phylum Rhodophyta

-

Phylum Bryophyta

-
-
-
-
-
-
-

Phylum Tracheophyta

-
-
-

Subphylum Psilopsida

-
-

Subphylum Lycopsida

-
-

Subphylum Sphenopsida

-

Subphylum Pteropsida

Subphylum Spermopsida

-

-

-

-

-

Gymnosperms

-

-

-

Class Cycadae

-

-

-

Class Gingkoae

-

-

-

Class Gnetalae

Class Coniferae

-

-

-

-

Angiosperms

-

-

-

Class Angiospermae

-

-

-

-

Subclass Monocotyledonae (monocots)

-

-

-

-

Subclass Dicotyledonae (dicots)

-

Seed

Flower

Leaf

Root

Stem

Fruit

APPENDIX D

Photosynthesis and Cellular Respiration Pretest

_____1. Photosynthesis requires each of the following except
A. light
B. pigment
C. enzyme-storing compounds
D. oxygen

_____2. Which term is least closely related to the others?
A. anaerobic respiration
B. aerobic respiration
C. lactic acid fermentation
D. alcoholic fermentation

_____3. The process that involves oxygen and breaks down food molecules to release energy is
A. respiration
B. alcoholic fermentation
C. lactic acid fermentation
D. glycolysis

_____4. The products of photosynthesis are
A. glucose and 0_2
B. glucose and $C0_2$
C. H_20 and $C0_2$
D. H_2 and 0_2

_____5. Bread rises as the result of
A. glycolysis
B. Pyruvic acid production
C. lactic acid fermentation
D. alcoholic fermentation

_____6. The energy stored by photosynthesis is released by
A. the light reaction
B. the dark reaction
C. respiration
D. digestion

_____7. Leaves of a plant appear green because chlorophyll
A. reflects blue light
B. absorbs blue light
C. reflects green light
D. absorbs green light

_____ 8. Green plants are
A. heterotrophs only
B. autotrophs only
C. both heterotrophs and autotrophs
D. neither heterotrophs nor autotrophs

_____ 9. The dark reactions of photosynthesis are also known as the
A. Calvin cycle
B. Krebs cycle
C. citric acid cycle
D. carbon cycle

_____10. Which process does not release energy?
A. glycolysis
B. photosynthesis
C. cellular respiration
D. respiration

_____11. In the last reaction of respiration
A. a pyruvic acid becomes CO_2 and a 2-carbon compound.
B. a 2-carbon compound enters the Krebs cycle
C. ATP is produced for use by body cells.
D. electrons are transferred to the electron transport chain.

_____12. A plant's response to a stimulus is called a(n)
A. auxin
B. gibberellin
C. tropism
D. hormone

_____13. The tissue that transports water and nutrients inward through the roots is the
A. epidermis
B. root hair
C. vascular cylinder
D. cortex

_____14. The primary root is called a taproot in
A. grasses
B. rye
C. carrots
D. wheat

_____15. The center of a dicot stem consists of a core of
A. xylem and phloem
B. cork cambium
C. pith
D. vascular cambium

_____16. Water moves across root hairs by osmosis from a region of
A. high concentration of water molecules
B. low concentration of water molecules
C. high concentration of dissolved minerals
D. low concentration of dissolved oxygen

_____17. In mature woody dicot stems,
A. xylem forms the inner part of bark
B. phloem forms the outer part of bark
C. a ring of xylem surrounds phloem
D. a ring of phloem surrounds xylem

_____18. Phloem tissue does not transport
A. organic molecules
B. inorganic ions
C. products of photosynthesis
D. water

_____19. The outer bark of trees consists of
A. phloem cells
B. heartwood C. sapwood D. corkcells

True and False - use a "+" for true and a "0" for false

____20. If muscle cells do not get enough oxygen during heavy exercise, glycolysis is followed by alcoholic fermentation.

____21. The most important energy-storing compound that is used by every living cell is chlorophyll.

____22. A leaf has xylem and phloem.

COMPLETION

In the equation $6CO_2$ + $6O_2$ -------------> $C_6H_{12}O_6$ + $6O_2$ for

photosynthesis, the $C_6H_{12}O_6$ represents______________________________.

The large thin, flat section of a maple leaf is the ____________________.

Short Answer

What is Transpiration?

Why do trees make leaves?

How would you know whether you were observing the cross section of a monocot or a dicot stem?

Discuss how stomata work.

Plant Anatomy Quiz

1. In the lab, Fit To Be Dyed, what part of the plant had been dyed red at the base of the stalk of celery?

2. From the seed dissection, name at least 2 parts of the bean seed that your group identified.

3. What indicated a positive test for starch in this lab? Explain.

True and False - use a "+" for True and a "0" for False.

_____4. Gymnosperms lack flowers.

_____5. There are only 2 classes of Gymnosperms

_____6. Angiosperms are typically plants that we are familiar with.

_____7. A monocot has 2 cotyledons.

_____8. A dicot has flowers with parts of flowers in multiples of 4 or 5.

_____9. The purpose of the flower is to protect the seed.

_____10. Phloem tissue transports nutrients.

11. What are stomata and discuss how they work.

FIT TO BE DYED **HOUR: _____**

1. Before you observed the celery in red water, did you understand how water moved up through a plant?

2. If your answer to #1 was no, did this activity help you to see how this works? Please explain.

SEED DISSECTION AND STARCH TEST **HOUR: _____**

1. Before you did this activity, did you know that a dry seed could begin to grow?

2. If no, did this activity help you to see that this could happen? Explain.

UNDERSTANDING PLANT TROPISM **HOUR: _____**

1. When you put seeds in the petri dish, what were the two parts that appeared after the few days that they were stored in the dark?

2. What directions did they grow and why?

PHOTOSYNTHESIS STUDY GUIDE AND LECTURE **HOUR: _____**

1. When you went through the book and took notes did you understand the information? Explain.

2. Was the study guide easy to work through, using the book? Explain.

3. Did going through the lecture in class help in understanding the the notes that you had already taken? Explain.

PLANT UNIT TEST

MULTIPLE CHOICE

_____1. Photosynthesis requires each of the following except
A. light
B. pigment
C. enzyme-storing compounds
D. oxygen

_____2. Which term is least closely related to the others?
A. anaerobic respiration
B. aerobic respiration
C. lactic acid fermentation
D. alcoholic fermentation

_____3. The products of photosynthesis are
A. glucose and O_2
B. glucose and CO_2
C. H_2O and CO_2
D. H_2 and O_2

_____4. The energy stored by photosynthesis is released by
A. the light reaction
B. the dark reaction
C. respiration
D. digestion

_____5. Leaves of a plant appear green because chlorophyll
A. reflects blue light
B. absorbs blue light
C. reflects green light
D. absorbs green light

_____ 6. The dark reactions of photosynthesis are also known as the
A. Calvin cycle
B. Krebs cycle
C. citric acid cycle
D. carbon cycle

_____7. Which process does not release energy?
A. glycolysis
B. photosynthesis
C. cellular respiration
D. respiration

_____8. A plant's response to a stimulus is called a(n)
A. auxin
B. gibberellin
C. tropism
D. hormone

____9. Water moves across root hairs by osmosis from a region of
A. high concentration of water molecules
B. low concentration of water molecules
C. high concentration of dissolved minerals
D. low concentration of dissolved oxygen

____10. Phloem tissue does not transport
A. organic molecules
B. inorganic ions
C. products of photosynthesis
D. water

____11. Lactic acid fermentation takes place in
A. MUSCLE CELLS
B. GREEN PLANTS
C. BREAD DOUGH
D. BONES

____12. The substance that glucose is broken down into in the anaerobic phase is called
A. PYRUVIC ACID
B. CITRIC ACID CYCLE
C. RDP
D. KREB'S CYCLE

____13. The substance that glucose continues to be broken down into in the aerobic phase is called
A. $C_6H_{12}O_6$
B. H_2O
C. RDP
D. CO_2

____14. Carbon dioxide and water are the beginning of what reaction
A. CELLULAR RESPIRATION
B. LACTIC ACID FERMENTATION
C. ALCOHOL FERMENTATION
D. PHOTOSYNTHESIS

MATCHING

_____15. With oxygen	A. Respiration
_____16. Without oxygen	B. ATP
_____17. Converts light energy to chemical energy	C. Aerobic
_____18. Energy is released	D. Anaerobic
_____19. Green pigment	E. Mitochondria
_____20. Gets the sun's energy directly	F. Autotroph
_____21. Gets the sun's energy indirectly	G. Photosynthesis
_____22. Stores energy	H. Chlorophyll
_____23. Primary place for Cellular Respiration	J. Heterotroph

True and False - use a "+" for true and a "0" for false.

_____24. Chlorophyll is necessary for photosynthesis to take place.

_____25. Energy is stored during cellular respiration.

_____26. The products of alcohol fermentation are not useful in the baking industry.

_____27. Lactic acid fermentation is the process that athletic coaches are concerned with.

_____28. Cellular respiration requires light and chlorophyll.

_____29. Photosynthesis breaks down sugar to get energy.

_____30. Everything gets its food directly from the sun.

_____31. Because they cannot make their own food, autotrophs rely on the food-making ability of green plants.

_____32. The most important energy-storing compound that is used by every living cell is chlorophyll.

_____33. A leaf contains xylem and phloem.

_____34. Gymnosperms lack flowers.

_____35. There are only 2 classes of Gymnosperms

_____36. Angiosperms are typically plants that we are familiar with.

_____37. The purpose of the flower is to protect the seed.

_____38. Phloem tissue transports nutrients.

SHORT ANSWER

List the 2 phases of Cellular Respiration.

1.
2.

Explain why muscles need to get enough oxygen during exercise. (3 points)

Explain the difference between a monocot and a dicot. (2 points)

Discuss how stomata work. (2 points)

What are ATP and NADP and why are they important. (2 points)

Write the balanced chemical equation for Photosynthesis. (5 points)

Explain why the series of reactions that make up the Calvin cycle and Kreb cycle are described as cycles. (2 points)

Describe the respiration process between plants and animals (similarities, differences, dependencies) (4 points)

List at least 3 types of indicators that were used in the labs/activities that were done in this unit and explain what they did and why it was important in the experimental process of that particular activity.(9 points)

Describe the difference between AMP, ADP, ATP and why one is more beneficial than the rest. (3 points)

NO POINTERS

Did the activities we did with this unit help you to understand the overall concepts?

What were some of the things you liked the best about this unit?

What were some things you liked least (BESIDES THE TEST)

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