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EVALUATION OF A TIME
SAVING TEAM LABORATORY
REPORT ASSESSMENT

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Heidi Elizabeth Krusenklaus

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EVALUATION OF A TIME SAVING TEAM LABORATORY REPORT ASSESSMENT

By

Heidi Elizabeth Krusenklaus

A THESIS

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ABSTRACT

EVALUATION OF A TIME SAVING TEAM LABORATORY REPORT ASSESSMENT

By

Heidi Elizabeth Krusenklaus

The intent of this study was to design new and adapt existing laboratory exercises from the Biological Science Interactions of Experiments and Ideas textbook. The second part of this study was to analyze a time saving assessment tool for student scientific laboratory reports to verify that it was a fair assessment and that it reflects a valid representation of student efforts.

During the 1996-1997 school year a co-worker and I incorporated the new laboratory exercises described in this thesis. All advanced biology students were surveyed and my students were used in the evaluation of the laboratory report assessment by collecting and grading every student's report and comparing their score to that of the report collected for the team grade.

Survey and statistical analyses showed that the laboratory report assessment was valid and fair.

This thesis is dedicated to my parents and my husband, Jeff, for their support throughout this project.

ACKNOWLEDGMENTS

This study would not have been possible without the data collected from all of my students. A special thanks to Dan Rasp and Derek Miller for creating a photographic log of the laboratory exercises. My co-worker, Kathy Beason, for trying the new creations from this thesis and providing her input and support.

Thanks to my parents and my husband for giving me the support needed to travel to another state to complete this master's program.

Thank you to Dr. Howard Hagerman for editing this thesis and Dr. Ken Nadler for helping me create new laboratory protocols for my advanced biology curriculum. A very special thanks to Dr. Merle Heidemann. Your time and feedback in the past three years has been greatly appreciated. You are a true role model for me. I do not know how you do it!

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INTRODUCTION

Rationale

The intent of this study was to design new and adapt existing laboratory exercises from the Biological Science Interactions of Experiments and Ideas textbook. The second part of this study was to analyze a time saving assessment tool for student scientific laboratory reports. The study was done to make sure that the time saving assessment is a fair assessment and that it reflects a valid representation of student efforts.

Background On Developing and Adapting of Laboratory Exercises

Germann, Haskins and Auls (1996) did a study of seven high school laboratory manuals. The study indicated that the manuals engaged students in the scientific method. Students were observing, measuring and recording data, drawing conclusions, and making inferences The missing components were 1) pre-laboratory discussions, 2) postulation of questions, 3) formulation of hypotheses, 4) prediction of outcomes, 5) construction of experimental procedures, 6) postulation of new questions, 7) application of the experimental technique from newly learned to new laboratory exercises, and 8) post laboratory discussions about possible sources

of experimental error. When possible all eight missing components listed have been incorporated into the laboratory exercises developed for the advanced biology course which was one objective of this thesis. We did not have students design their own laboratory exercises without some sort of pre-laboratory outline to lead them to a protocol. In addition to what was expected by Germann, Haskins and Auls, we taught the students statistics so they could quantitatively analyze their data and draw conclusions about the relationships.

I wanted to design a laboratory manual to get away from the old BSCS textbook and to format new laboratory protocols that called for students to generate hypotheses. The advanced biology course was designed to teach students how to problem solve, organize data, design experiments, use laboratory equipment, achieve common goals through team effort, and write scientific reports. In order to evaluate these items on a regular basis and in an efficient manner, a special method of assessment was needed.

Eight laboratory exercises were conducted by the students in the first semester of the 1996 school year. Of the eight exercises, three were new to the curriculum, while the others were modified.

I designed the three new laboratory exercises with the help of my professors at Michigan State University and my school colleagues. Three laboratory exercises, *Enzyme Specificity and Digestive Disorders, The Effects of Light on Three Different Plant Species,* and *Testing for Seed Viability*, were the basis for evaluating the time saving assessment tool described in this thesis.

Background on The Need for Group Learning

During field trips to local industries, the staff at our high school learned that local employers want employees that know how to work in groups. The employers explained that their workers come to them lacking this skill. By the year 2000 three fourths of all jobs in the United States will require such skills as technical reading, professional writing, analytical reasoning and computation. Employers required employees that: 1) know how to learn, 2) are competent in reading, writing and computation, 3) have communication, listening and oral skills, and 4) are creative in problem solving and group effectiveness.

My advanced biology classes were structured to present students with scientific concepts and to provide students with opportunities to develop all four characteristics listed above. I

stressed to students what employers want and I conducted the classroom like the "everyday" world. The main technique used to aid students with their communication, listening, oral and group skills was to place students in teams for a majority of the class time. "Since scientists frequently work in groups, science educators recognize that discussion promotes thinking and problem solving by leading students to compare alternative ideas and solutions. When differences occur in a group, the students are naturally forced to elaborate their explanations" (Zemelman, 1993).

People work in teams in various jobs, careers and organizations. To create an environment that fosters these skills in the advanced biology courses, the structure of the class was ninety percent laboratory experiments in cooperative groups. The other ten percent was lecture and pre-laboratory activities. Repeated research has shown that lecture, demonstrations, and memorization of explanations lead to very little long-term understanding. The "hands on" approach is much more effective(Zemelman, 1993). Research has also shown that cooperative learning groups can lead to higher achievement, increased self-esteem, more on-task behavior, less disruptive behavior and increased retention (Lord, 1994).

Applegate (1995) compared quiz scores in a field ecology class. He gave a quiz to the individual students and then gave the same quiz again, but he allowed the students to work in teams. Applegate found that students shared new insights and that group performance should be considered along with the student's individual effort. Applegate tried dictating the team membership as well as letting students select their own team. He found that selecting team members by the teacher worked best.

Students in the advanced biology classes were required to work in teams of three or four and each student prepared scientific laboratory reports consisting of a purpose, hypothesis, data tables, questions, discussion, and conclusion. Often laboratory reports would include one or more of the following: graphs, calculations, statistical evaluations and sketches. To insure that students communicated and shared different insights in the laboratory exercise, one report was collected at random from each team for evaluation. Time is needed and set aside for students to evaluate each other's reports so that all team member's reports are competently done. Time was also provided for students to correct or improve their reports. In the advanced biology classes the laboratory reports had two due dates.

The first due date, the Initial Evaluation Day, allowed students to evaluate their own team's laboratory reports. Students were given grade sheets to guide them through the evaluation. Team members then received time in and out of class to improve their laboratory report based on the input from their peers. The second due date was the Final Evaluation Day. Students evaluated the corrected parts of each member's report. The Initial and Final Evaluation days insure that each member is writing his own report and understands the material in that report.

My laboratory report assessment was designed to encourage students to do well through peer pressure. I believed that peer pressure is be more effective than that which I might apply. Studies on "peer pressure" support this belief. One study (Steinburg, 1996) found that "at least in high school...when it comes to day to day influences on schooling - whether students attend class, how much time they spend on homework, how hard they try in school and the grades they bring home - friends are more influential than parents" . Team members may not have started out being friends, but by working together for an eight week period they formed a sense of friendship or the group failed. My study will show that peer

pressure improved student attitudes toward their performance.

Steinburg (ibid) also found

> " members of academically oriented crowds do best in school and members of alienated crowds do worst. Perhaps it is merely that students who choose to associate with brainy classmates are themselves more academically inclined, whereas those that select friends from alienated crowds are themselves less oriented towards school."

The teams in this study were designed to encourage new peer groups to form and for the students to feel a sense of responsibility to their team. If the laboratory reports were left up to the individual students to turn in I believe that the good students would still turn them in, but the low achieving students would not attempt to turn in the required reports. With the Initial and Final evaluation procedures in the cooperative groups there is more of an incentive to do well.

School Profile

The high school in this study is located in a town with a population of 60,000, and is one of two high schools. Both high schools share one administration building. The study high school has 1469 students, 18.6% of the student body are minorities. The break down of the minorities is as follows: 14.6% Black/African American, 2.4% Hispanic/ Chicano/ Latino, 1.4% Asian/Pacific Islander, and .2%

Native American. White/ Caucasians make up 81.4% of the total school population. Approximately 14% of the students qualify for free lunches, while 3% get reduced prices. The school has programs for gifted and talented, physically handicapped, and emotionally handicapped. In addition there are classes offered for at-risk students and students with lower than "normal" reading levels.

Students must take Biology 1 and 2 as prerequisites for advanced biology. Together biology 1 and 2 are the "usual" introduction to scientific methods, biochemistry, cells, genetics, evolution, classification, and ecology. Advanced biology is an elective class which should mean the class is intended for students that have some interest in science. The "Core 40" is the college preparatory group of courses. Unfortunately in my school we have no non-elective science class, besides the Biology 1 and 2, that will count toward the "Core 40". Because of my school's class offerings most students take Biology 1 and 2 as freshmen and then the advanced biology classes as sophomores instead of taking the non-elective sophomore level science class we offer. Despite the one year of biology in high school, students come into advanced biology with weak backgrounds in laboratory skills such as hypothesis

formulation, organization, evaluation, and data analysis.

METHODS AND MATERIALS

Class Demographics

This study was conducted in two advanced biology classes. The third hour group consisted of 25 students: 3 black (one female and two males) and the rest were white. The class had 15 females and 11 males. There were 14 sophomores, 9 juniors, 1 senior and 1 exchange student from Switzerland. By the end of the first nine weeks four of the students withdrew from the class. Of the four that withdrew, two were females and two were males. By the end of the semester an additional female withdrew from the class. In the fourth hour class there were 22 students. Of these, 1 was a black female, 2 were Asian males, and the rest were white. The class consisted of 13 females and 9 males. There were 16 sophomores, 3 juniors, and 3 seniors. In both classes there were few behavior or discipline problems. No referrals were written or parents called for disciplinary reasons.

Background on the Use of the Laboratory Exercises and Assessment Tool

During the 1996-1997 school year a co-worker and I taught the advanced biology classes. We both used all the described laboratory exercises, pre-laboratory activities, exercise quizzes and

the laboratory report assessments. Only my students were used in the evaluation of the laboratory report assessment. All advanced biology students were surveyed on their attitude toward the laboratory report assessment. An outline of the advanced biology curriculum can be found in Appendix A.

Introduction Unit in Advanced Biology

During the first two weeks of school another teacher and I reviewed with the students the scientific method (Appendix B). We used the BSCS book to read the "Nature of Theory" last year, but this year I developed a handout for students to use. Students answered the questions on that handout and completed two other worksheets, "Using Concepts" and "Formulating Hypotheses," that were useful for the teaching of how to formulate hypotheses. Next we reviewed how to present data in graphs. Different sets of data were given to students to graph. A quiz was given after the work on the scientific method (Appendix B) and graphing (Appendix B).

The class structure is 90% laboratory experience and 10% lecture. A listing of the new and revised laboratory exercises that were used in the classroom for the 1996-1997 school year is shown in Table 1. What follows is a summary of the laboratory exercises

Table 1: Summary of New and Revised Lab Exercises.

Lab Exercises	State Science Objectives	Bibliography Number	Class Time
Yeast and A Relationship Between Food and Energy	1.1,1.2,1.3,1.4,2.1, 2.3	3,4,18	3 days
The Relationship Between Different Food Sources and Energy	1.1,1.2,1.3,1.4,2.1	3,4,18	3 days
The Relationship Between Temperature and Yeast Fermentation	1.1,1.2,1.3,1.4,2.1	3,4,18	3 days
*Enzyme Specificity and Digestive Disorders	1.1,1.2,1.3,1.4,2.1, 2.2,2.3	3,4,18	3 days
Respiration in Peas and Corn	1.1,1.2,1.3,1.4,2.1	4,14	1 day
Respiration in Crickets	1.1,1.2,1.3,1.4,2.1	3,4	2 days
Two Seed Viability Tests	1.1,1.2,1.3,1.4,2.1	3,4	2 days
*The Effects of Light on Three Different Plant Species	1.1,1.2,1.3,1.4,2.1	3	2 days
*•The Effects of Light on Radish Cotyledons	1.1,1.2,1.3,1.4,2.1, 2.2	3,4,12	12 days
*•The Effects of Different Wavelengths on Radish Cotyledons	1.1,1.2,1.3,1.4,2.1, 2.2	3,4,12	2 days
*•Can Different Wavelengths of Light Cause Fruit To Ripen?	1.1,1.2,1.3,1.4,2.1, 2.2	3,4,12	2 days
*Meiosis with Insect Chromosomes	1.1,1.2,1.3,1.4,2.1, 2.2	3,4,12	1.5 days
* = New Lab Exercise	1.1,1.2,1.3,1.5,2.1, 2.2,2.3,3.3,3.4,	4,5,13,15,17,19	8 days
• = Lab Exercise not used in 1996			

used in the first semester of the 1996-1997 school year. All laboratory protocols used from previous years were modified and two laboratory protocols, laboratory exercises 1-4 and 4-4 were introduced into the first semester curriculum . Also one new laboratory protocol will be discussed that was used in the second semester, Exercise 12-2. The numbers in the laboratory titles represent the unit and laboratory exercise number.

Laboratory Exercise 1-1: Yeast and A Relationship Between Food and Energy

This first laboratory exercise (Appendix C) illustrated the processes of fermentation and showed students a technique for dilutions. I created a pre-laboratory activity (Appendix C) for students to complete before the laboratory exercise. The pre-laboratory activity was difficult for students to complete because the protocol did not provide enough information for them to understand the content of the activity. I ended up walking students through the activity with a class discussion and leaving some items for them to complete on their own. In this way the pre-laboratory worked well. Student grades on the laboratory reports for this laboratory activity were overall higher than last year's.

Laboratory Exercise 1-2: The Relationship Between Different Food Sources and Energy

The second laboratory exercise was an extension of the first, where students were able to choose their own food source (Appendix C). Students were expected to use what they learned from the first exercise to set up the second. The major difference in this exercise was that students were to find a new food source for yeast, such as maple syrup or orange juice instead of the molasses used in the first laboratory exercise. Students learned that the sugar concentration in the food source had a direct effect on the amount of carbon dioxide produced. Two additions that should be made to the laboratory exercise handouts are a control space, test tube 11, in the data table and a graph of the team's 24 and 48 hour data. After beginning the laboratory we added both of the items that were missing.

Laboratory Exercise 1-3: Relationship Between Temperature and Yeast Fermentation

The third laboratory protocol was not new to the curriculum, but it had a whole new protocol. In the past we used a protocol in which the variable was temperature of incubation. We had trouble setting up reliable differences in the temperature. This difficulty

lead me to develop this new laboratory exercise (Appendix C), which calls for five different temperatures. Test tubes were placed in the freezer (0 °C), refrigerator (11 °C), classroom(22 °C), water bath (37 ° C) and an oven (63 °C). Students learned that there is a preferred environment for the yeast. Their results showed that the ideal temperature for carbon dioxide production was the water bath at 37° C. Improvements needed in the laboratory protocol include adding the temperatures below the locations on the x axis of the bar graph. Students should plot the class average along with team's 24 and 48 hour data on the same graph.

Quiz on First Three Fermentation Laboratory Exercises

After the third laboratory exercise was returned, we gave a quiz on Fermentation (Appendix C), which was based on results and information from the first three laboratory exercises. Students used their reports during the quiz. Quiz scores were low. Out of 25 points the average score in my third hour class was 13.2 with a range of 8 to 21 and in my fourth hour class it was 15.7 with a range of 3 to 20. It is hard to compare these scores to last year because the quizzes were not comparable. The scores indicated that students did not prepare for the quiz and/or they did not understand the material

well enough to apply it.

Laboratory Exercise 2-1: Measuring Rates of Respiration in Peas and Corn

The major focus of this laboratory exercise and the next was for students to learn about respiration and compare it to fermentation (Appendix D). Before the exercise students were assigned to read a handout which was taken from the old BSCS textbook and to complete an accompanying pre-laboratory worksheet (Appendix D). Students learned how to calculate respiration rates and develop graphs to compare the respiration rates of two different organisms. I developed a background study guide on cellular respiration to accompany our Campbell Biology textbook (Appendix D). The study guide helped students find and use the relevant information in our college-level textbook (Campbell).

Laboratory Exercise 2-2: Measuring Rates of Respiration in Crickets

This laboratory exercise (Appendix D) was a continuation of the Exercise 2-1. Students were instructed to adapt their Exercise 2-1 procedure sheet to complete Exercise 2-2 protocol. The only handout provided to the students was the questions needed to accompany

their report.

Quiz over Respiration Laboratory Exercise

After the completion of Exercise 2-2, we used the respiration review sheet (Appendix D) to review the Respiration Exercises and gave a quiz. The quiz was very similar to the quiz used in 1996 and was worth 25 points. The average score was 14.9 points in my third hour class with a range from 8 to 22. In my fourth hour class the average was 14.5 with a range of 9 to 22.

Laboratory Exercise 1-4: Enzyme Specificity and Digestion Disorders

The sixth Laboratory Exercise was a new exercise (Appendix E) and was adapted from that written by L. Reinking, J. Reinking, and Miller (1994). Students were given a pre-laboratory activity, developed by me, to learn about enzymes and to design their experiment (Appendix E). Using Laboratory Exercises 1-1,1-2 and 1-3, students were able to answer pre-laboratory questions to help them understand the reasoning for the procedure needed in Laboratory Exercise 1-4. Exercise 1-4 illustrates how enzymes are specific for substrates and why some people are unable to break down certain sugars. Students were able to observe enzyme specificity and conclude that different sugars require different

enzymes to break them down. Most students chose this exercise for their semester's end portfolio essay. Students explained that it was easy, they understood the protocol, or it was the laboratory report on which they got their best score. Since the data section on the student procedure sheets was vague, students needed to design their own tables and figure out what data to graph. Many students needed help or references to old reports.

Laboratory Exercise 4-4: The Effects of Light on the Growth of Three Different Plant Species

This Laboratory Exercise (Appendix F) was developed in conjunction with two other exercises related to the effects of different wavelengths of light on seed germination. The two exercises used in 1995 did not show any differences in the germination of lettuce seeds under different wavelengths of light. When the experiments were repeated in the research summer (1996), I was still unable to get germination differences using different wavelengths of light. These differences were needed in order for students to use a t-test to support their conclusions. When students did the old protocol there was no need to do the statistics, because they could easily see there was no difference. As a result of

not being able to improve the old protocols, three new experiments were developed: *4-4: The Effects of Light on Three Different Plant Species*, *4-5: The Effects of Light on Radish Cotyledons* (Appendix F) and *4-6: The Effects of Different Wavelengths on Radish Cotyledons* (Appendix F) and a Laboratory Exercise extension *Can Different Wavelengths of Light Cause Fruit to Ripen?* (Appendix F). Unfortunately time permitted us to only carry out Laboratory Exercise 4-4.

4-4: The Effects of Light on Three Different Plant Species turned out to be a very complex laboratory exercise. Students were excited about growing their plants and they were very surprised by the outcome. This seemed like a very simple exercise where students should have been able to predict the outcome, but they could not. To introduce the exercise, students completed a pre-laboratory activity (Appendix F) on information about germination in the Campbell textbook. We had 29 different t-tests to do to compare the growth of the different parts of the plants. An example of one t-test was done on bean hypocotyl length in the light compared to that of one germinated in the dark. To see a complete list of all t-tests calculated see "Results" table in Appendix (F). Each team did its two

assigned t-tests then reported the calculations to me. I checked the calculations on the computer to be sure they were sharing accurate answers with their classmates. Whatever t- tests were not assigned I did on a spreadsheet program.

Sample Student Work for T-test:

Null Hypothesis-There is difference between the hypocotyl length of corn plants grown in the light for nine days and those grown in the dark for nine days.

t formula when two data sets do not have the same number of samples:

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{(n_1-1)\,S_1^2 + (n_2-1)S_2^2}{n_1 + n_2 - 2} \bullet \left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

and

degrees of freedom = (n_1 - 1) + (n_2 - 1)

$$t = \frac{12.46-6.06}{\sqrt{\frac{(11-1)11.6 + (13-1)6.9}{11 + 13 - 2} \bullet \left(\frac{1}{11} + \frac{1}{13}\right)}}$$

t= 5.20

d.f. = (11 - 1) + (13 - 1) =22

Using a t table look up the degrees of freedom and the t value to get the probability to reject or let the null hypothesis stand.

This exercise required many measurements, sketches and statistical analysis so we increased its value to 45 points. Next year we will have students take fewer measurements or use fewer plants to reduce the number of statistical tests.

Laboratory Exercise 4-1 Comparison of Two Seed Viability Tests.

This was the last Laboratory Exercise of the first semester (Appendix F). The exercise was done last year, but I altered the protocol based on the information in the BSCS textbook. This exercise illustrated two different viability tests where students could calculate a chi square value to compare them. The chi square formula used by the students was:

$$\chi^2 = \Sigma \frac{(\text{observed} - \text{expected})^2}{\text{expected}}$$

Laboratory Exercise - Meiosis with Insect Chromosomes

I also developed a meiosis exercise (Appendix G) adapted from several exercises out of American Biology Teacher , (Cordero, 1994; Stencel, 1995; Taylor, 1988). Paper representations of an insect genome were used to illustrate crossing over between genes and how different gametes result . Students could see the "alleles" that represent the genes carried on the chromosomes. Some revisions

should be made to make the laboratory exercise clearer for the students and to aid the teacher in the grading process. See Appendix (G) for a summary of changes.

The Need for A Time Saving Assessment

A major focus of this study was to determine if the time saving assessment used to grade student laboratory reports was fair. During the 1995-96 school year two coworkers and I took over the teaching of the advanced biology classes. We all agreed that a time saving assessment was needed to reduce the hours spent grading students' laboratory reports that would be very similar in content since the students worked in groups. When trying to decide how to develop this assessment, I remembered that we received peer review in college on our Fruit Fly laboratory report. Each paper was given a number and assigned to another student in the class. They were to read it and make comments for improvement. This assessment was the basis for the assessment scheme that follows.

Explanation of the Laboratory Report Time Saving Assessment

The assessment we used is diagrammed in Figure 1. Although the details changed along the way the procedure remained the same (Appendix H). Students completed their laboratory reports

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according to the required format and guidelines (Appendix H) for Initial Evaluation Day. All students were given a grade sheet that outlined the required objectives for each section of the report. All students met in their groups and exchanged reports. Each student was required to make suggestions on all their teammates' reports. At the end of the evaluation period students decided the degree of completion of each teammates' report. They chose 1) "done" for laboratory reports that were acceptable and could be graded by the teacher without revisions, 2) "corrections" for reports that were completed but needed improvements, or 3) "not done" for reports that were incomplete. At this point the teacher visited each team to see that all laboratory reports were complete to assure that each team member completed his or her report. Students had 24 -48 hours to make changes before the final evaluation date.

During final evaluation day students were expected to review all team members' reports, and to verify that corrections had been made and that all reports were complete. The reports that were incomplete or not corrected, as found by the students in their teams, were graded separately by the teacher. This means that grades for

Initial Evaluation Day:

Initial Evaluation Examinate ID#:

Student ID#:_____

Final Evaluation Date:

Initial Evaluation: Student ID#:_____ Final Evaluation Date:

Teammate ID#:

ID#_____ Done Corrections Not Done ID#_____ Done Not Done

ID#_____ Done Corrections Not Done ID#_____ Done Not Done

ID#_____ Done Corrections Not Done ID#_____ Done Not Done

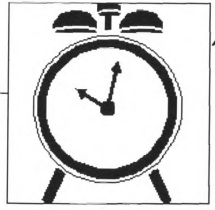
I agree to make the corrections discussed with my team _____ (Initial)

1. Students receive grade sheets. In their groups, all team members evaluate each lab report

2. On the grade sheet students identify if a lab report is 1) done (complete), 2) corrections are needed or 3) not done (not completed)

3. The teacher checks to see if each lab report is complete. If a lab report is not complete that individual will lose 25% of their lab report grade.

4. Time is given for students to make corrections.



5. Team members evaluate corrections in each lab report.

Figure 1: Flow Chart of the Evaluation Assessment Tool.

incomplete work affected only the individual that composed the report. All laboratory reports determined to be "done", by the team, were put into the drawing for the report to be graded by the teacher. Everyone in the drawing received the same grade based on the report except for individuals who lost points or received extra credit. Figure 2 illustrates how students got deductions or extra credit on their reports.

Procedure Used to Evaluate Laboratory Report Assessment

To evaluate the fairness and accuracy of the assessment technique I collected and graded every student's laboratory report and compared their score to that of the laboratory report collected for the team grade. Students were instructed that all laboratory reports would be collected so I could review answers to the questions. They were not aware that I was grading each individual's report. Team reports were graded first then I went back to grade all individual reports. Students used an assigned ID number on their report instead of their names, so I was unaware of whose laboratory report I was grading. This procedure was done for three different laboratory exercises, Exercise 1-4, 4-4, and 4-5, and the results are discussed in the evaluation section.

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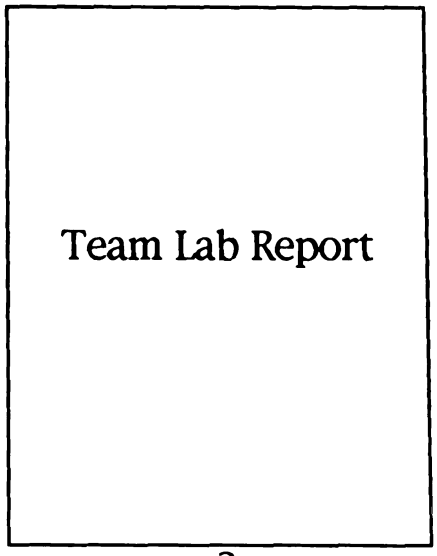
Extra Credit Possibilities:

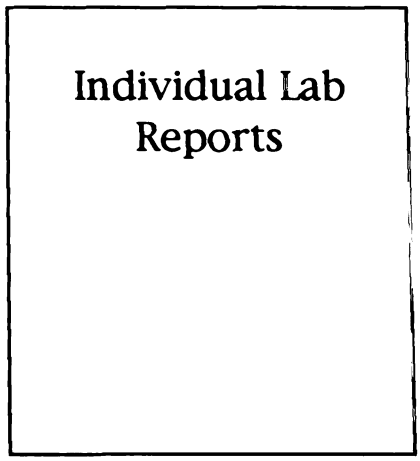


+5
If every team member had a complete lab report on the Initial and Final Evaluations and one lab report is collected for a team grade

+3
If one lab report is collected for team grade, but not every team member had a complete lab report on the Initial Evaluation

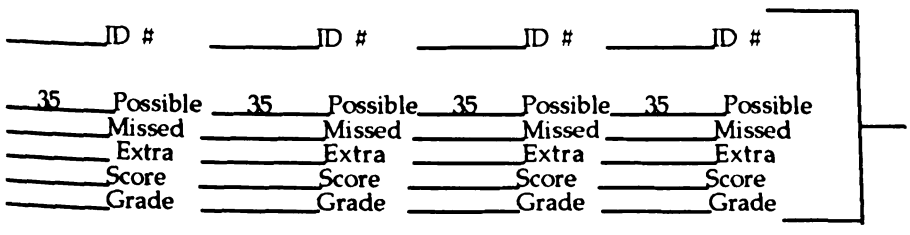
+3
If an individual typed their lab report they receive extra credit even if their report is not collected.

Points Deducted:



-25%
If a student does not have a complete lab report on the Initial Evaluation

-25%
If a student does not have a complete lab report on the Final Evaluation or they did not make suggested changes



The grade sheets include places for each member because each may receive extra credit and missed points.

Figure 2: Summary of Point System Used on Laboratory Reports.

Procedure Used to Organize Groups

For the first grading period I had students tell me what grades they remembered earning in their Biology 1 and 2 courses. I also conducted learning style and left brain right brain learning tests. All the information was then considered when groups were formed. Group size ranged between three and four students. For the second grading period students were ranked by their percent of achievement in my class then, the highest student, the lowest student and the two in the middle were put into group. This process was continued until all students were placed in groups. I then looked at the number of females and males per team and made sure that I had not placed very many students with any of their first quarter teammates. Students were switched if necessary.

Changes in Team Building and Team Evaluations for 1996-1997

Changes that were made to team building and team assessments for the 1996-1997 school year included: 1) Making laboratory reports worth at least 35 points instead of 30 points; 2) restructuring ways to receive extra credit and increasing the credit available (see Figure 2); 3) adding team building activities; 4) adding closing teams procedures for students to give constructive

feedback to their team members; 5) evaluating teams during laboratory exercises on their work effort; 6) having students evaluate themselves; 7) requiring students to organize portfolios, and 8) interviewing students about their feelings on the assessment used to evaluate laboratory reports. Details of these changes are as follows.

1) and 2) Changes in Possible Points For Laboratory Reports and Extra Credit

The decision to increase the point value of the laboratory reports was made because the students were expected to do a lot of work for each report. It was only fair that the total possible points to be earned reflect the required work. In 1995-1996 students could earn three points extra credit if one laboratory report was graded for the whole team and each team member had a completed report for the Initial and Final evaluation due dates. At the beginning of the 1996 school year we decided to increase extra credit to five points. The change was made to provide more incentive to individuals to work together in teams. After the first nine week grading period we decided we were discouraging team members who did not have completed laboratory reports for the Initial evaluation

day, but did have for the Final evaluation day. The rule was that all members had to have complete laboratory reports on Initial Evaluation to receive extra credit. We changed the rule so that if one report was graded for the whole team, but not everyone had a completed laboratory report on the Initial Evaluation day, then all team members earned three points extra credit.

3) Team Building Activities

Team building activities were added to help teams learn to communicate and work together toward a common goal. Two activities," NASA" and" Murder Mystery", were added to the curriculum. Students learned that each member provides a different point of view which can help to solve their tasks. Contact me if you are interested in copies of these activities.

4) Closing Team Feedback Sessions

My coworker and I added a closing team procedures at the end of each grading period. This was simply a time for team members to give positive and constructive feedback to each other. A detailed procedure on how to close a team can be found in Appendix (H).

5) Team Evaluations During Laboratory Exercises

As part of my research for the thesis I conducted team

evaluations. The evaluation form is in Appendix (H). I found it very difficult to do the evaluations because I was so busy during the class answering questions and moving around the room to visit each team. To find the time to step back and evaluate how well the teams were on task was hard. The team evaluations were for the purpose of this thesis only and will be discussed in the evaluation section.

6) Student Self Evaluations

At the completion of the 1996 semester I had each student complete a self evaluation (Appendix H). The questionnaire asked students to evaluate their team position and the consistency of their efforts. The results are discussed in the evaluation section.

7) Portfolios

During the 1995-96 school year the advanced biology teachers collected all student laboratory reports at the end of both semesters. We did not want them passed on to future students and we wanted to select a few to use for samples next year. When we collected the laboratory reports, they were in disorganized piles. This year I had the students create portfolios with their laboratory reports. The portfolio included a table of contents, laboratory reports, concept maps over terms learned in the laboratory exercises, an essay on one

chosen laboratory report, quizzes, team evaluations, self evaluation, and the final exam (Appendix H). The portfolio served as a tool to organize students before the final exam. The laboratory reports, concept map and the quizzes served as the most important review materials. After the final exam, I graded (Appendix H) and kept the portfolios.

Additional Time Saving Tools

As part of this study I improved the laboratory exercises and enhanced other time saving tools to grade the laboratory reports. I used grade sheets that outline the objectives that needed to be met for each part of the student laboratory report. Examples of the grade sheets are included with most of the laboratory exercises in the Appendix (See list of Appendices). The literature reveals that others use similar assessments in science and other subjects (Doran, 1993) (Doyle, 1996). I did not use the grade sheet format in other classes, and it took me twice as long to grade those reports. Next year I plan to develop grade sheets for all laboratory exercises in my scholars biology class.

Whenever there were data tables to grade I created spreadsheet programs (Appendix H) using Microsoft Excel. This

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allowed me to enter the student data and the program performed the calculations.

When students had graphs for their reports, they were required to develop the graphs by hand first then they were allowed to created computer generated graphs. Upon showing us the completed graph they were permitted to enter their team data into a Claris Works Spreadsheet that would generate color graphs. The computer generated graph was then compared to the student generated graph when the laboratory report was graded. The computer graphs made grading student graphs easier and saved time.

RESULTS

ANALYSIS OF COLLECTING ONE LABORATORY REPORT PER TEAM

Analysis of Third Hour Laboratory Exercise 1-4

The analysis was done to see if the laboratory report assessment was fair and valid. To find out, all student laboratory reports were collected and compared to the team laboratory report grade. Table 2 shows the scores earned by the individual students in my third hour class compared to their team score on laboratory reports. The team grade reflects the points earned on the collected laboratory report along with points that were added for students who earned extra credit and points that were deducted for students that lost points for not having completed laboratory reports on Initial or Final Evaluation days (Refer to Figure 2 for a summary of extra credit and the deduction of points). The difference column reflects the points gained by an individual whose own laboratory report score was lower than the team score. A negative number means the individual score was higher than the team score. When I calculated the total points that the students missed on their laboratory report I rounded any half points to whole points. For example it a student missed five and half points, I rounded it to six points off on the

Table 2: Third Hour Report Grade Comparisons on Exercise 1-4.

	Student ID Number	Score on Collected Report	Score on Individual Report	Difference Between Two Scores
TEAM 1:				
•	1A	NA	3	NA
	1B	23	19	4
	1C	32	27	4
Collected Report	1D	29	29	NA
TEAM 2:				
Collected Report	2A	27	27	NA
	2B	27	25	2
	2C	27	27	0
TEAM 3:				
Collected Report	3A	25	25	NA
	3B	25	28	-3
	3C	28	35	-7
	3D	25	25	0
TEAM 4:				
•	4A	NA	13	NA
Collected Report	4B	26	26	NA
	4C	26	24	2
TEAM 5:				
	5A	27	21	6
Collected Report	5B	27	27	NA
	5C	18	14	4
TEAM 6:				
	6A	28	31	-3
Collected Report	6B	28	28	NA
	6C	25	24	1
	6D	25	25	0
Total Points Possible on the Lab = 35				
Numbers Shown are Students Points Earned				
NA = Not Applicable				
• = Lab Report Not accepted by the team				
r obs. = .725, r .025 = .553, n = 13				

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ort. This rounding could have contributed to differences between team grade and individual grades in the teams.

The correlation coefficient was used to test significance ween the individual student laboratory report scores and the m laboratory report scores. The $r_{obs} = .725$, $r_{.025} = .553$ with n= There was a significant relationship between the individual and up scores.

alysis of Fourth Hour Laboratory Exercise 1-4

Table 3 shows the results on the same laboratory exercise for fourth hour class. The student with the ID of 1D did not turn in laboratory report. Because of this I was unable to fully evaluate ir report. They had been absent a lot and became disorganized, so nehow they lost their report when I requested it for further luations. Student 5B did not turn in a laboratory report. They eived a zero on their laboratory report, therefore there is no luation on that report. The $r_{obs} = .810$, $r_{.025} = .553$ with n= 13, ch showed that there was a significant relationship between the n and individual scores.

Table 3: Fourth Hour Report Grade Comparisons on Exercise 1-4.

	Student ID Number	Score on Collected Report	Score on Individual Report	Difference Between Two Scores
TEAM 1:				
Collected Report	1A	35	35	NA
	1B	32	26	6
	1C	23	19	4
	1D	23		
TEAM 2:				
	2A	32	33	-1
Collected Report	2B	32	32	NA
	2C	32	27	5
	2D	35	36	-1
TEAM 3:				
	3A	30	36	-6
	3B	27	26	1
	3C	27	27	0
Collected Report	3D	27	27	NA
TEAM 4:				
	4A	25	32	-7
Collected Report	4B	25	25	NA
	4C	25	33	-8
TEAM 5:				
Collected Report	5A	24	24	NA
	5B	0	0	0
	5C	15	10	5
	5D	24	18	6
TEAM 6:				
Collected Report	6A	19	19	NA
	6B	19	13	6
•	6C	NA	13	NA
Total Points Possible on the Lab = 45				
Numbers Shown are Students Points Earned				
NA = Not Applicable				
• = Lab Report not accepted by the team				
r obs = .810, r .025 = .553, n= 13				

alysis of Third Hour Laboratory Exercise 4-4

The second laboratory exercise analyzed was *4-4 The Effects of ht on Three Different Plants* (Table 4). This was a new oratory exercise developed in my research summer with Dr. Ken dler. Since this laboratory report required many tables and tistical analysis, it was worth 45 points while the first laboratory ort evaluated (Laboratory Exercise 1-4) was only worth 35 points. e $r_{obs} = .811$, $r_{.025} = .707$ with n= 8 showed that there was a nificant relationship found between the two scores. During the al Evaluation day two teams requested that all student laboratory orts be graded on their team. Students have this option if all oratory reports are unacceptable. In both cases the teams did not y understand the purpose and function of the Initial Evaluation , when students exchange laboratory reports for feedback from team members. It was clear to me that both teams did not fulfill requirements on the Initial Evaluation day. Discussions took ce with each team to clarify any misunderstandings on the ial/Final Evaluation day procedures.

Table 4: Third Hour Report Grade Comparisons on Exercise 4-4.

	Student ID Number	Score on Collected Report	Score on Individual Report	Difference Between Two Scores
TEAM 1:				
	1A	50	47	3
Collected Report	1B	48	48	NA
	1C	51	40	11
	1D	48	40	8
TEAM 2:				
	2A	33	40	-7
	2B	33	34	-1
Collected Report	2C	36	36	NA
TEAM 3:				
•	3A	NA	35	NA
•	3B	NA	34	NA
•	3C	NA	40	NA
•	3D	NA	32	NA
TEAM 4:				
	4A	WITHDREW FROM CLASS		
	4B	36	40	-4
Collected Report	4C	39	39	NA
TEAM 5:				
	5A	23	19	4
Collected Report	5B	32	32	NA
	5C	32	31	-1
TEAM 6:				
•	6A	NA	23	NA
•	6B	NA	16	NA
•	6C	NA	34	NA
•	6D	NA	19	NA
Total Points Possible on the Lab = 45				
Numbers Shown are Students Points Earned				
NA = Not Applicable				
• = Lab Report not accepted by the team				
r obs = .811, r .025 = .707, n= 8				

lysis of Fourth Hour Laboratory Exercise 4-4

The analysis of the fourth hour 4-4 laboratory reports are nmarized in Table 5. A correlation coefficient test comparing ividual scores to team scores found $r_{obs} = .422$, $r_{.025} = .632$ with 10. There was no significant relationship between team scores d individual scores. Individual 3A shows a 16 point reduction in score due to the fact that his individual laboratory report was t much better than the team laboratory report collected. viously 3A did not accurately or honestly evaluate report 3B, the lected laboratory report for the team, on the Initial Evaluation y. Student 3A concluded that 3B had a complete laboratory report, t 3B did not answer the questions as well as 3A. In this type of uation, as long as students have accurately graded laboratory orts during Initial and Final Evaluations and corrections were de, a laboratory report may be collected separately for a grade. no report will receive extra credit, in this situation, unless they e typed. When the extreme set a data for individual 3A was oved from the calculation, then $r_{obs} = .743$, $r_{.025} = .666$ with . This correlation was a positive relationship. Persons 1C and 1D

Table 5: Fourth Hour Report Grade Comparisons on Exercise 4-4.

Fourth Hour Lab Exercise 4-4				
	Student ID Number	Score on Collected Report	Score on Individual Report	Difference Between Two Scores
TEAM 1:				
•	1A	24	24	NA
•	1B	30	30	NA
No Lab Report	1C	0	0	NA
No Lab Report	1D	0	0	NA
TEAM 2:				
	2A	MOVED TO TEAM FOUR		
Collected Report	2B	47	47	NA
	2C	50	38	12
	2D	50	43	7
TEAM 3:				
	3A	32	48	-16
Collected Report	3B	29	29	NA
	3C	29	33	-4
	3D	29	32	-3
TEAM 4:				
Collected Report	2A	40	40	NA
	4B	40	37	3
	4C	40	39	1
TEAM 5:				
Collected Report	5A	33	33	NA
	5B	36	29	7
	5C	33	26	7
	5D	33	25	8
TEAM 6:				
•	6A	27	27	NA
•	6B	0	0	NA
No Lab Report	6C	0	0	NA
Total Points Possible on the Lab = 45				
Numbers Shown are Students Points Earned				
NA = Not Applicable				
• = Lab Report not accepted by the team				
r obs = .422, r .025 = .632, n= 10				

l not turn in laboratory reports because of their many absences. ey were overwhelmed with making up the several laboratory ercises.

alysis of Third Hour Laboratory Exercise 4-1

The last evaluation was done on *4-1 Comparison of Two Seed ability Tests.* This laboratory exercise was not new to the rriculum. A summary of the Third Hour laboratory report scores n be found in Table 6. The r_{obs} = .393, $r_{.025}$ = .532 with n= 14 owed that there was no significant relationship between the team ores and the individual scores. Team three had a laboratory report aded that hurt all team members laboratory report grade. This ggests that team members did not accurately evaluate the oratory report, during the Final Evaluation day, for corrections it were to be made.

alysis of Fourth Hour Laboratory Exercise 4-1

Table 7 shows the results of the fourth hour Exercise 4-5 ort scores. When a correlation coefficient was calculated on the m score compared to the individual score the r_{obs} = .906, $r_{.025}$ = 2 with n= 10. There was a significant relationship between the

Table 6: Third Hour Report Grade Comparisons on Exercise 4-1.

	Student ID Number	Score on Collected Report	Score on Individual Report	Difference Between Two Scores
TEAM 1:				
	1A	32	33	-1
Collected Report	1B	29	29	NA
	1C	32	30	2
	1D	29	32	3
TEAM 2:				
	2A	32	31	1
	2B	32	25	7
Collected Report	2C	35	35	NA
TEAM 3:				
	3A	30	37	-7
	3B	21	26	-5
	3C	33	38	-5
Collected Report	3D	21	21	NA
TEAM 4:				
Collected Report	4B	39	39	NA
	4C	39	33	6
TEAM 5:				
	5A	31	29	2
Collected Report	5B	31	31	NA
	5C	31	28	3
TEAM 6:				
Collected Report	6A	34	34	NA
	6B	34	33	1
	6C	31	28	3
	6D	31	28	3
Total Points Possible on the Lab = 35				
Numbers Shown are Students Points Earned				
NA = Not Applicable				
r obs = .393, r .025 = .532, n= 14				

Table 7: Fourth Hour Report Comparisons on Exercise 4-1.

	Student ID Number	Score on Collected Report	Score on Individual Report	Difference Between Two Scores
TEAM 1:				
Collected Report	1A	23	23	NA
	1B	20	15	5
•	1C	NA	4	NA
	1D	20	18	2
TEAM 2:				
	2A	MOVED TO TEAM FOUR		
	2B	32	38	-6
	2C	35	36	-1
Collected Report	2D	35	35	NA
TEAM 3:				
	3A	29	32	-3
•	3B	NA	10	NA
•	3C	NA	20	NA
Collected Report	3D	26	26	NA
TEAM 4:				
	2A	25	20	5
	4B	34	32	2
Collected Report	4C	34	34	NA
TEAM 5:				
	5A	36	36	0
	5B	33	33	0
Collected Report	5C	33	33	NA
	5D	33	27	5
TEAM 6:				
Collected Report	6A	29	29	NA
No Lab Report	6B	0	0	NA
No Lab Report	6C	0	0	NA
Total Points Possible on the Lab = 35				
Numbers Shown are Students Points Earned				
NA = Not Applicable				
• = Lab Report not accepted by the team				
r obs = .906, r .025 = .632, n= 10				

scores and the individual scores.

One cannot ignore the obvious differences between some team individual scores and group scores (See tables 2-7). Students gained as much as eleven points or lost as much as sixteen points when another team member's laboratory report was graded for the team. I believe students allowed unacceptable laboratory reports to represent them because they wanted the available extra credit. They did not realize that the extra credit did not help if the laboratory report chosen for a grade was a bad report. Another reason laboratory reports not representative of a whole team were included when collecting team reports could be peer pressure. This will be discussed in the survey evaluation.

Comparison Between Student Laboratory Report Scores and Quiz Scores

Student laboratory report scores were compared to quiz scores to again make sure that the assessment tool was fair and valid (Table 8 and 9). The comparison was made to ascertain whether students were performing exceptionally higher on their quiz score compared to their laboratory report scores. In the third hour class, most students performed about the same or worse on their quiz than on

Table 8: Third Hour Laboratory Report Grades Compared to Quiz Grades.

ID	LAB		QUIZ	
	Percent	Grade	Percent	Grade
1A	62%	C-	78%	B-
1B	79%	B-	75%	B-
1C	97%	A	61%	C-
1D	91%	A-	76%	B-
2A	82%	B	64%	C-
2B	51%	D-	50%	D-
2C	86%	B+	68%	C
3A	65%	C	66%	C
3B	72%	C+	66%	C
3C	88%	B+	93%	A-
3D	56%	D	52%	D
4A	WITHDREW			
4B	82%	B	90%	A-
4C	91%	A-	52%	D
5A	72%	C+	42%	F
5B	76%	B-	85%	B+
5C	57%	D	54%	D
6A	78%	B-	60%	C-
6B	57%	D	67%	C
6C	76%	B-	54%	D
6D	72%	C+	63%	C-

laboratory report. Three students had better quiz scores than laboratory report scores, 1A, 3C, and 4 B.

Student 1A had a problem getting his laboratory reports completed when due. His quiz score indicates that he understood the concepts in the laboratory exercises, but his laboratory report score indicates he was unable or unwilling to organize information into a scientific report. This was supported by three responses to 1A's self evaluation results (Table 10) which were not anonymous. 1A responded "sometimes" to the following statements: "I asked my

Table 9: Fourth Hour Laboratory Grades Compared to Quiz Grades.

ID	LAB		QUIZ	
	PERCENT	GRADE	PERCENT	GRADE
1A	82%	B	80%	B
1B	74%	C+	80%	B
1C	26%	F	53%	D
1D	39%	F	52%	D
2A	68%	C	72%	C+
2B	95%	A	85%	B+
2C	72%	C+	45%	F
2D	90%	A-	64%	C-
3A	80%	B	77%	B-
3B	49%	F	44%	F
3C	68%	C	53%	D
3D	66%	C	66%	C
4A	WITHDREW			
4B	59%	D+	67%	C
4C	83%	B	67%	C
5A	83%	B	75%	B-
5B	50%	D-	62%	C-
5C	63%	C-	50%	D-
5D	75%	B-	50%	D-
6A	74%	C+	68%	C
6B	22%	F	32%	F
6C	21%	F	46%	F

team for help when I needed it," "I asked the teacher for help when I needed it," and "I worked hard to meet the Initial and Final Evaluation dates." Of the eight laboratory reports collected during the first semester, I graded 1A's laboratory report separately more than once. During an interview, 1A said he liked getting team feedback during the Initial Evaluation day, but felt there were communication problems in his group.

Student 3C was a very bright student with the capacity to do better on his laboratory report score, but he allowed poor laboratory

reports to be included in the team's representative laboratory reports almost every time. This individual was the leader of the group but comments in their self survey indicated that he did not always make sure the team understood the goal at hand. Student 3C responded "sometimes" to the following statements: "I made sure everyone in my group understood how to do the laboratory work," and "I included everyone in team discussions." When interviewed 3C said "everyone relies on one person to get the laboratory done and there is a fear of leading people to the wrong answer." This person did like receiving feedback during Initial Evaluation sessions but felt that some points should be given for having complete laboratory reports on the Initial Evaluation day.

Student 4B did not come in for an interview. This student was also bright but had trouble with communication since he was an exchange student. I did not understand why his laboratory score was less than his quiz score. This student worked with only one other student for most of the second quarter and they seemed to work well together. As seen in table 7, 4B got a B on laboratory report score and an A- on their quiz score, while 4C, 4b's partner mention above, got an A- on laboratory average and a D on their

quiz score. Student 4B responded "sometimes" to questions 2,3,5,6,7 as seen in table 10.

When laboratory scores were compared to quiz scores for fourth hour (Table 9) five individuals did better on their quizzes than on their laboratory reports, 1B, 1C, 1D, 4B, 5B. Most of the other students got the same grade or did worse on the quiz. Student 1B was a hard working student during the first nine weeks but his work effort declined in the second nine weeks. This student responded sometimes to the following statements on their self evaluation (Table 11): "I helped the other members of my group learn," and "I included everyone in team discussions." When interviewed 1B said in response to what they did not like about groups: " if someone in your group doesn't complete their work or there are people in the group that are absent a lot..[it is hard] catching them up." It is true this individual had to deal with inconsistent group members. This individual also said in the interview that they like working in groups because " when you do not understand something, there are people to explain and [people] to share the work." Student 1B liked the Initial Evaluation days for feedback on their report, but he thought the individuals should be able to pick their own groups.

Student 1C also did better on their quiz score than on laboratory report score. This individual was very ill and missed a lot of school. They had a difficult time keeping up with the laboratory reports. This individual liked the class , but he earned a D score on the quizzes and he did not have the time or energy to complete the reports. This explains the F score on the laboratory reports. This individual did not take advanced biology second semester since he realized the demands of the class. Student 1C answered "sometimes" to all but question 2 on his self evaluation. When interviewed this individual said he liked getting help from his teammates but " sometimes two people would pair off and work on an assignment and isolate others or people would not work and assume others would take care of them."

The third person that had a better quiz score was 1D. This individual missed several days also. This individual could do excellent work on his laboratory reports, I found out in the second semester, but during the first semester he was not in the "game." This was supported by responses to his self evaluation. 1D responded "sometimes" to the following statements: " I summarized all our team ideas and information," "I helped the other members of

my group learn," " I made sure everyone in my group understood how to do the laboratory work," and "I worked hard to be done for Initial and Final Evaluation dates." This individual did not work up to their potential, which hurt the other group members as seen in 1B and 1C. Student 1D was not interviewed.

Lastly, 5B did worse on their laboratory score than on their quiz score. This individual did not complete laboratory reports. No matter what team he was in or how much pressure the team applied, he would not turn in laboratory reports. Student 5B responded "sometimes" to the following self evaluation questions: 2,3,5,6,7,8 and they did not answer question 9. When interviewed 5B said they liked to work in groups "to help each other, but one person might be doing more work than others."

Student Self Evaluations

Tables 10 and 11 summarize the results of the self evaluation surveys given to students in the third and fourth hour advanced biology classes to evaluate their cooperation in their teams. I requested student's ID numbers so that I could relate self evaluations to the laboratory report scores. As a result, students may not have been completely honest in their answers. Students

were informed that their responses would not affect their grade. I was surprised by the lack of people choosing "never" as their response to some of the questions. Most students circled always, sometimes or between always and sometimes for all questions.

Assuming students were honest the responses from the students earning As and Bs were what I expected. The responses to number 10 surprised me the most. Three A or B students "sometimes" worked hard to complete their laboratory report for the Initial and Final Evaluation due dates. To have earned an A or B those students should have "always" had to work hard. The students that were earning a D or F answered "always" or "sometimes" to all but one statement. I expected more "nevers" circled for this grade range.

Team Evaluations

To monitor team participation during laboratory exercises I evaluated them based on a number scale. If all members were working efficiently the team received three points. If the team was not working together or wasting time they received 1. These points did not affect any grade, but were used for the purpose of this study only. Most teams received a 3 when during the exercises.

Table 10: Results of Third Hour Self Evaluations.

ID Number	1. I contribute my ideas and information.	2. I asked others for their ideas and information.	3. I summarized all our team ideas and information.	4. I asked my team for help when I needed it.	5. I asked the teacher for help when I needed it.	6. I contributed my ideas and information.	7. I helped the other members of my group learn.	8. I made sure ..... group understood how to do the lab work.	9. I included everyone in team discussions.	10. I worked hard to be done for Intial/Final Evaluations.
1A	A	A	S	S	S	A	S	S	S	S
1B	A/S	A/S	S	A/S	S/N	A	A/S	S	A/S	A/S
1C	A/S	A	S	A	A	A/S	A	A	A	A
1D	A	S	S	A	A	A	S	S	A	A
2A	A	S	A	S	A	A	A	S	S	A
2B	S	S	N	A	S	S	S	A	A	A
2C	S	S	S	A	A	S	A	A	S	S
3B	A	S	A	S	A	A	A	A	A	A
3C	A	S	A	S	A	A	A	S	S	A
3D	A	A	S	A	A	S	S	S	S	S
4B	S	S	S	A	S	S	S	A	A	A
4C	A	A	S	A	A	A	A	A	A	
5A	S	A	S	A	S	S	A	S	A	S
5B	A	A	S	A	S	A	S	A	A	S
5C	A	A	S	A	S	S	S	S	S	S
6A	A	S	S	A	S	S	S	S	S	S
6B	A	A	A	A	A	A	A	A/S	A	S
6C	A	S	S	A	A	A	S	A	A	A
6D	S	A	S	A	S	A	S	S	A	S
A= Always										
A/S = Between always and sometimes										
S = Sometimes										
N= Never										

Table 11: Results of Fourth Hour Self Evaluations

ID Number	1. I contribute my ideas and information.	2. I asked others for their ideas and information.	3. I summarized all our team ideas and information.	4. I asked my team for help when I needed it.	5. I asked the teacher for help when I needed it.	6. I contributed my ideas and information.	7. I helped the other members of my group learn.	8. I made sure..... group understood how to do the lab work.	9. I included everyone in team discussions.	10. I worked hard to be done for Intial/Final Evaluation dates.
1A		S	A	S	A	S	A	S	N	A
1B		S	S	A	A	A	S	A	S	A
1C		A	S	S	S	S	S	S	S	S
1D		A	S	A	A	A	S	S	A	S
2A		S	S	A	S	A	A	A	A	A
2B		A	S	A	S	A	S	A	A	A
2D		A	S	A	A	A	A	A	A	A
3A		S	S	A	A	A	S	S	A	A
3B		S	N	A	S	S	S	A	S	A
3C		A	A	A	A	A	A	S	A	A
3D		S	S	A	A	A	S	S	A	A
4B		A	A	A	S	A	S	S	A	A
4C		A	S	A	A	S	S	S	A	S
5A		N	N	S	N	A	A	A	S	A
5B		S	S	A	S	S	S	S		A
5C		S	N	A	A	S	S	A	A	A
5D		A	A	A	A	S	S	A	A	S
6B		A	S	S	S	S	N	S	S	A
A= Always										
A/S = Between always and sometimes										
S = Sometimes										
N= Never										

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ANALYSIS OF STUDENT SURVEYS

In June of 1996 and January of 1997, I surveyed all the advanced biology students regarding their attitudes about the laboratory report assessment tool (Appendix H). The survey was to determine if the students thought the assessment was fair. In 1996, with eight sections of the advanced biology, 150 surveys were returned. This year (1997) with four sections 79 surveys were received. Since the number of students surveyed in 1996 and 1997 was different, a percentage of students was used for comparative purposes, unless otherwise noted.

Grade Level

As explained in the introduction, advanced biology has become a class taken mostly by sophomores.

Teachers

During the 1995-1996 school year three people taught advanced biology. All three teachers' classes were surveyed during the last week of the second semester. During the 1996-1997 school year two teachers taught the advanced biology classes. Both surveyed their classes at the end of the first semester.

Grades Earned

A summary of grades earned by students at the time of the survey is shown in Figure 3. All students that received an A, including A+, A- were grouped together. The same is true for the other grades. Grades were requested on the survey, so that comparisons could be made between the grades earned by the individuals and the comments they made about the assessment tool.

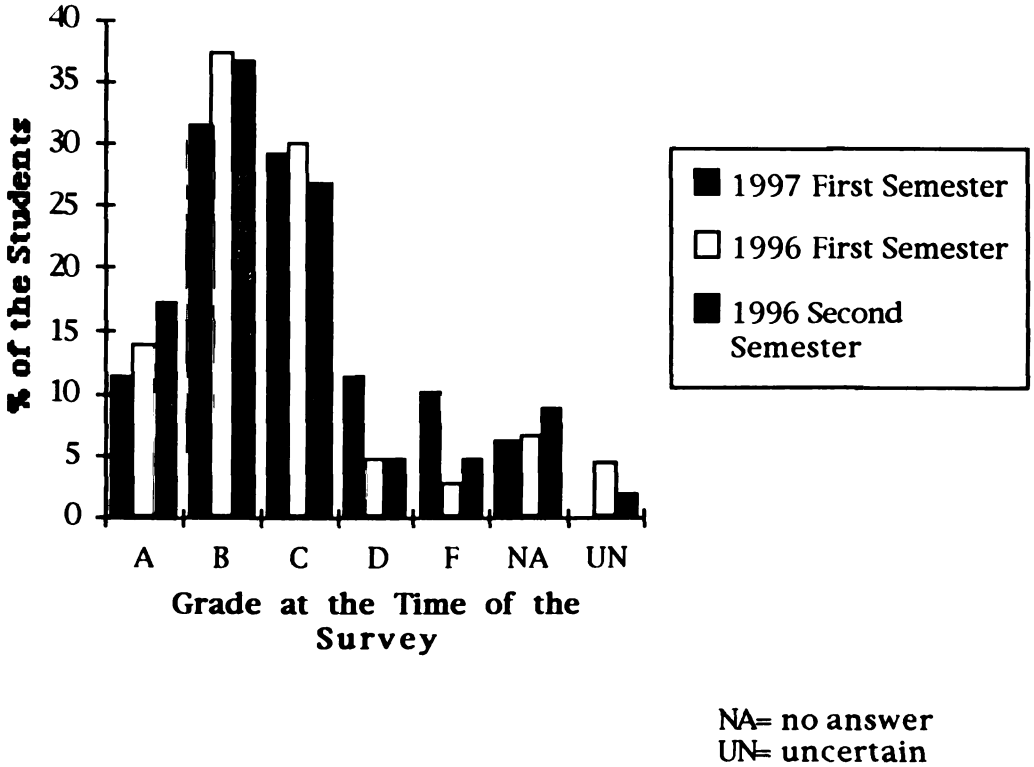


Figure 3: Percent of students receiving the different grades.

Question 1: I understood the Initial and Final Evaluation procedures.

It is clear that the majority of the students claim to understand the evaluation procedures (Figure 4). What is most disturbing is the small number that confessed they did not understand these procedures after 18 weeks of using them. In all graphs with a

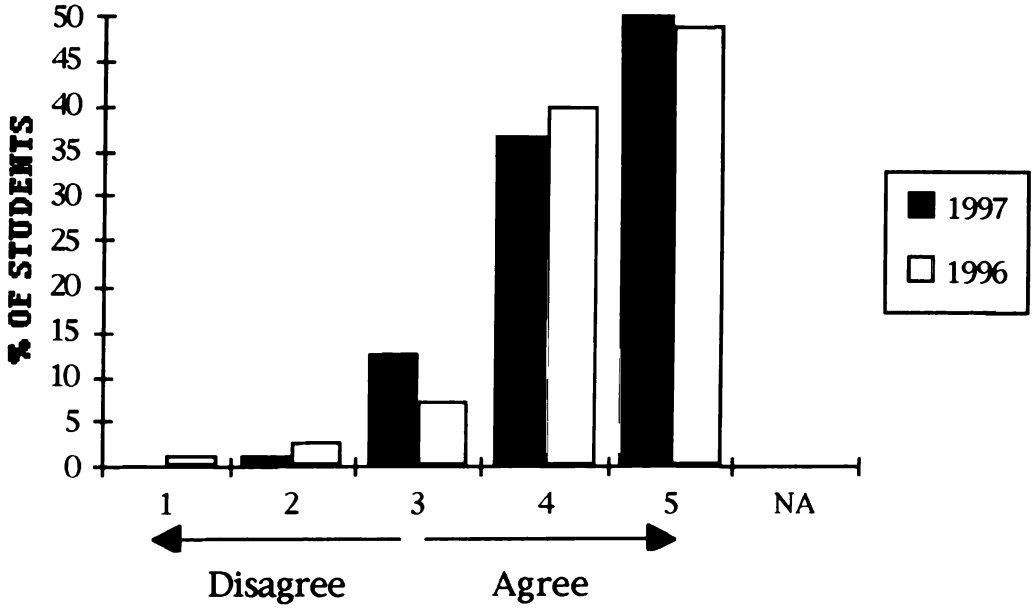


Figure 4: Percent responses for question one.

number scale of 1-5, "1" equals strongly disagree, "2" equals disagree, "3" equals neutral, "4" equals agree, "5" equals strongly agree and "NA" equals no answer. One student claimed to not understand the procedures in 1997 and he received an F for his semester grade. Of the six that claimed to not understand the evaluation procedures in 1996 two earned an A, three a B and one

with a D. It is not clear why these students did not learn these evaluation procedures. The students' understanding was not linked to a certain teacher or grade. Each teacher fully explained the Initial and Final Evaluation procedures.

Question 2: I accurately evaluated each laboratory for each member of my team during the Initial Evaluation

Question 3: I accurately evaluated each laboratory for each member of my team during the Final Evaluation.

Both in 1996 and 1997 a large percent of the students agreed to questions two and three (Figure 5).

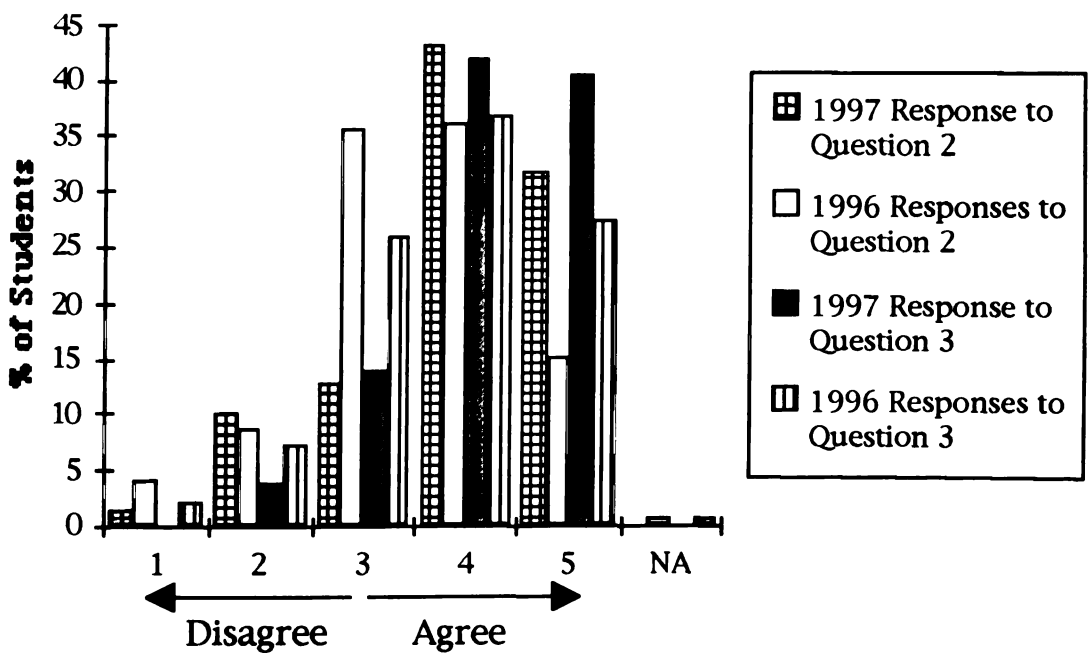


Figure 5: Percent of responses for question one and question two.

The following were some of the reasons students gave for not agreeing with questions 2 or 3: "everyone else on the team had looked at the laboratory so I just scanned it," "ran out of time," " I just copied what they had and never looked at their laboratory," and "no one cared." The most common response was "not enough time" to look over three laboratory reports. Generally 30 minutes were allotted for Initial Evaluations of laboratory reports. Students that understood the Evaluation procedures (agreed with question 1) agreed with questions two and three.

Question 4: Peer pressure is a factor when circling "done" or "not done" on laboratory reports.

More students felt peer pressure to accept their teammates laboratory report in 1996 than in 1997 (Figure 6). This item concerned me from the beginning, so when I presented the evaluation procedures I gave a speech about honesty. Overall, 40.6% of the students agreed with the statement that there was peer pressure in the 1996 school year. In 1997 only 25.4% said there was peer pressure when determining if laboratory reports were complete. What is surprising is more students getting good grades said no to the peer pressure question (Figure 7). In Figure 7 actual

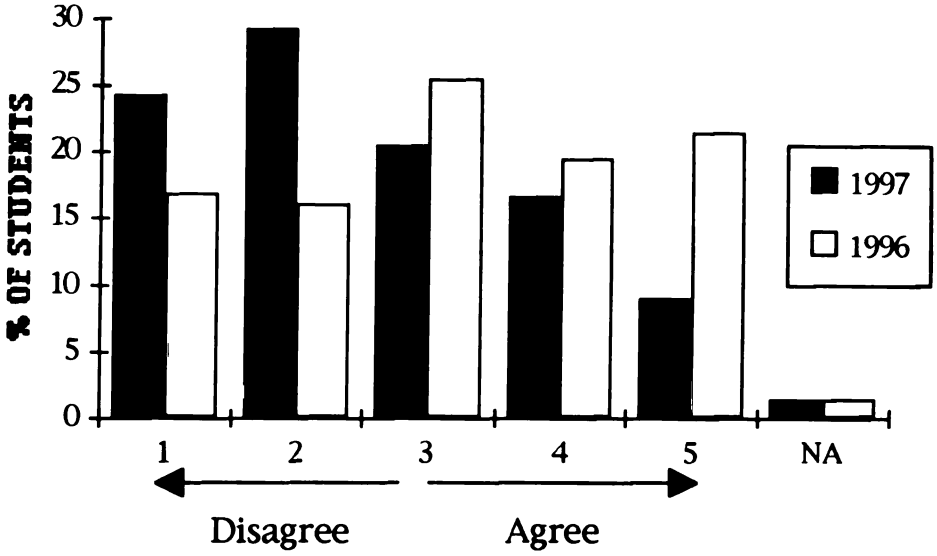


Figure 6: Percent responses for question four.

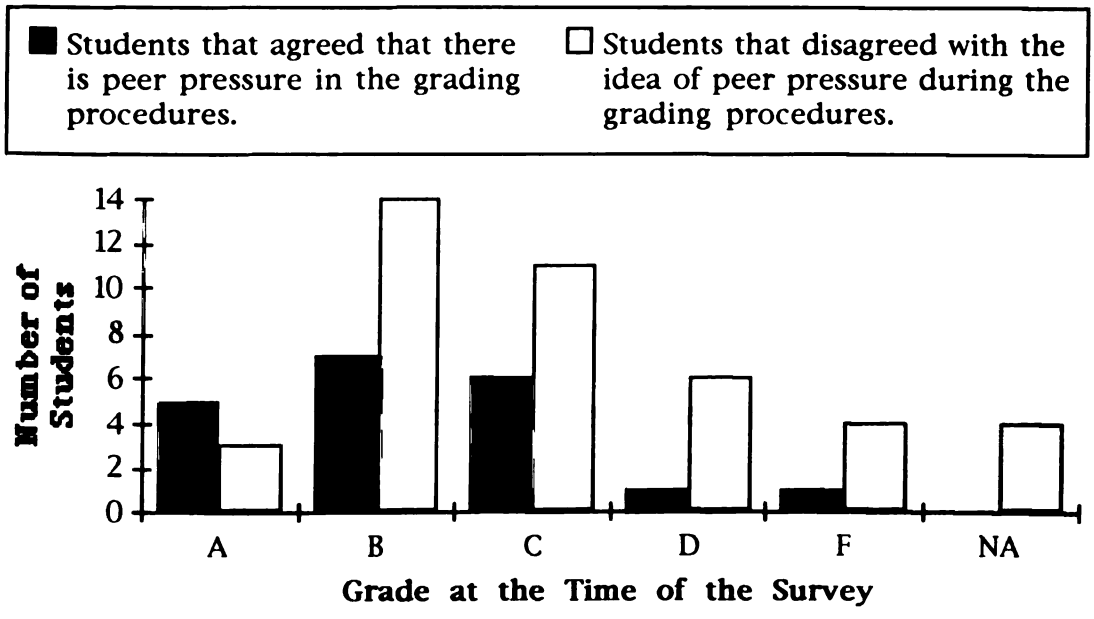


Figure 7: 1997 Grade distribution compared to answers to question 4

numbers were used since no comparison was made to the 1996 data.

Question 5: Did you ever circle "done" on a laboratory report that was not done? (Either in Initial or Final Evaluations)

The number of students covering for teammates decreased in 1997 (Figure 8).

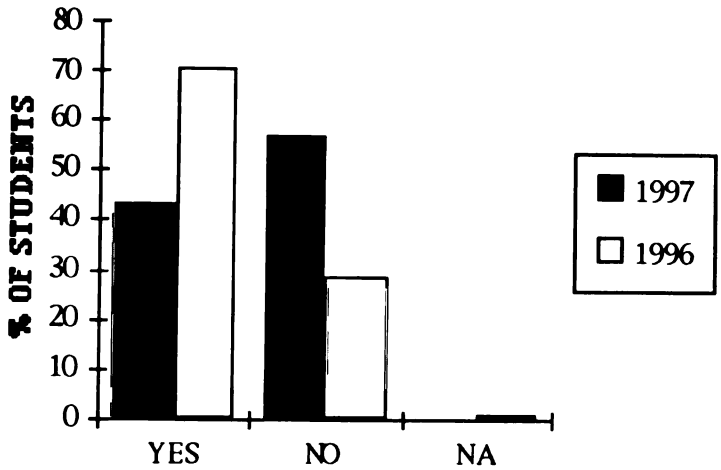


Figure 8: Percent responses to question five

One would not expect a team to allow incomplete laboratory reports because if an incomplete laboratory would have been collected for a grade the whole team would have lost 25% of their laboratory grade.

Why did students claim teammates were done with their laboratory reports when they were not? The results are presented in Figure 9. Figure 9 shows that extra credit was the main reason for covering up for incomplete laboratory reports in 1997. What this

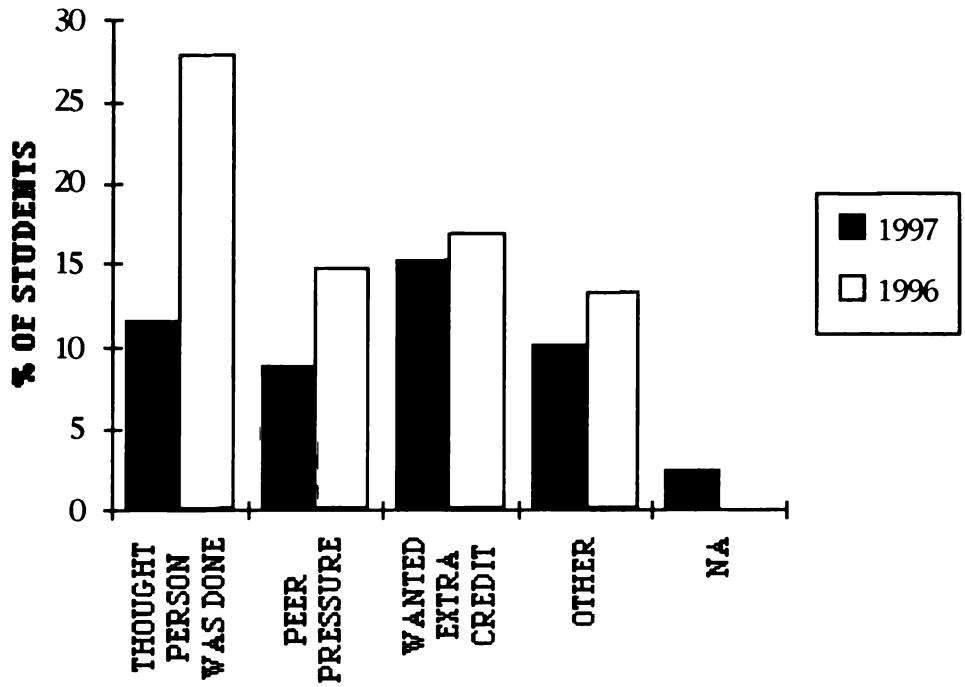


Figure 9: Reasons for responding yes to question five.

means is that the teams were willing to take the risk that a complete laboratory report would be collected and graded so they would get the extra credit. In a sense they were gambling.

Question 6: I made corrections that my team told me to make on my laboratory reports.

After laboratory reports were initially evaluated students had a day or two outside of class to make corrections (Figure 10). There was a place on the grade sheet used during Initial Evaluations where students initialed that they agreed to make teammate's suggested changes . This was incorporated to give the student a sense of responsibility to revise their laboratory report. Of all the students

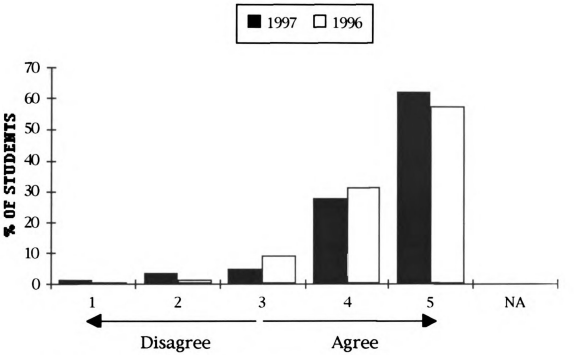


Figure 10: Percent responses to question six.

surveyed in 1996, 14 students were neutral to this question and 3 disagreed. In 1997, 4 students were neutral and 4 students disagreed. This data illustrates that students were willing to take team comments to heart and make the necessary changes to improve their laboratory report. The majority of the students interviewed liked receiving feedback on their reports from teammates. They liked the opportunity to make corrections that they would not have had if the laboratory report was turned in without an Initial Evaluation day. One student realized that "there were many points of view when analyzing laboratory reports". On several occasions students mentioned being uneasy telling

teammates that their work was poor or incomplete. I now point out that almost all students surveyed want feedback from their teammates.

We expected mastery learning to develop by giving students a second chance to turn in a good laboratory report. We hoped that more students would ask questions of their teammates and feel a sense of responsibility to do well on their laboratory reports. Analysis of the responses to survey questions 2, 3, 4, and 5 suggests that some students were taking advantage of the Initial Evaluation day, but responses to question six suggest they got serious by the Final evaluation day. Receiving feedback from teammates on Initial Evaluation day gave many students a second chance at doing well on their laboratory report.

Question 7: It is fair that everyone on the team gets the same grade on laboratory reports?

More students agreed with this statement in 1997 than in 1996, as shown in Figure 11. One major aspect of this study was to find out if the laboratory report assessments were fair and valid. The statistical analysis illustrates that the assessment is fair and the students agreed.

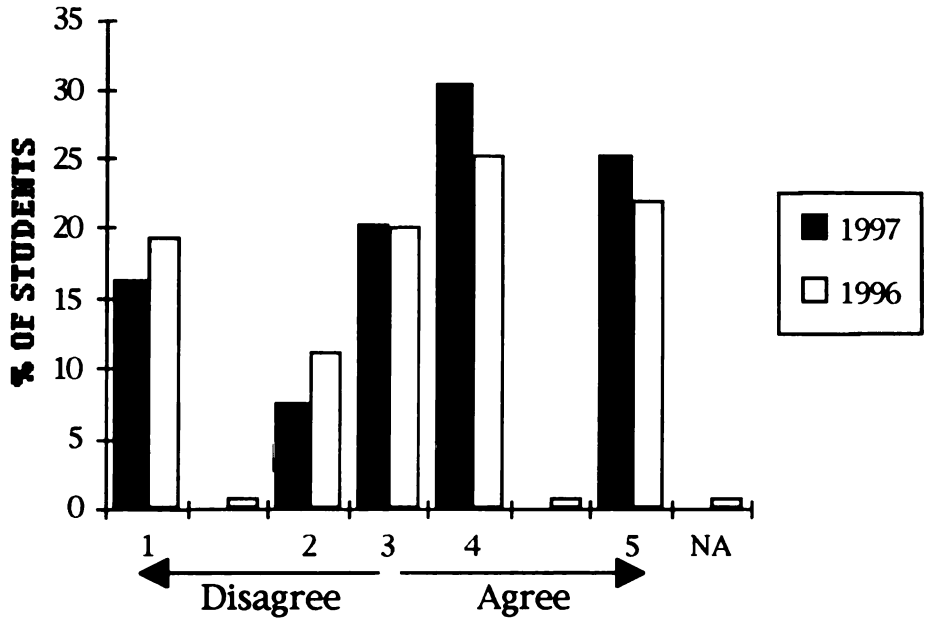


Figure 11: Percent responses to question seven

Figure 12 shows the grade distribution of the student responses for the 1997 students only. In this graph the actual numbers were used because I was not comparing 1997 data to 1996 data. Overall, students thought grading one laboratory report for a whole team was fair.

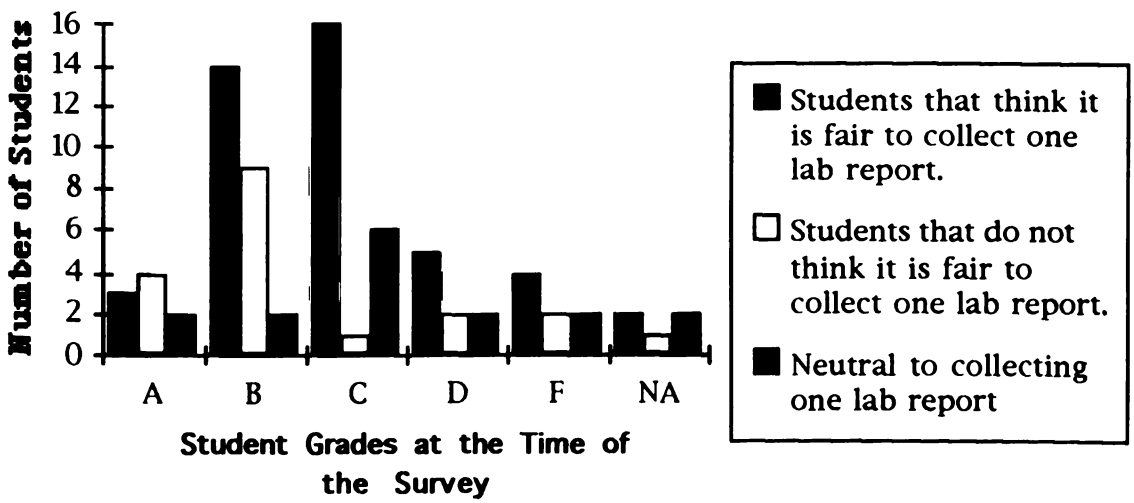


Figure 12: 1997 Grade distribution compared to answers to question seven.

Question 8: Having the opportunity to correct mistakes on laboratory reports improved my grade.
Question 9: It was easy to get along with team members for a nine week period.
Question 10: In general, working on teams to complete laboratory reports is helpful.
Question 11: In general, working alone on the laboratory reports would be better than teams.

Having the opportunity to correct mistakes was appreciated by most students. As seen in Figure 13, students believed that having time with their team for the Initial Evaluation of laboratory reports improved their grade. Most students became attached to their groups in a nine week period (Figure 14). The group members learned what to expect from their team. Students would prefer to work as part of a team compared to working alone (Figure 15 and 16).

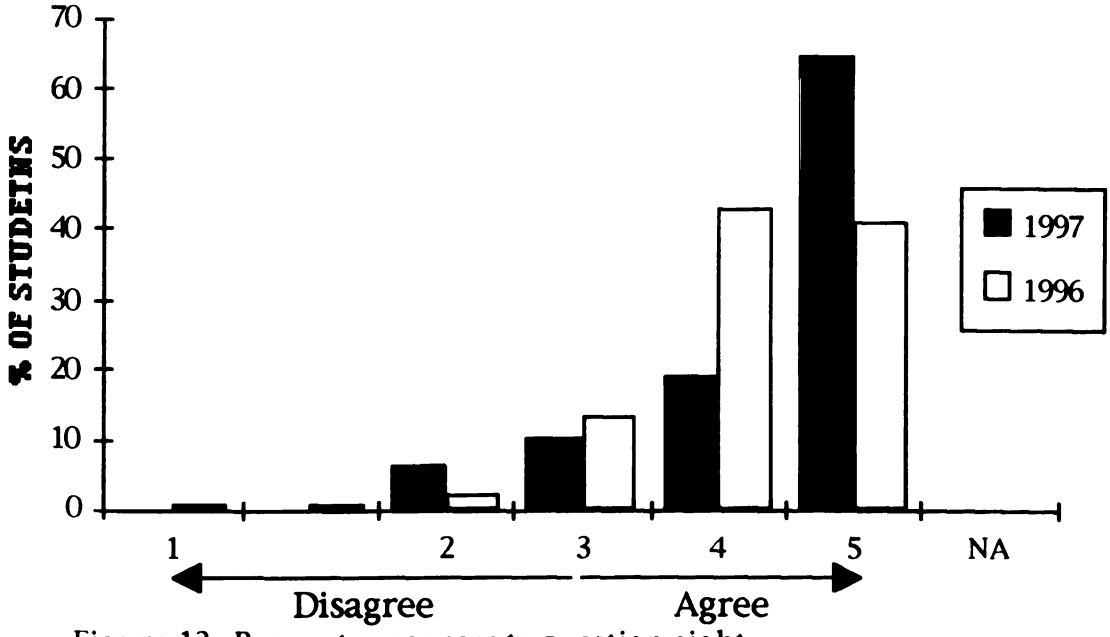


Figure 13: Percent responses to question eight.

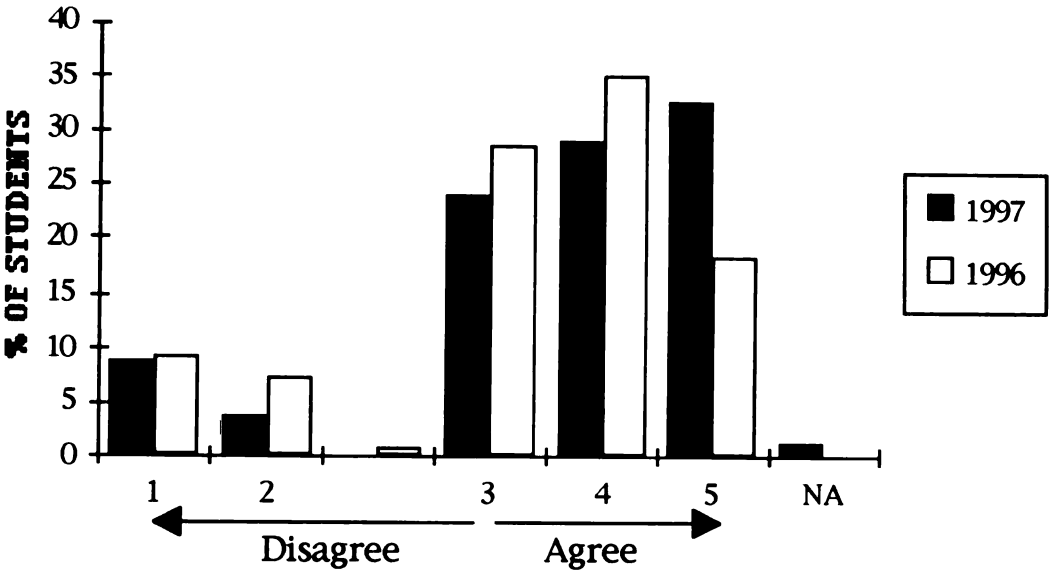


Figure 14: Percent responses to question nine

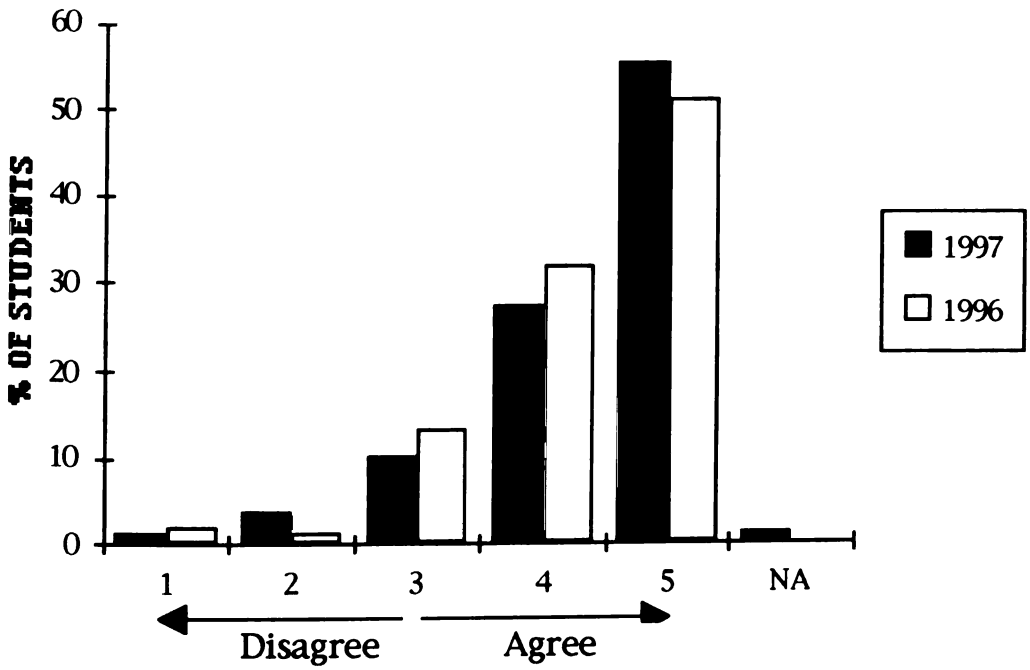


Figure 15: Percent responses to question ten

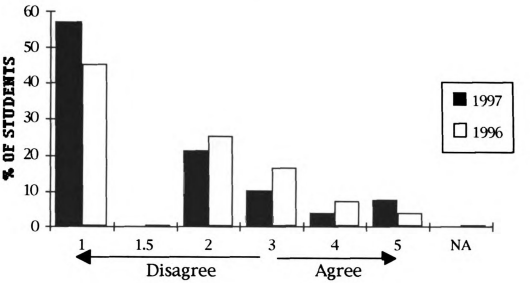


Figure 16: Percent responses to question eleven.

Question 12: I prepared for laboratory exercises before starting the laboratory procedure by reading background material, asking questions, and completing pre-laboratory activities.

Many times before a laboratory exercise no background information or a pre-laboratory activity was provided. Many students might have responded "neutral" to question 12, because they did not remember when they did have pre-laboratory activities (Figure 17). This year (1996-1997) the number of pre-laboratory activities increased.

Question 13: I helped set up labs, record results, measure data and clean up.

Figure 18 shows that the majority of the students helped out with laboratory procedures and clean up.

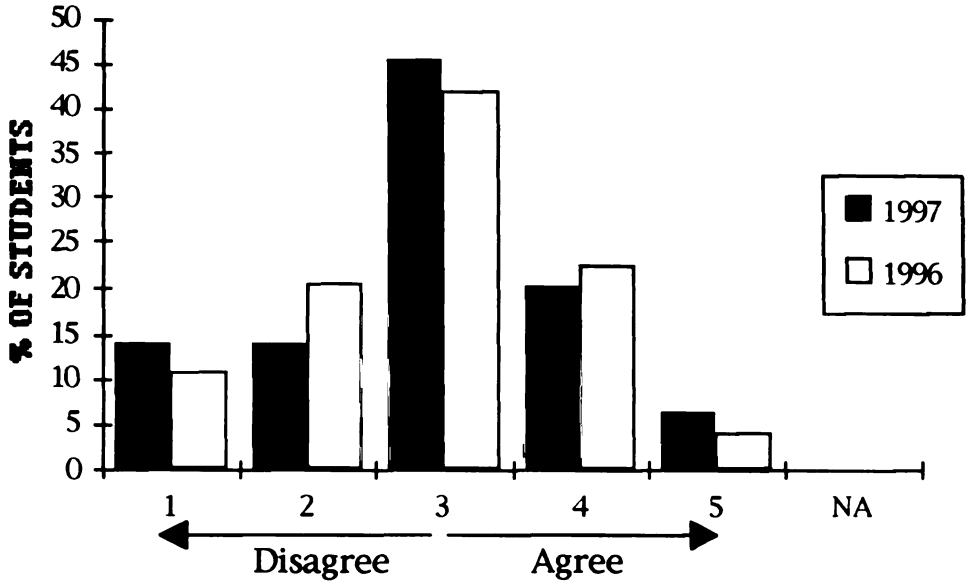


Figure 17: Percent responses to question twelve.

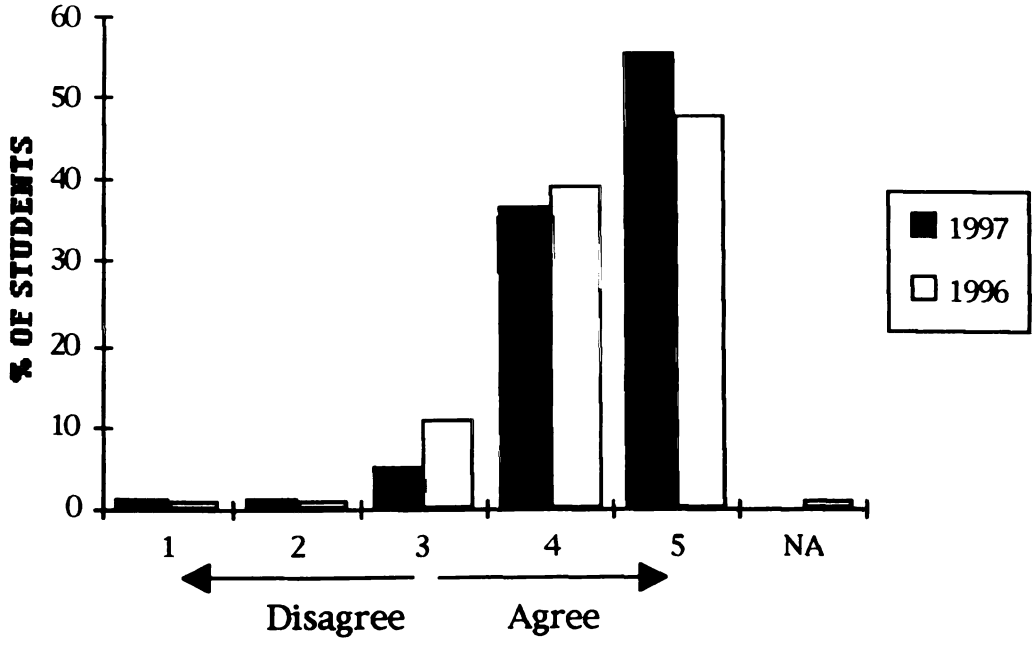


Figure 18: Percent responses to question thirteen.

Question 14: Did you write up each laboratory report once or more than once?

The majority of the students in 1996 and 1997 wrote up their laboratory report more than once. I asked this question to understand the time management of the students. Students, in my opinion, spend too much time rewriting their laboratory reports instead of trying to understand them.

Question 15: How do you best learn a concept in science? Rank the following ways to learn form 5 to 1. A 5 should be given to the most effective learning method and a 1 should be given to the least effective. (Lecture, Worksheets, Presentations, Group Work, and Labs)

During our school's Performance Based Accreditation study a committee surveyed students to see how they learned the best. I polled the advanced biology students to see if they would respond in the same way (Figure 19). Although presentations were not used in the advanced biology curriculum, students in the advanced biology feel they learn by this method. The worksheets were scored higher than the presentations. All worksheets used in the advanced biology classes were directly relevant to the study of the concept that was necessary for understanding the laboratory exercises. It was clear that students did not like lectures in a laboratory oriented class. There was very little time or need for lecture in the advanced

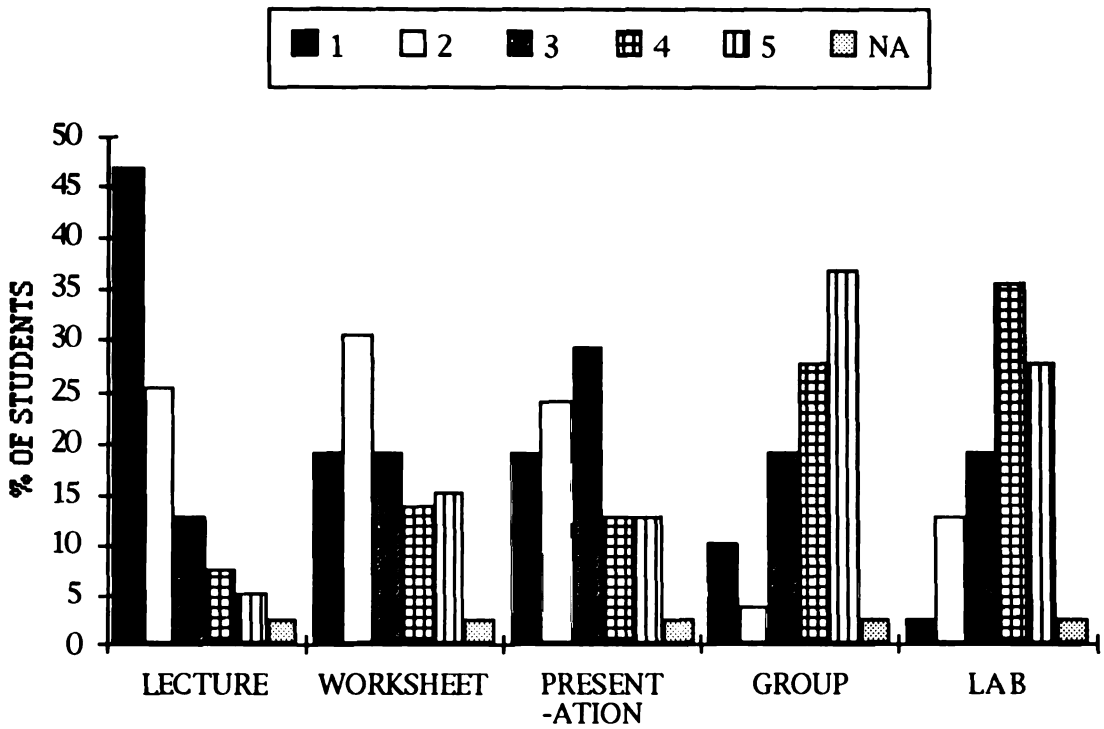


Figure 19: Percent responses to each learning method

biology classes except during the statistical unit. We relied on the information students learned in their Biology 1 and 2 classes.

Assessment Tool Evaluation Summary

The survey supported the notion that students preferred to work in groups (Figure 15 and 16) and they felt this was a good way to learn (Figure 19). Students liked receiving feedback on their laboratory reports, which was supported by student interview responses. They think it is fair to collect one laboratory report to grade for the team. The statistical analysis comparing the team scores and the individual scores supports the fairness of the assessment.

CONCLUSION AND SUMMARY

Reaction to New Laboratory Exercises

I was very pleased with the revised laboratory exercises and the new laboratory exercises used this past year. In all cases the laboratory protocols were an improvement from last year. I know many students enjoyed the new laboratory exercise *Enzyme Specificity and Digestive Disorders* because they wrote about it in their portfolio essay. Many students felt that it was a laboratory exercise they understood. Students also seemed to enjoy the new laboratory exercise *The Effects of Light on Three Different Plant Species.* Students could not wait to see their plants and to take care of them.

Future Directions

Laboratory Exercise 1-1: Yeast and A Relationship Between Food and Energy and *Laboratory Exercise 1-2: The Relationship Between Different Food Sources and Energy* both required students to take measurements after 24 and 48 hours. In the 8 block the first chance they will have to take their data is 48 hours. When I read about the design used by Reinking and Miller for fermentation and carbon dioxide collecting I realized our fermentation laboratory

protocols could be altered to enable us to complete them in one class period. Our results may not be as accurate but we should see a definite difference in measurements taken. Laboratory 1-4: Enzyme Specificity and Digestive Disorders was adapted from Reinking and Miller's laboratory of fermentation. The purpose of this laboratory exercise was to demonstrate to students that enzymes are specific and for us to see how effective the protocol for fermentation would be in an hour's time. We hope to repeat laboratory exercise 1 -4 next year but the melibiose sugar is expensive. We may cut back the concentrations used, have only one team use the melibiose sugar (which is what we did this year), or eliminate the sugar. If we eliminate the sugar, we will still use both enzymes. Students should see that one works and one does not. *Laboratory Exercise 1-3: The Relationship Between Temperature and Yeast Fermentation* will probably be moved to precede laboratory exercises 1-1 and 1-2, so students can see which temperature works best. Once they know the temperature that produces the most carbon dioxide they can conduct laboratory 1-1, 1-2, and 1-4 at that temperature. Laboratory 1-3 requires a 24 and 48 hour reading but students could come in the success period, a study hall where students may travel to different

classrooms to take measurements.

The respiration labs should work really well in an extended period. At this time no changes will be made to those labs. *Laboratory 4-4: The Effects of Light on Three Different Plant Species* will be used again, but its execution took a lot of class time this year. Next year we will cut back on the number of plants each team has and on the number of measurements they take. One of the main objectives in this exercise was to use statistics to show significant differences between growth under light and in dark conditions. Students do not require as many measurements as we took this year for successful analysis. *Laboratory 4-1: Comparison of Two Seed Viability Tests* will be done the same way if we use it. Again because of the time limitations we will not be able to do as many laboratory exercises as we have in the past.

Reaction to the Laboratory Report Assessment

Through this research I have found that the Initial and Final Evaluations are fair and valid assessments of students effort on their laboratory reports. When team report scores were compared to individual report scores, statistical analysis established significant relationships between the two sets of data in five cases out of six.

Most students agreed that the assessment including collecting one laboratory report per team was fair. During interviews students explained that they appreciated receiving feedback on their laboratory report before it was graded by the teacher. As seen in the attitude survey, they thought that having time to make the suggested changes to their laboratory report improved their grade.

Students need to understand the laboratory exercise well to effectively evaluate team member's laboratory reports. If a student does not understand what is required in their report, they learn by reading two other laboratory reports written by their teammates and by the comments they receive during the Initial Evaluation. Teachers choosing one laboratory report per team for a grade truly forces the team to work together. Group members want everyone to understand the laboratory reports because their grade is at risk if they do not. If each student's laboratory report was collected, students would only be accountable to themselves and they would not spend time helping each other. Our assessment is designed that no one should get a bad grade unless they choose to.

Opening and closing teams will become a permanent part of my class structure. Students need time to reflect and evaluate their

participation in their old team before they start out with a new team. This year I did not require students to make a commitment to their goals for the new team. Next year I hope to make students more accountable to the behaviors they say they are going to improve. Students could be given incentive points if one or more of their goals show up as a strength in their new team.

Changes to Improve the Laboratory Report Assessment

The parts of the Initial and Final Evaluations that need to be improved are negative peer pressure, the number of students who come to Initial Evaluation with an incomplete laboratory report, poor evaluation skills, and apathy. Peer pressure can be a good to an extent. If a team is strongly encouraging a teammate to complete their laboratory and do well, that is good. The student feels a commitment to others. But if students are pressuring teammates to cover for them when they have incomplete or sub par laboratory reports that is counter productive. To encourage students to be ready for the Initial Evaluation, I will collect all laboratory reports the class period before the Initial Evaluation and return the day of the Initial Evaluation. I will read through the laboratory reports and make sure all sections are present and circle "done" or "not done" on

the student grade sheet. The team would then decide what corrections need to be made on each member's laboratory report before the Final Evaluation. By picking up all laboratory reports before teams have time to evaluate the reports, student cannot finish their report during the Initial Evaluation. On Final Evaluation days I will check the laboratory reports that were not done on the Initial Evaluation day to see if they are now complete. The students will then be responsible for making clear constructive comments on each others' work and making sure all team members have complete and accurate reports for the Final Evaluation day. This should eliminate cheating and most of the negative peer pressure. Although there is a concern for cheating, the survey results show that it is lower than last year. Hopefully the new improvements will further discourage cheating.

To improve evaluating skills I am going to give sample labs and discuss the mistakes in the labs and how they can be improved. I tried this technique this year with copies of student laboratory reports without names. I would show laboratory reports with excellent answers to questions, discussion, or conclusion to give examples of what is expected.

Other changes to implement next year are to work on social skills, assign specific tasks to specific team members incorporate expert groups, and explain ways to disagree (Bellanca, 1991) in teams. I want to incorporate social skills in the team building process. Each week a different social skill will be the team focus as they interact. This should improve team communication. I am going to assign responsibility to individuals on each team to collect papers, to distribute equipment, collect data, etc. For example if I need data from each team, I would say that I need all the "threes" to come to the board and record their data. This will result in the teams sharing responsibility. To incorporate expert groups would be to put all the "one's" in a group, all the "two's" in another group, the "three's" in yet another group. This could be used to discuss the questions or possible sources of error. Students could share their knowledge with all teams instead of just their own. To encourage the positive aspect of disagreement we will illustrate that there is more than one way to see the data or laboratory protocol. I want students to be more aware of group dynamics and why they are occurring. Right now if there is a disagreement too many students shut down. They need to understand that it is good thinking to disagree and discuss their

differences.

How This Study is Affecting Other Classes

The Initial and Final Evaluation grade sheets helped reduce the amount of grading time so that I have started to design them for my scholars' biology class. The grade sheets enable me to stay focused on the objectives required in a good laboratory report and to be more consistent in my grading. Next year I hope to design grade sheets for any laboratory exercise I do for any class. Students also like the grade sheets to use as check off sheets to see if they have all the components for the completed laboratory.

APPENDIX

APPENDIX A

APPENDIX A

Outline of Units

Introduction:

1. Student Learning Styles
2. Student Personalities
3. Scientific Method
   - How to formulate a hypothesis
   - How to make graphs (Hand and Computer)
4. Team Building Activities

Unit One: Fermentation and Enzymes

5. Lab: Yeast and A Relationship Between Food and Energy
   (Fermentation with yeast and molasses)
6. Lab: The Relationship Between Different Food Sources and Energy
7. Lab: The Relationship Between Temperature and Yeast
   Fermentation
8. Lab: Enzyme Specificity and Digestive Disorders

Unit Two: Respiration

9. Lab: Respiration in Peas and Corn
10. Lab: Respiration in Crickets

Unit Three: Analysis of Data / Statistics

11. Random and Systematic Error
12. Discrete and Continuous Variable
13. Mean, Median, Mode
14. Standard Error
15. Probability
16. t test
17. chi-square

Unit Four: Plant Physiology

18. Lab: The Effects of Light on Three Different Plants
19. Lab: Testing For Seed Viability

Unit Five: Review Genetics / Forensics

20. Lab: Human Blood Types (Including the Rh Factor)
21. Lab: Urinalysis
22. Lab: PTC Test (Hardy Weinberg)
23. Lab: Gene and Genotype Frequencies in Successive Generations

APPENDIX A

24. Lab: Gene and Genotype Frequencies in Successive Generations if Natural Selection Favors Dominant Allele
25. Lab: DNA Profiling

Unit Six: Mitosis and Meiosis

26. Lab: Relative Lengths of Mitotic Stages in Onion Root Tip
27. Lab: Meiosis with Insect Chromosomes

Unit Seven: Genetics with Fruit Flies

28. Lab: Identifying *Drosophila* Characteristics and Preparing Stock Cultures
29. Lab: *Drosophila* Study of Autosome and Sex Chromosome Traits
30. Lab: *Drosophila* Study of the Observed and Expected Ratios of Two Trait Crosses
31. Lab: The Preparations of Human Chromosome Slides for Pictures and the Study of Human Karyotypes

APPENDIX B

Steps Used in Every Lab

1. Define Problem

2. Collect information relating to the problem

3. Form a Hypothesis
    - •Tentative explanation which tries to explain the past and predict the future. ex. light switch

    - •If (condition) ..... then....(prediction).....

4. Experiment
    - •Only one variable
    - •control and experimental groups
    - •once collected must be put in form to make the most sense of the data (graph, tables, charts)
5. Make a Conclusion
    - •Do you accept or reject your hypothesis

APPENDIX B

Quiz 1 - Science Methods Name:_____

Directions: Answer the following questions as true or false.

1. T or F A good experiment has more than one variable.

2. T or F Scientists can prove hypotheses to be true.

3. T or F Scientists can disprove hypotheses.

4. T or F It is bad to reject a hypothesis.

5. T or F A control is used for a comparison.

6. T or F Observations are part of the scientific method.

7. T or F Every questions can be answered scientifically.

Directions: Read the following experiment, then answer the following questions about the experiment.

Four students wanted to find out what happens to the heart rate of pike fish when they are placed in near freezing water. The students set up a tank with a near freezing temperature and feed all the fish the same food in the same amount at the same time. Last the students decide to observe the heart rate for 60 minutes after the fish has been placed into the tank.

8. What is the problem?

9. Make one hypothesis that could be tested for this experiment.

10. What is the control in this experiment?

APPENDIX B

Quiz 2 - Graphing Name:_____

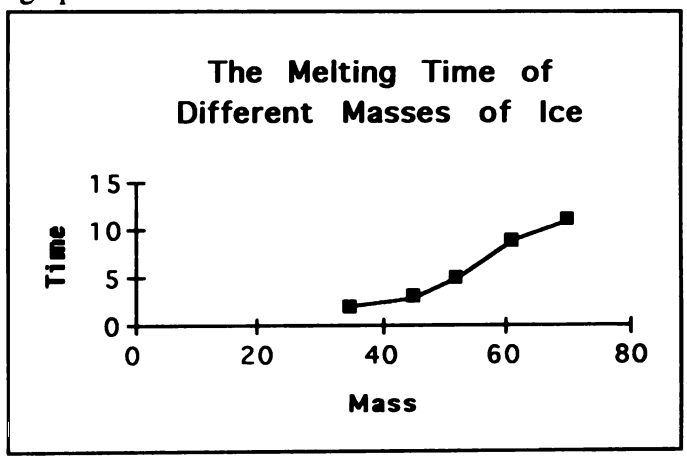
Directions: Complete the following statement about graphing variables.

_____1. The _____ variable is the unit that is controlled in the _____ experiment. The _____ variable cannot be controlled.

Directions: Determine what is wrong with the following graphs. If nothing is wrong then state that nothing is wrong with the graph.

_____

_____2.



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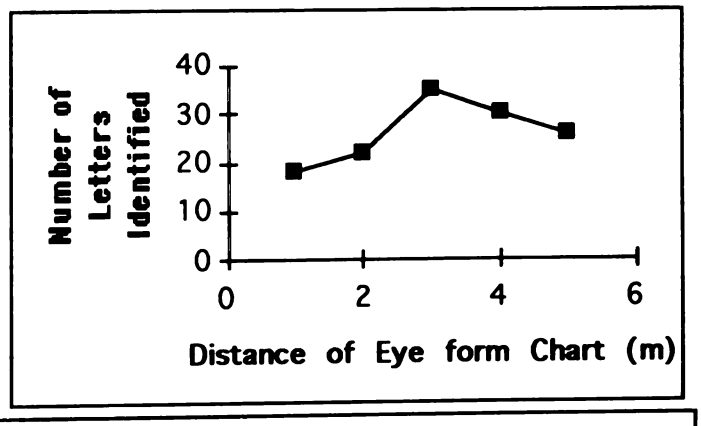
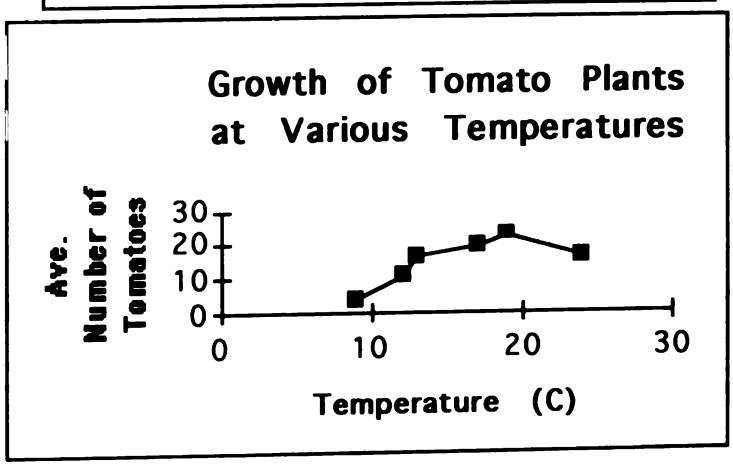
_____3.



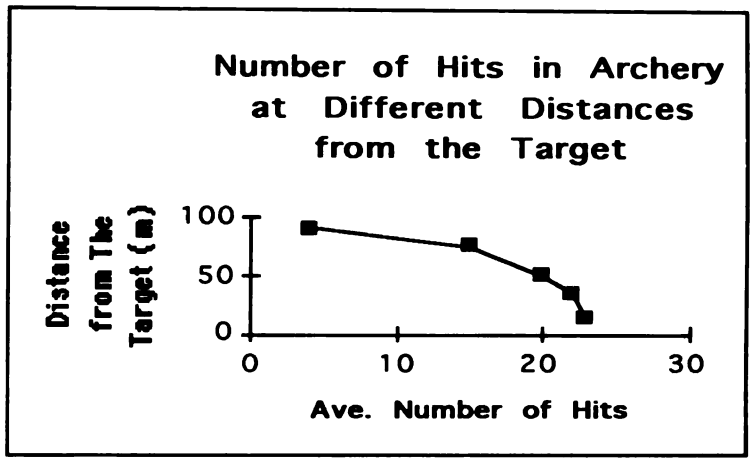
_____

_____4.

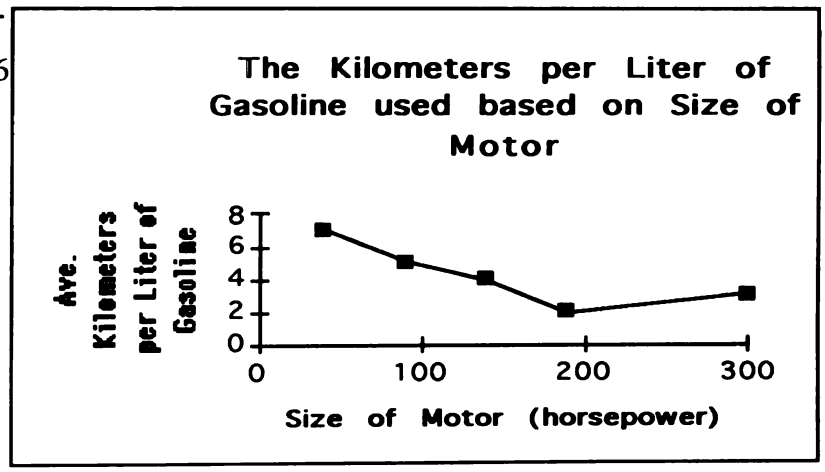


APPENDIX B

5.



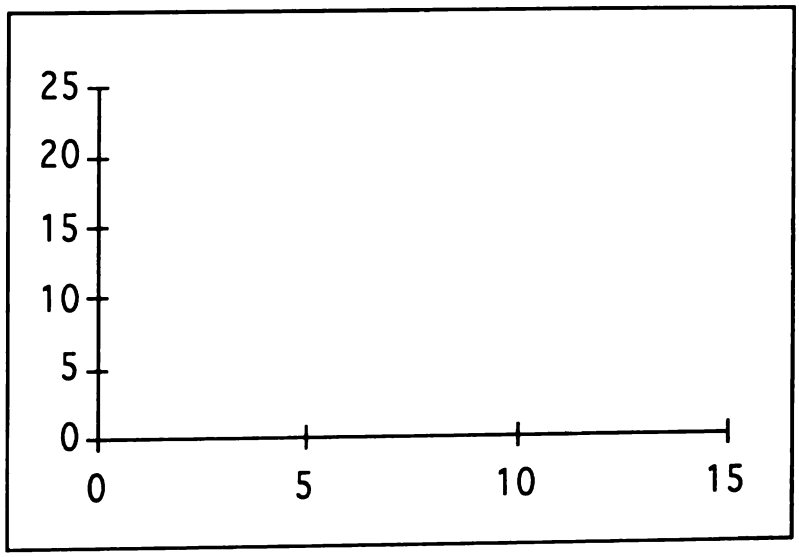
6



Directions: Graph the following data. Be sure to include all relevant information.

7.
Electricity Bill ($):
10, 12, 16, 22, 25

No. of People Living in the House:
4, 6, 8,10 ,12



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APPENDIX C

Investigation 1-1: Yeast and A Relationship Between Food and Energy

Purpose: To determine the effect of different concentration of molasses(food) on yeast energy production by comparing amounts of carbon dioxide released.

Materials:

(per class)

package of dry yeast in 1 liter distilled water
500 ml of commercial molasses (without preservatives / sulfur dioxide)
distilled water

(per team)

graduated cylinder, 100 ml
test tube rack for large test tubes
11 test tubes, 22 X 175 mm (clean)
11 test tubes, 13 X 100 mm (clean)
Erlenmeyer flasks, 125 ml
1 ml pipette
millimeter ruler
marking pen
2 stoppers for large test tubes

Procedure:

Day 1:

1. Label the test tube openings 1 through 11 using tape on a test tube rack. Also label the team number and period number on the test tube rack.
2. Label eleven large test tubes 1 through 11.
3. Prepare yeast solution by adding 30 ml of stock yeast solution to 70 ml of distilled water.
4. Make serial dilutions of solution made in step three by method discussed in pre-lab.
5. The last test tube should contain 26 ml of yeast.
6. Shake flask of yeast solution and add 1 ml to each large test tube.
7. Put a stopper on each test tube and shake the yeast and molasses

APPENDIX C

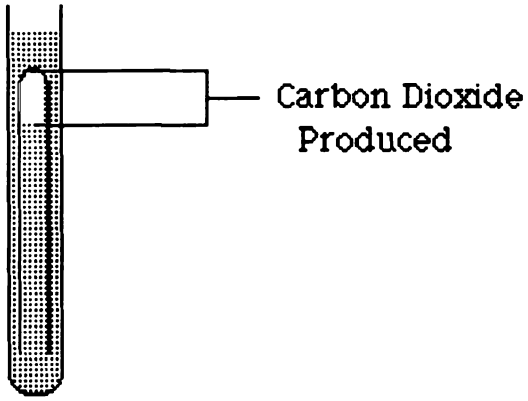
mixture. **Rinse stopper with distilled water before moving to the next test tube.**

8. Invert one small test tube into each of the large test tubes. There should be no air bubbles in the small test tubes. If there are, redo the inverting. The more concentrated solutions should be held up to overhead to look for air bubbles.
8. Take the pH of the molasses using pH paper and record in data section.
9. Set test tubes aside for 24 hours.

Day 2:

1. Tap tubes then measure the amount of gas collected in the small test tube using a millimeter ruler. Measure to the nearest millimeter.

Figure 1: How to Measure Gas in Small test tube.



2. Record results in table one under "24 hours".
   If there was so little gas there was no measurement--record "trace"
   If the whole small test tube was filled with gas--record that measurement and put a "+" next to the number
   If test tube is 1/3 filled with gas, record gas measurement, then retip test tube. --record a " * " next to the measurement
3. Allow test tubes to sit for another 48 hours.

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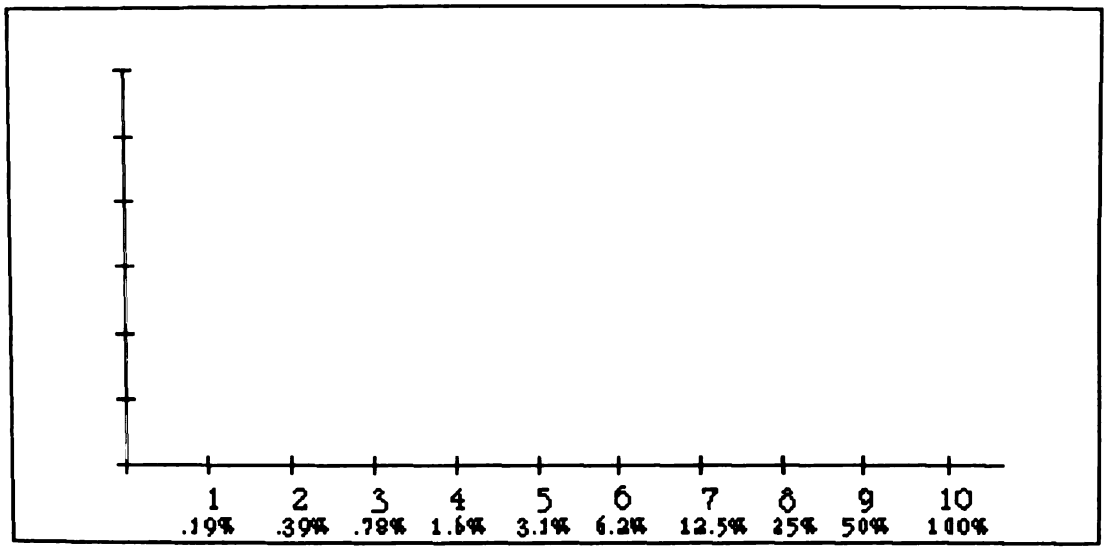
Day Three:

1. Repeat procedure of day two and record results under "48 hours" in table 1.
2. If a test tube was retipped yesterday, then add today's measurement to yesterday's measurement.
3. Create a line graph representation of team "24 hour", team "48 hour", and class "48 hour" averages of CO_2 production for each concentration of molasses.
   The graph needs a specific title, X and Y axis titles and labels, and a key is needed. See figure 2 for an example.

Figure 2: Format for the Line Graph in this Lab



Organism: - Give scientific name and common name

Hypothesis: -

(Need a hypothesis graph to match hypothesis above. [see pre-lab activity])

Data:

pH =

APPENDIX C

Table 1:

Test Tube Number	Concentration of Molasses	CO2 in mm (24 hours)	CO2 in mm (48 hours)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			

Table 2: Class Results and Averages of CO_2 Production After 24 and 48 Hours

Teams	1	2	3	4	5	6	7	Total	Ave.
Test Tube	-----	-----	-----	-----	-----	-----	-----	-----	-----
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									

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Questions:

1. Write out the reaction that was taking place in the test tubes.
2.. What gas was produced in the small test tube?
3. What substance was causing the smell? (Hint: Refer to reaction.)
4. What was the organism used in the lab protocol?
5. What was the variable?
6. Compare your team 48 hour CO_2 production with the class average.
7. Compare your two observed graph results with your predicted hypothesis graph.
8. What is the relationship between sugar concentration and CO_2 production?
9. What is the relationship between the amount of CO_2 and the amount of energy produced?

Discussion:

1. What problems did you encounter during the experiment?
2. What factors contributed to your results?
3. What were sources of error? and how did they affect your data?

Conclusion: Restate your hypothesis. Explain whether or not you accept or reject the hypothesis and use observed data to support your statements. Give a concluding relationship between yeast and energy that was learned from doing this experiment.

Sources:

Biological Science: Interaction of Experiments and Ideas. 4th ed. New Jersey: Prentice-Hall, Inc., 1983.

Campbell, Neil A, Biology 2nd ed., The Benjamin/Cummings Publishing Co., Inc., New York, 1990.

Tatina, Robert. "Apparatus & Experimentation Design for Measuring Fermentation Rates in Yeast." The American Biology Teacher, vol. 51 (1), January 1989:35-39.

Adapted by H. Krusenklaus 1996

APPENDIX C

TEACHER NOTES
Investigation 1-1: Yeast and A Relationship Between Food and Energy

Purpose: To determine the effect of different concentration of molasses(food) on yeast energy production by comparing amounts of carbon dioxide released.

Materials:

(per class)

package of dry yeast in 1 liter distilled water
500 ml of commercial molasses (without preservatives / sulfur dioxide)
distilled water

(per team)

graduated cylinder, 100 ml
test tube rack for large test tubes
11 test tubes, 22 X 175 mm (clean)
11 test tubes, 13 X 100 mm (clean)
Erlenmeyer flasks, 125 ml
1 ml pipette
millimeter ruler
marking pen
2 stoppers for large test tubes

Time Frame:

3 days

Teacher Prep:

1. Make stock yeast solution. (1 package of yeast to 100 ml of distilled water)
2. Put molasses in a water bath to soften.

Procedure:

Day 1:

1. Label the test tube openings 1 through 11 using tape on a test

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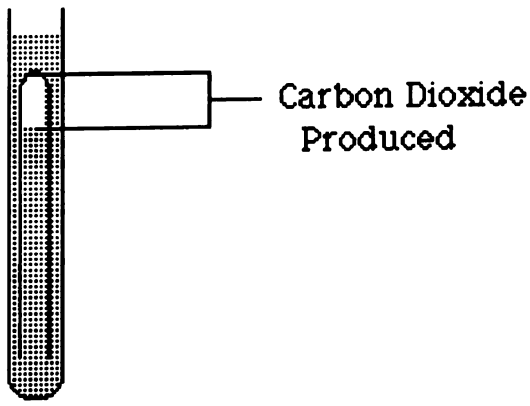
tube rack. Also label the team number and period number on the test tube rack.
2. Label eleven large test tubes 1 through 11.
3. Prepare yeast solution by adding 30 ml of stock yeast solution to 70 ml of distilled water.
4. Make serial dilutions of solution made in step three by method discussed in pre-lab.
5. The last test tube should contain 26 ml of yeast.
6. Shake flask of yeast solution and add 1 ml to each large test tube.
7. Put a stopper on each test tube and shake the yeast and molasses mixture. **Rinse stopper with distilled water before moving to the next test tube.**
8. Invert one small test tube into each of the large test tubes. There should be no air bubbles in the small test tubes. If there are, redo the inverting. The more concentrated solutions should be held up to overhead to look for air bubbles.
8. Take the pH of the molasses using pH paper and record in data section.
9. Set test tubes aside for 24 hours.

Day 2:
1. Tap tubes then measure the amount of gas collected in the small test tube using a millimeter ruler. Measure to the nearest millimeter.

Figure 1: How to Measure Gas in Small test tube.



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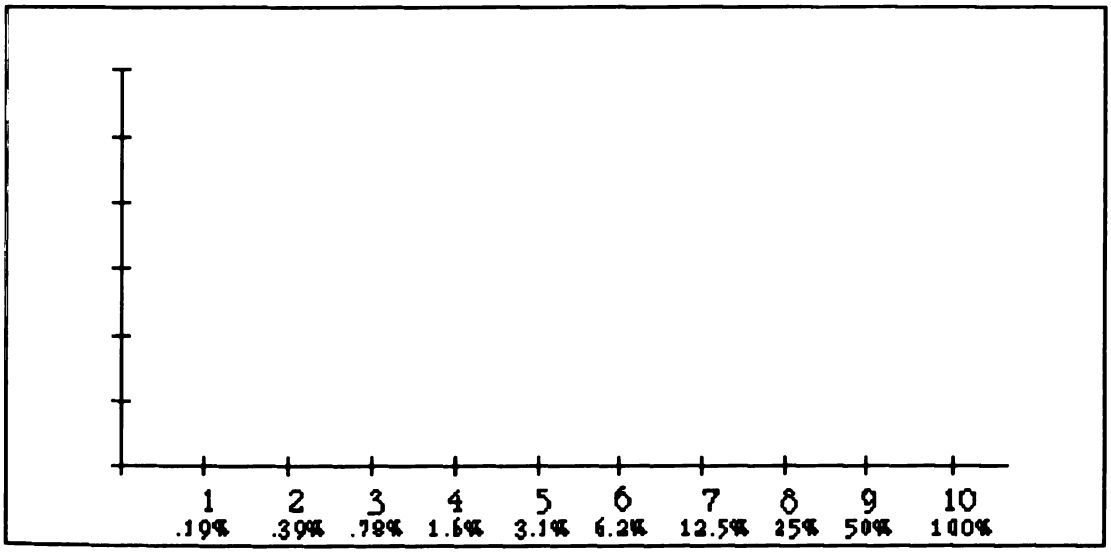
2. Record results in table one under "24 hours".
   If there was so little gas there was no measurement--record "trace"
   If the whole small test tube was filled with gas--record that measurement and put a "+" next to the number
   If test tube is 1/3 filled with gas, record gas measurement, then retip test tube. --record a " * " next to the measurement
3. Allow test tubes to sit for another 48 hours.

Day Three:

1. Repeat procedure of day two and record results under "48 hours" in table 1.
2. If a test tube was retipped yesterday, then add today's measurement to yesterday's measurement.
3. Create a line graph representation of team "24 hour", team "48 hour", and class "48 hour" averages of CO_2 production for each concentration of molasses.
   The graph needs a specific title, X and Y axis titles and labels, and a key is needed. See figure 2 for an example.

Figure 2: Format for the Line Graph in this Lab



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Organism: Saccharomyces cerevisiae - "yeast"

Hypothesis: If the yeast is given a higher concentration of molasses, then the energy production and the amount of carbon dioxide will be greatest_____.

(Need a hypothesis graph to match hypothesis above. [see pre-lab activity])

Data:
pH = 5

Table 1:

Test Tube Number	Concentration of Molasses	CO2 in mm (24 hours)	CO2 in mm (48 hours)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			

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Table 2: Class Results and Averages of CO_2 Production After 24 and 48 Hours

Teams	1	2	3	4	5	6	7	Total	Ave.
Test Tube #	-----	-----	-----	-----	-----	-----	-----	-----	-----
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									

Questions:

1. Write out the reaction that was taking place in the test tubes.

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{\text{yeast}} 4\,CH_3CH_2OH + 4CO_2 + \text{energy}$$

(sucrose) (water) (ethanol) (carbon dioxide)

2. What gas was produced in the small test tube?
   carbon dioxide
3. What substance was causing the smell? (Hint: Refer to reaction.)
   ethanol
4. What was the organism used in the lab protocol?
   yeast
5. What was the variable?
   different concentrations of the sugar in each test tube
6. Compare your team 48 hour CO_2 production with the class

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average.
7. Compare your two observed graph results with your predicted hypothesis graph.
8. What is the relationship between sugar concentration and CO_2 production?
9. What is the relationship between the amount of CO_2 and the amount of energy produced?

Discussion:
1. What problems did you encounter during the experiment?
2. What factors contributed to your results?
3. What were sources of error? and how did they affect your data?

Conclusion: Restate your hypothesis. Explain whether or not you accept or reject the hypothesis and use actual observed data to support your statements. Give a concluding relationship between yeast and energy that was learned from doing this experiment.

Sources:

Biological Science: Interaction of Experiments and Ideas. 4th ed. New Jersey: Prentice-Hall, Inc., 1983.

Campbell, Neil A, Biology 2nd ed., The Benjamin/Cummings Publishing Co., Inc., New York, 1990.

Tatina, Robert. "Apparatus & Experimentation Design for Measuring Fermentation Rates in Yeast." The American Biology Teacher. vol. 51 (1), January 1989:35-39.

Adapted by H. Krusenklaus 1996

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Lab Entry: 1-1 Yeast and A Relationship Between Food and Energy

Student I.D._____ Date:_____ Period:_____

GENERAL ITEMS:

_____ Neat and orderly (.5 pt.)
_____ Ink used (.5 pt.)
_____ Proper deletion used (.5 pt.)
_____ Entries underlined (.5 pt.)

LAB WRITE-UP:

_____ Heading (ID# / Date / Period #) (.5 pt.)
_____ Descriptive title (.5 pt.)
_____ Purpose: [concentrations and carbon dioxide](1 pt.) (2 pt.)
_____ Hypothesis: If (organism,variable), then(predicted concentration)
_____ Organism (1 pt.)

DATA:

_____ Molasses pH (1 pt.)
_____ Table 1: Team # ____ Results of CO2 Production After 24 and 48 Hours(3 pts.)
Title Concentrations CO_2 produced
_____ Table 2: Class Results and Averages of CO2 Production After 24 and 48 Hours (3 pts)
Title Team data Averages
_____ Graph: Line Graph (5 pts.)
Title X/Y axis labels Key 24 / 48 team 48 class

QUESTIONS:

_____1. Write out the reaction. (1 pt.)
_____2. What gas was produced? (1 pt.)
_____3. What substance was causing the smell? (1 pt.)
_____4. What was the organism in the lab? (1 pt.)
_____5. What was the variable? (1 pt.)
_____6. Compare your team 48 hour CO_2 with the class ave. (1 pt.)
_____7. Compare observed graph results with your predicted (1 pt.)
_____8. What is the relationship between sugar concentration and CO_2 production? (2 pts.)
_____9. What is the relationship between the amount of CO_2 and the amount of energy produced? (1 pt.)

DISCUSSION:

_____ (Sources of error / affect on results) (2 pts.)

CONCLUSION:

_____ Hypothesis (1 pt.)
_____ Reject or Accept (1 pt.)
_____ Data support (1pt.)
_____ Concluding relationship (1 pt.)

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_____ID #	_____ID #	_____ID #	_____ID #
35 Possible	35 Possible	35 Possible	35 Possible
_____Missed	_____Missed	_____Missed	_____Missed
_____Extra	_____Extra	_____Extra	_____Extra
_____Score	_____Score	_____Score	_____Score
_____Grade	_____Grade	_____Grade	_____Grade

Student Comments:

Pre-Grade: Due Date:

ID#_____	Done	Corrections	Not Done	ID#_____	Done	Not Done
ID#_____	Done	Corrections	Not Done	ID#_____	Done	Not Done
ID#_____	Done	Corrections	Not Done	ID#_____	Done	Not Done

I agree to make the corrections disccussed with my team _____(Initial)

Teacher Comments:

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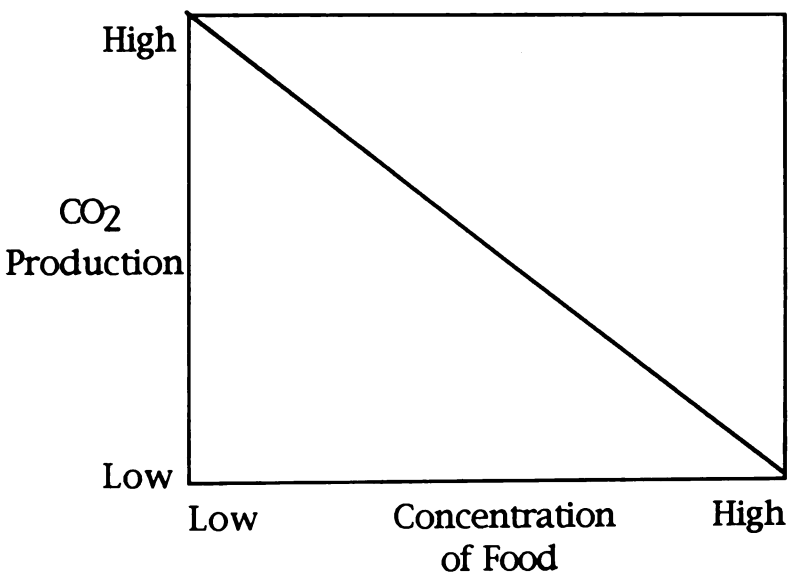
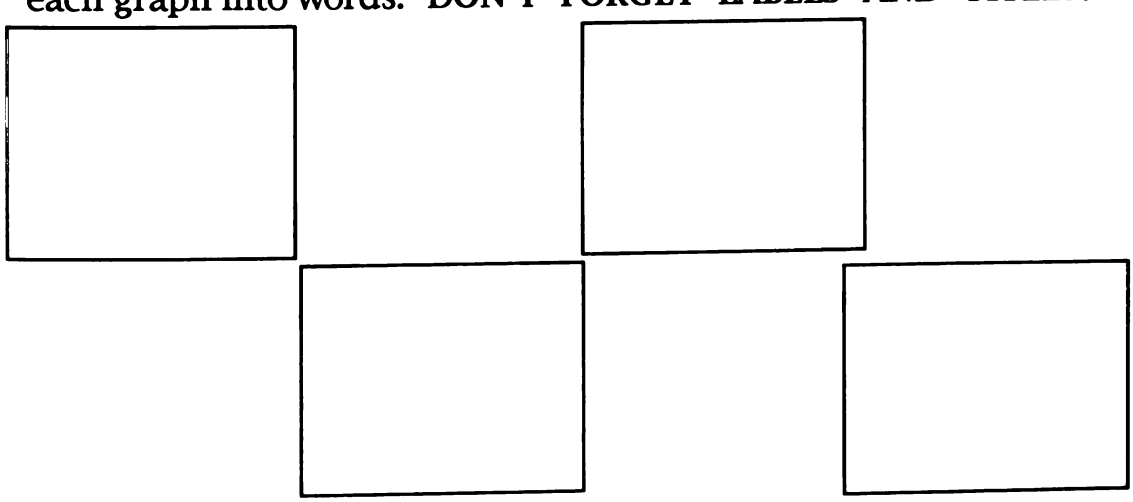
Pre-Lab Activity Name:_____
Lab 1-1 Relationship Between Food and Energy ID #:_____Period:___
Date:_____

Background: In this lab you will need to formulate your first lab hypothesis with a graph representation. Yeast will convert sucrose with water to ethanol, carbon dioxide and energy. You need to hypothesize as to how the concentration of sucrose will change the amount of carbon dioxide produced. One example is as follows:



1. Put the above graph into a word hypothesis and use "If.....then....."

2. Draw four other possible hypotheses for this lab and then put each graph into words. **DON'T FORGET LABELS AND TITLES.**



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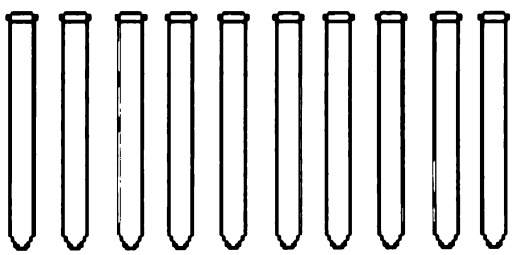
Background: In this lab a serial dilution needs to be prepared. Since the purpose of the lab is to study the effects of sugar concentration on carbon dioxide production, the concentrations of the sugar needs to be varied. The technique used to do this is called serial dilution. The end result will be ten test tubes with the concentrations seen below:



10	9	8	7	6	5	4	3	2	1
(100%)	(50%)	(25%)	(12.5%)	(6.2%)	(3.1%)	(1.6%)	(.78%)	(.39%)	(.19%)

If you want each test tube to have 25 ml of the molasses solution at the above concentrations, how would you go about making the serial dilution?
Explain and draw diagrams to illustrate your procedure.

Questions:

1. What is the organism in this lab? What type of organism is it?

2. What is the variable in this lab? How do you know?

3. Do we have a control in this lab?

4. If we do, what is it?

5. Pick one hypothesis to serve as your team hypothesis for this lab. Write out the word form and show the graph form in this area.

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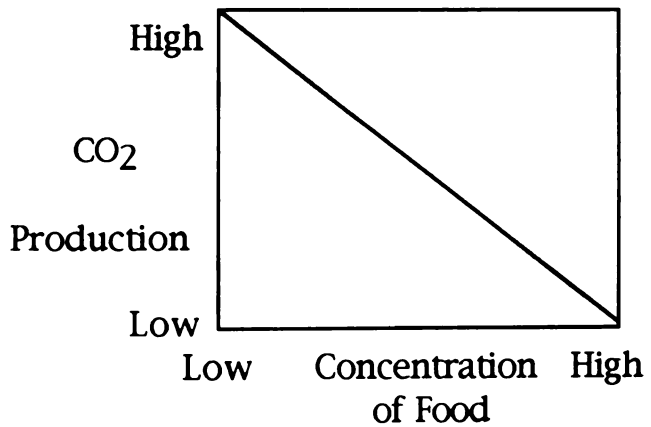
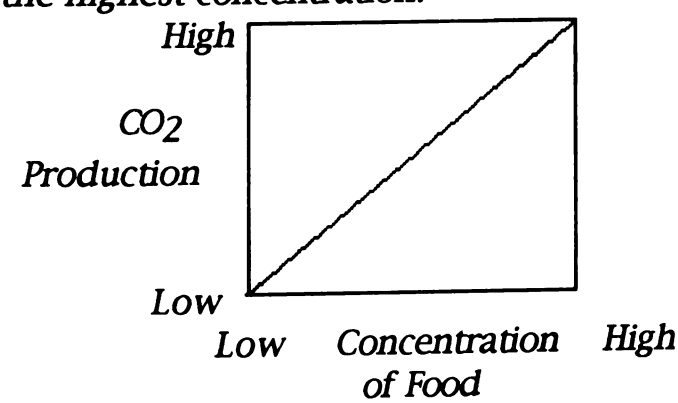
Pre-Lab Activity Name:_____
Lab 1-1 Relationship Between Food and Energy ID #:____Period:____
Background: In this lab you will need to formulate your first lab hypothesis with a graph representation. Yeast will convert sucrose with water to ethanol, carbon dioxide and energy. You need to hypothesize as to how the concentration of sucrose will change the amount of carbon dioxide produced. One example is as follows:



Possible Title:
Rate of CO_2 Production Compared to Food Concentration

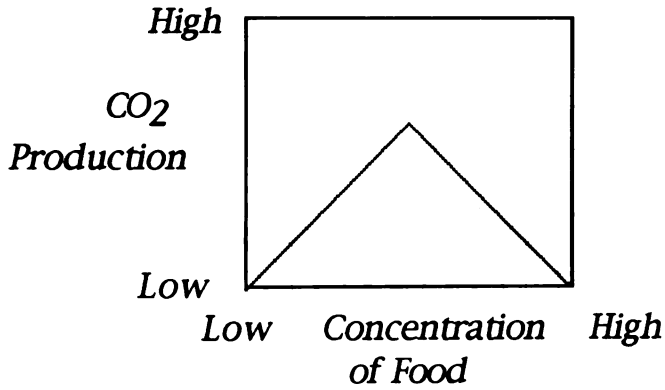
1. Put the above graph into a word hypothesis and use "If.....then....."
   If the yeast is given different concentrations of molasses, then the CO_2 and energy production will be greatest in the test tubes with the lowest concentrations.
2. Draw four other possible hypotheses for this lab and then put each graph into words. **DON'T FORGET LABELS AND TITLES.**

Hypothesis: If the yeast is given a different concentrations of molasses then the CO_2 and energy production will be greatest in test tube with the highest concentration.

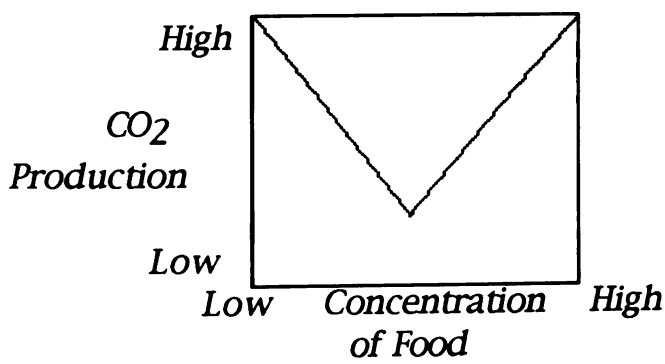


APPENDIX C

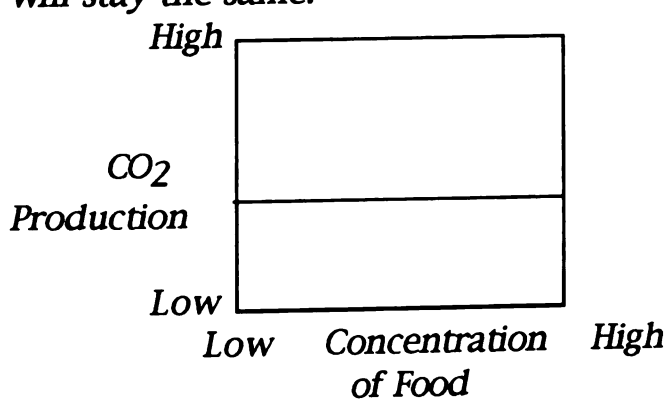
Hypothesis: same if statement, then the CO_2 and energy production will be greatest in the middle test tubes with the middle concentrations.



Hypothesis: then greatest carbon dioxide production and energy production will be in the highest and lowest concentrations of molasses.



Hypothesis: then the carbon dioxide production and energy production will stay the same.



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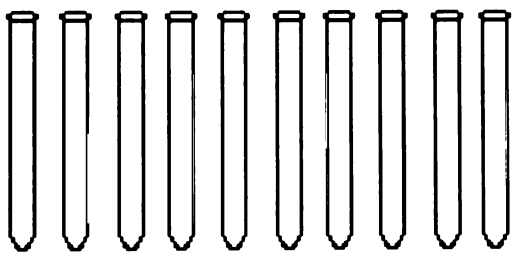
Background: In this lab a serial dilution needs to be prepared. Since the purpose of the lab is to study the effects of sugar concentration on carbon dioxide production, the concentrations of the sugar needs to be varied. The technique used to do this is called serial dilution. The end result will be ten test tubes with the concentrations shown below:



10	9	8	7	6	5	4	3	2	1
(100%)	(50%)	(25%)	(12.5%)	(6.2%)	(3.1%)	(1.6%)	(.78%)	(.39%)	(.19%)

If you want each test tube to have 25 ml of the molasses solution at the above concentrations, how would you go about making the serial dilution?
Explain and draw diagrams to illustrate your procedure.

1. *Put 25 ml of the molasses in a graduated cylinder and add 25 ml of distilled water. Shake up the two components.*
2. *Pour 25 ml of the 50 ml into test tube number nine.*
3. *Put 25 ml of distilled water into the graduated cylinder (should have 50 ml) and shake up.*
4. *Pour 25 ml of the solution into test tube number eight.*
5. *Repeat this procedure until test tubes nine through one are filled with 25 ml of solution.*
6. *Test tube ten should have 25 ml of pure molasses.*

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Questions:

1. What is the organism in this lab? What type of organism is it?
   yeast, single celled fungi

2. What is the variable in this lab? How do you know?
   the different concentrations of sugar in the test tubes--
   everything else in the test tubes are kept the same

3. Do we have a control in this lab?
   yes

4. If we do what is it?
   Test tube with 1 ml of yeast and just water no molasses.

5. Pick one hypothesis to serve as your team hypothesis for this lab. Write out the word form and show the graph form in this area.
   Answers will vary

Source:

Biological Science: Interaction of Experiments and Ideas. 4th ed. New Jersey: Prentice-Hall, Inc., 1983.

APPENDIX C

Investigation 1-2: The Relationship Between Different Food Sources and Energy

Directions: Discuss information needed in lab report with your team. Decide on the purpose of this lab after the pre-lab discussion. Decide on a food source that you would like to test and report it to the teacher. Formulate a word and graph hypothesis based on the purpose of this lab. Decide on materials needed and a procedure to follow for your experiment. All the proceeding directions need to be written up before your team will be allowed to start the testing.

Data:

Make sure you include the following items in the data section:

1. pH of the molasses and chosen food source
2. Brand name of your food source
3. Ingredients found in the food source listed in the order they appear on the label.
4. A table with CO_2 production after 24 and 48 hours for the team.
5. Table 2 (see next page)

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Table 2: Each Team's Results of CO_2 Production in mm for 48 Hours in a Chosen Food (Sucrose) Medium

Test Tube	Concentration	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Team 7
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
	Food Source:							
	Highest CO2 Amount:							
	Ideal Concentration							
	pH of Source:							

Questions:

1. How do the rates of CO_2 production and energy production of your food source compare to those of molasses? Be specific. Compare ideal concentrations and amounts of CO_2 produced for each sugar solution.
2. Discuss differences in CO_2 production between the molasses and your food source (Note: Ingredients of molasses is in the background information.)
3. Which food source produced the most CO_2 after 24 hours? After 48 hours?
4. Which food source lead to the least CO_2 production after 48 hours? Why?

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5. List as many other variables (other than those discussed above) that could have affected the yeast fermentation process. Explain how these items are variables.

Discussion:

1. What problems did you encounter as you ran your experiment?
2. What other factors contributed to your results?
3. What were sources of error? and how did they affect your data?

Conclusion: Restate your hypothesis. Explain whether or not you accept or reject the hypothesis and use actual observed data to support your statements. Last give a concluding relationship between the different food sources and the carbon dioxide production.

Sources:

Biological Science: Interaction of Experiments and Ideas. 4th ed. New Jersey: Prentice-Hall, Inc., 1983.

Campbell, Neil A, Biology 2nd ed., The Benjamin/Cummings Publishing Co., Inc., New York, 1990.

Tatina, Robert. "Apparatus & Experimentation Design for Measuring Fermentation Rates in Yeast." The American Biology Teacher. vol. 51 (1), January 1989:35-39.

Adapted by H. Krusenklaus

APPENDIX C

TEACHER NOTES
Investigation 1-2: The Relationship Between Different Food Sources and Energy

Purpose: To observe what effect different food sources will have on the amount of energy and carbon dioxide produced by yeast.

Materials:

(per class)

package of dry yeast in 1 liter distilled water
distilled water

(per team)

each team should bring in a different food sources (ex: honey, syrup, apple juice) **Students should not use a source that lists first ingredient as water.**

graduated cylinder, 100 ml
test tube rack for large test tubes
11 test tubes, 22 X 175 mm (clean)
11 test tubes, 13 X 100 mm (clean)
Erlenmeyer flasks, 125 ml
1 ml pipette
millimeter ruler
marking pen
2 stoppers for large test tubes

Time Frame:

3 days

Teacher Prep:

1. Make stock yeast solution. (1 package of yeast to 100 ml of distilled water)

Procedure:

Day 1:

1. Label a test tube rack 1 through 11 using tape. Also label the team number and period number on the test

APPENDIX C

tube rack.
2. Label eleven large test tubes 1 through 10.
3. Prepare yeast solution by adding 30 ml of stock yeast to 70 ml of distilled water.
4. Get food source ready for serial dilutions. Some may need to be heated.
5. Make serial dilutions of your food source by method used in lab exercise1-1.
6. The last test tube should be filled with 26 ml of yeast solution.
7. Shake flask of yeast solution and add 1 ml to each test tube.
8. Put a stopper on each test tube and shake the yeast and food source mixture. **Rinse stopper with distilled water before moving to the next test tube.**
9. Invert one small test tube into each of the large test tubes. There should be no air bubbles in the small test tubes. If there are redo the inverting. The more concentrated solutions should be held up to over- head to look for air bubbles.
10. Take the pH of your food source using pH paper and record in data section.
11. Set test tubes aside for 24 hours.
12. Record the Brand name and ingredients of the food source used in the order they are given on the label.
13. Record the pH of molasses from lab exercise1-1.

Day 2:
1. Tap tubes then measure the amount of gas collected in the small test tube using a millimeter ruler. Measure to the nearest millimeter.
2. Record results in table one under "24 hours".

If there was so little gas there was no measurement--record "trace"
If the whole small test tube was filled with gas--record the measure and put a "+" next to the number
If test tube is 1/3 filled with gas, record gas measurement, then retip test tubes. ---record a " * " next to the measurement

3. Allow test tubes to sit for another 24 hours.

APPENDIX C

Day Three:

1. Repeat procedure of day two and record results under 48 hours in table 1. Complete the rest of table 2.
2. If a test tube was retipped yesterday, then add today's measurement to yesterday's measurement.
3. Create a line graph representation of team 24 hour, team 48 hour, and team 48 from lab 1-1 of CO_2 production for each concentration. The graph needs a specific title, X and Y axis titles and labels, and a key is needed. See figure 2 for a start.

Organism: Saccharomyces cerevisiae - "yeast"

Hypothesis: If the yeast is given a higher concentration of _____, then the energy production and the amount of carbon dioxide will be greatest_____. (Give specific concetration(s) [test tube(s)])

(Need a hypothesis graph to match hypothesis above. [see pre-lab activity 1-1])

Data:
molasses pH = 5

own food source pH =

Brand Name
Ingredients

APPENDIX C

Table 1: Team # _____ Results of CO_2 Production After 24 and 48 Hours

Test Tube Number	Concentration of	CO2 in mm (24 hours)	CO2 in mm (48 hours)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			

APPENDIX C

Table 2: Each Team's Results of CO_2 Production in mm for 48 Hours in a Chosen Food (Sucrose) Medium

Test Tube	Concentration	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Team 7
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
	Food Source:							
	Highest CO2 Amount:							
	Ideal Concentration							
	pH of Source:							

Questions:

1. How do the rates of CO_2 production and energy production of your food source compare to those of molasses? Be specific. Compare ideal concentrations and amounts of CO_2 produced for each sugar solution.
2. Discuss differences in CO_2 production between the molasses and your food source (Note: Ingredients of molasses is in the background information.)
3. Which food source produced the most CO_2 after 24 hours? After 48 hours?

APPENDIX C

4. Which food source lead to the least CO_2 production after 48 hours? Why?
5. List as many other variables (other than those discussed above) that could have affected the yeast fermentation process. Explain how these items are variables.

Discussion:

1. What problems did you encounter as you ran your experiment?
2. What other factors contributed to your results?
3. What were sources of error? and how did they affect your data?

Conclusion: Restate your hypothesis. Explain whether or not you accept or reject the hypothesis and use actual observed data to support your statements. Last give a concluding relationship between the different food sources and the carbon dioxide production.

Sources:

Biological Science: Interaction of Experiments and Ideas. 4th ed. New Jersey: Prentice-Hall, Inc., 1983.

Campbell, Neil A, Biology 2nd ed., The Benjamin/Cummings Publishing Co., Inc., New York, 1990.

Tatina, Robert. "Apparatus & Experimentation Design for Measuring Fermentation Rates in Yeast." The American Biology Teacher. vol. 51 (1), January 1989:35-39.

Adapted by H. Krusenklaus

APPENDIX C

Investigation 1-2: The Relationship Between Different Food Sources and Energy

Student I.D._____ Date:_____ Period:_____

GENERAL ITEMS:

_____ Neat and orderly (.5 pt.)
_____ Ink used (.5 pt.)
_____ Proper deletion used (.5 pt.)
_____ Entries underlined (.5 pt.)

LAB WRITE-UP:

_____ Heading (ID# / Date / Period #) (.5 pt.)
_____ Descriptive title (.5 pt.)
_____ Purpose: (organism / variable / problem [ideal concentration and compare to molasses]) (2 pts.)
_____ Procedure: (3 pts.) (2 pts.)
_____ Hypothesis: (If organism /variable, then prediction[ideal conc]
_____ organism (1 pt.)

DATA:

_____ Brand name (1pt.)
_____ Ingredients (1 pt.)
_____ pH reading of molasses (1 pt.)
_____ pH reading of own source (1 pt.)
_____ Table 1: Team 24-48 hrs. (CO_2 Produced in mm) (3 pts.)
Title Column Headings Conc. % of Own Source
_____ Table 2: Class Results 48 hrs. (CO_2 Produced in mm) (3 pts.)
Title Labels All data
_____ Graph (4 pts.)
Title/Scale/Spacing /Key /Labels/Units /3 Plottings/Comp.Graph

QUESTIONS:

_____ 1. General Comparison incl. heights/ Ideal Concentration for molasses / Ideal Concentration for own food source (1.5 pts.)
_____ 2. Reason for different results (.5 pt.)
_____ 3. Most CO_2 in 24 hrs? in 48 hrs.? (1 pt.)
_____ 4. Worst CO_2 in 24 hrs? in 48 hrs.? (1 pt.)
_____ 5. Other variables we've ignored (1 pt.)

DISCUSSION:

_____ (Sources of error / affect on results) (1 pts.)

CONCLUSION:

_____ Hypothesis (1 pt.)
_____ Reject or Accept (1 pt.)
_____ Data support (1pt.)
_____ Concluding relationship (1 pt.)

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_____ID #	_____ID #	_____ID #	_____ID #
35 Possible	35 Possible	35 Possible	35 Possible
_____Missed	_____Missed	_____Missed	_____Missed
_____ Extra	_____Extra	_____Extra	_____Extra
_____Score	_____Score	_____Score	_____Score
_____Grade	_____Grade	_____Grade	_____Grade

Student Comments:

Pre-Grade: Due Date:

ID#_____	Done	Corrections	Not Done	ID#_____	Done	Not Done
ID#_____	Done	Corrections	Not Done	ID#_____	Done	Not Done
ID#_____	Done	Corrections	Not Done	ID#_____	Done	Not Done

I agree to make the corrections disccussed with my team _____
(Initial)

Teacher Comments:

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APPENDIX C

Investigation 1-3: Relationship Between Temperature and Yeast Fermentation

Purpose: To determine the effect of different temperatures on yeast energy production by comparing amounts of carbon dioxide produced.

Procedure:

Day 1:

1. Determine the ideal concentration of molasses from lab 1-1.
2. Make up a molasses solution based this concentration.
3. Get 4.5 ml of the stock yeast solution and dilute it with 10.5 ml of distilled water.
4. Label 10 test tubes with the following information:
   - 1 - Freezer, Team #, Period #
   - 2 - Refrigerator, Team #, Period #
   - 3 - Room Temperature, Team #, Period #
   - 4 - Water Bath, Team #, Period #
   - 5 - Oven, Team #, Period #
5. Record the temperature of each environment.
6. Repeat the above labels and add the word CONTROL. The team should have ten test tubes when done.
7. Put 25 ml of the molasses solution in each test tube that is not labeled as a control.
8. Put 25 ml of water in each control test tube.
9. Add 1 ml of yeast to all ten test tubes.
10. Invert small test tubes into large as done in lab 1-1 and 1-2.
11. Place test tubes in the location that is written on their label.

Day 2:

1. Tap tubes then measure the amount of CO_2 collected in the small test tube using a millimeter ruler. Measure to the nearest millimeter.
2. Record results in table one under "24 hours". Use the same procedure for recording data as in lab 1-1 and 1-2.
   - T = Trace
   - * = Test tube was retipped
   - 100+ = The whole test tube was full of carbon dioxide

APPENDIX C

3. Allow test tubes to sit for another 24 hours.

Day Three:
1. Repeat procedure of day two and record results under "48 hours" in table 1.
2. If a test tube was retipped yesterday, then add today's measurement to yesterday's measurement.
3. Create a bar graph for the 24 and 48 team data. See figure 1 for the graph set up. Make sure you record the temperature on the graph under each location.

Organism: Saccharomyces cerevisiae - "yeast"

Hypothesis: If the yeast is given a specific concentration of molasses and placed in different temperatures, then the energy production and the amount of carbon dioxide will be greatest_____.

Data:

Table 1: Team # ___ Results of CO_2 Production After 24 and 48 Hours of Yeast and Molasses in Different Temperatures

Location	Temperature (°C)	24 Hour CO2 Prod. (mm)	48 Hour CO2 Prod. (mm)
Freezer			
Freezer Control			
Refrigerator			
Refrigerator Control			
Room			
Room Control			
Water Bath			
Water Bath Contol			
Oven			
Oven Control			

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Table 2: Class Results and Averages of CO_2 Production After 24 and 48 Hours of Yeast and Molasses in Different Temperatures.

Teams	1	2	3	4	5	6	7	Total	Ave.
Test Tube #	-----	-----	-----	-----	-----	-----	-----	-----	-----
1									
2									
3									
4									
5									
Controls:									
1									
2									
3									
4									
5									

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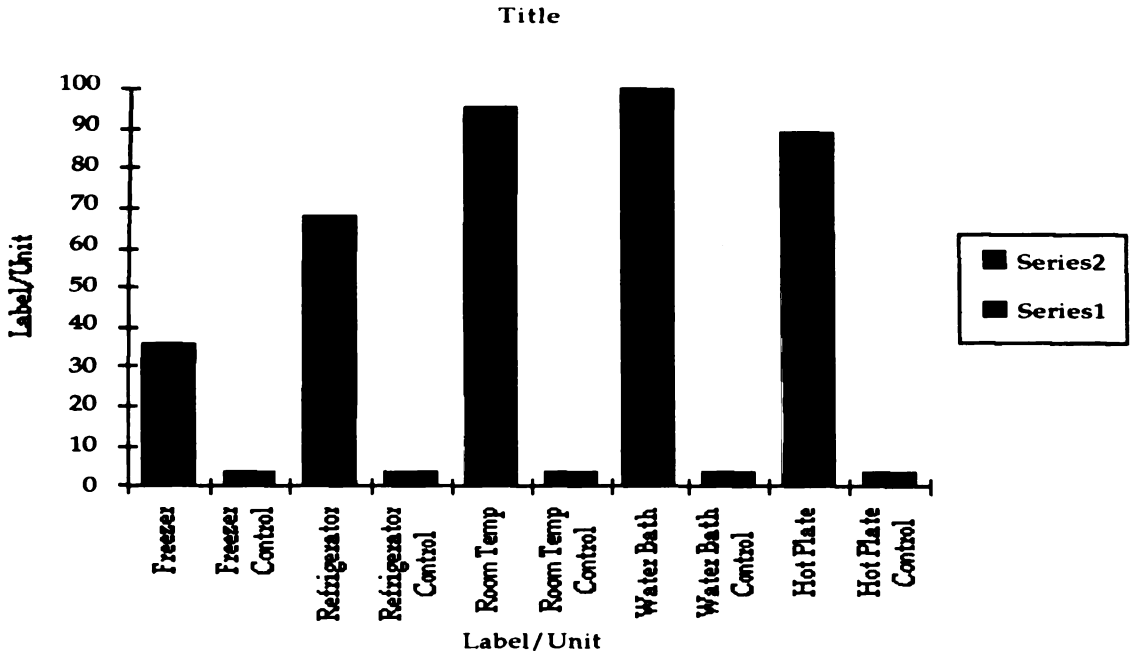
Figure 1: Format for the Bar Graph



Questions:

1. What, if any, relationship or pattern is there between experimental conditions and yeast CO_2 production?
2. What is the ideal experimental condition for optimum yeast CO_2 production? Why?
3. If there was no carbon dioxide produced in any of the envirnments, explain a possible reason(s) for these results.

Discussion:

Conclusion:

Sources:

Biological Science: Interaction of Experiments and Ideas. 4th ed. New Jersey: Prentice-Hall, Inc., 1983.

Campbell, Neil A, Biology 2nd ed., The Benjamin/Cummings Publishing Co., Inc., New York, 1990.

Tatina, Robert. "Apparatus & Experimentation Design for Measuring Fermentation Rates in Yeast." The American Biology Teacher. vol. 51 (1), January 1989:35-39.

Adapted by H. Krusenklaus 1996

APPENDIX C

TEACHER NOTES
Investigation 1-3: Relationship Between Temperature and Yeast Fermentation

Purpose: To determine the effect of different temperatures on yeast energy production by comparing amounts of carbon dioxide produced.

Procedure:

Day 1:

1. Determine the ideal concentration of molasses from lab 1-1.
2. Make up a molasses solution based this concentration.
3. Get 4.5 ml of the stock yeast solution and dilute it with 10.5 ml of distilled water.
4. Label 10 test tubes with the following information:
   - 1 - Freezer, Team #, Period #
   - 2 - Refrigerator, Team #, Period #
   - 3 - Room Temperature, Team #, Period #
   - 4 - Water Bath, Team #, Period #
   - 5 - Oven, Team #, Period #
5. Record the temperature of each environment.
6. Repeat the above labels and add the word CONTROL. The team should have ten test tubes when done.
7. Put 25 ml of the molasses solution in each test tube that is not labeled as a control.
8. Put 25 ml of water in each control test tube.
9. Add 1 ml of yeast to all ten test tubes.
10. Invert small test tubes into large as done in lab 1-1 and 1-2.
11. Place test tubes in the location that is written on their label.

Day 2:

1. Tap tubes then measure the amount of CO_2 collected in the small test tube using a millimeter ruler. Measure to the nearest millimeter.
2. Record results in table one under "24 hours". Use the same procedure for recording data as in lab 1-1 and 1-2.
   - T = Trace
   - * = Test tube was retipped
   - 100+ = The whole test tube was full of carbon dioxide

APPENDIX C

3. Allow test tubes to sit for another 24 hours.

Day Three:
1. Repeat procedure of day two and record results under "48 hours" in table 1.
2. If a test tube was retipped yesterday, then add today's measurement to yesterday's measurement.
3. Create a bar graph for the 24 and 48 team data. See figure 1 for the graph set up. Make sure you record the temperature on the graph under each location.

Organism: Saccharomyces cerevisiae - "yeast"

Hypothesis: If the yeast is given a specific concentration of molasses and placed in different temperatures, then the energy production and the amount of carbon dioxide will be greatest_____.

Data:

Table 1: Team # ___ Results of CO_2 Production After 24 and 48 Hours of Yeast and Molasses in Different Temperatures

Location	Temperature (°C)	24 Hour CO2 Prod. (mm)	48 Hour CO2 Prod. (mm)
Freezer			
Freezer Control			
Refrigerator			
Refrigerator Control			
Room			
Room Control			
Water Bath			
Water Bath Contol			
Oven			
Oven Control			

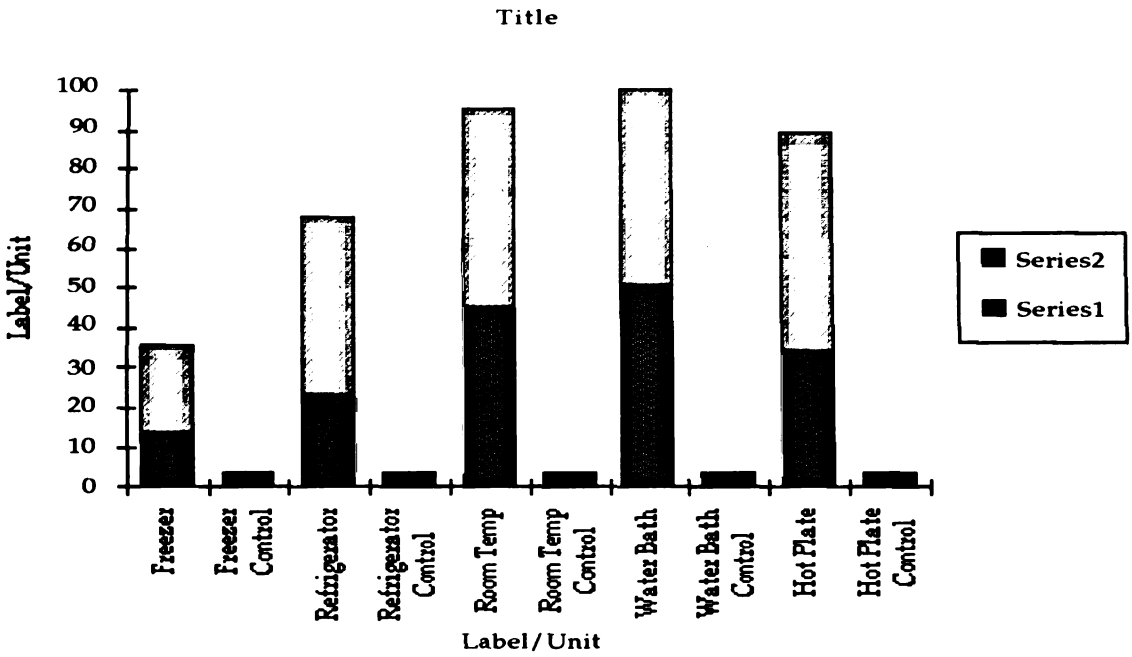
APPENDIX C

Table 2: Class Results and Averages of CO_2 Production After 24 and 48 Hours of Yeast and Molasses in Different Temperatures.

Teams	1	2	3	4	5	6	7	Total	Ave.
Test Tube #	-----	-----	-----	-----	-----	-----	-----	-----	-----
1									
2									
3									
4									
5									
Controls:									
1									
2									
3									
4									
5									

APPENDIX C

Figure 1: Format for the Bar Graph



1. What, if any, relationship or pattern is there between experimental conditions and yeast CO_2 production?
2. What is the ideal experimental condition for optimum yeast CO_2 production? Why?
3. If there was no carbon dioxide produced in any of the envirnments, explain a possible reason(s) for these results.

Discussion:

Conclusion:

Sources:

Biological Science: Interaction of Experiments and Ideas. 4th ed. New Jersey: Prentice-Hall, Inc., 1983.

Campbell, Neil A, Biology 2nd ed., The Benjamin/Cummings Publishing Co., Inc., New York, 1990.

Tatina, Robert. "Apparatus & Experimentation Design for Measuring Fermentation Rates in Yeast." The American Biology Teacher. vol. 51 (1), January 1989:35-39.

Adapted by H. Krusenklaus 1996

APPENDIX C

Investigation 1-3: Relationship Between Temperature and Yeast Fermentation

Student I.D._____ Date:_____ Period:_____

GENERAL ITEMS:

_____ Neat and orderly (1 pt.)
_____ Ink used (1 pt.)
_____ Proper deletion used (1 pt.)
_____ Entries underlined (.5 pt.)

LAB WRITE-UP:

_____ Heading (ID# / Date / Period #) (.5 pt.)
_____ Descriptive title (.5 pt.)
_____ Purpose: (1 pt.)
_____ Hypothesis: If (organism,variable), then(predicted temperature)
_____ Organism (1 pt.) (2pts.)

DATA:

_____ Table 1: Team # ___ Results of CO2 Production After 24 and 48 Hours(4 pts.)
Title Temperature CO2 produced 24 48
_____ Table 2: Class Results and Averages of CO2 Production After 24 and 48 Hours (3 pts)
Title Team data Averages
_____ Graph: Bar Graph (6 pts.)
Title X/Y axis labels Key 24 / 48 team

QUESTIONS:

_____1. What, if any, relationship or pattern is there between temperature and yeast CO_2 production? (2 pts.)
_____2. What is the ideal temperature(or range) for optimum yeast CO_2 production? Why? (2 pts.)
_____3. If there was no carbon dioxide produced in any of the environments, explain a possible reason(s) for these results.(2)
_____ Questions written out (1 pt.)

_____ Space between answer and next question (.5 pt.)

DISCUSSION:

_____ (Sources of error / affect on results) (2 pts.)

CONCLUSION:

_____ Hypothesis (1 pt.)
_____ Reject or Accept (1 pt.)
_____ Data support (1pt.)
_____ Concluding relationship (1 pt.)

APPENDIX C

_____ID #	_____ID #	_____ID #	_____ID #
___35____Possible	___35____Possible	___35____Possible	___35____Possible
_____Missed	_____Missed	_____Missed	_____Missed
_____Extra	_____Extra	_____Extra	_____Extra
_____Score	_____Score	_____Score	_____Score
_____Grade	_____Grade	_____Grade	_____Grade

Student Comments:

Pre-Grade: Due Date:

ID#_____Done	Corrections	Not Done	ID#_____	Done	Not Done
ID#_____Done	Corrections	Not Done	ID#_____	Done	Not Done
ID#_____Done	Corrections	Not Done	ID#_____	Done	Not Done

I agree to make the corrections disccussed with my team _____
(Initial)

Teacher Comments:

APPENDIX C

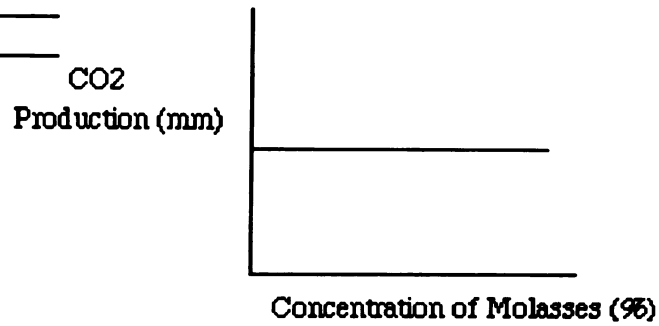
QUIZ-Fermentation

Name:_____
ID#:_____Period:_____
Date:_____

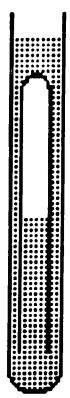
Directions: Use lab reports 1-1, 1-2, and1-3 to answer the following questions.

_____1. What was the organism used in the labs?
_____2. Every hypothesis must have an "If...then" format.
_____ What are the other three components that must be
_____ included in every hypothesis?
_____3. Write a hypothesis that matches the following graph.

_____
_____



_____4. What was the variable in lab exercise 1-1?
_____5. What was the variable in lab exercise 1-2?
_____6. What was the variable in lab exercise 1-3?
_____7. Write the reaction for fermentation.
_____8. What was the independent variable in lab exercise 1-2?
_____9. What was produced in the fermentation process that can have an order?
_____10. Measure the amount of CO_2 produced in the following diagram. Measure the CO_2 in mm.



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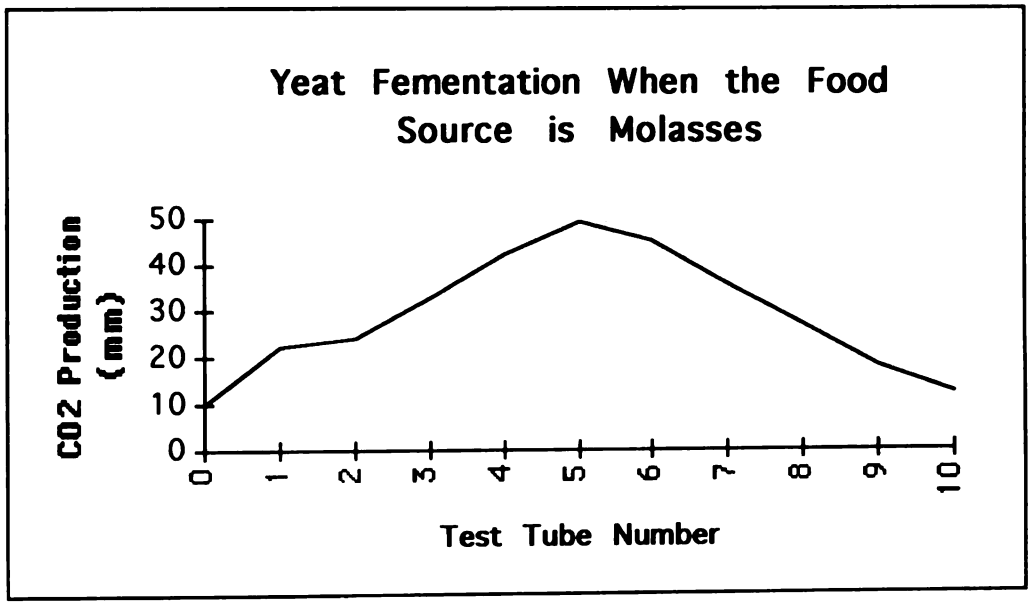
_____11. Using the graph below, which test tube contained the the right concentration of molasses to give the most carbon dioxide. Give answer in %



_____12. If the concentrations in the test tubes in problem #11 are set up like lab exercise 1-1, what would be the ideal concentration for carbon dioxide production.

_____(Total)_____13. A student is designing a new lab exercise that
_____(Molasses) requires the use of yeast and molasses. The student
_____(Water_____ needs 10 test tubes, five will serve as controls, and each test tube will need 25 ml of the molasses solution. How much molasses is required to complete this lab exercise? Calculate how much molasses and water will be needed to make a solution with the concentration found in question #12.

_____14. What was the best food source in lab exercise 1-2?

_____15. Why wouldn't a food source with the first ingredients work in lab exercise 1-2?

_____16. What was the ideal temperature in lab exercise 1-3?

_____17. Why didn't you average the class data table in lab exercise 1-2?

_____18. What was in the control in lab exercise 1-3?

APPENDIX D

Investigation 2-1: Measuring Rates of Respiration in Peas and Corn

Purpose:

organism: Zea mayz - "corn" and Pisum sativa - "peas"

Materials:

(per team)

45 Alaska pea seeds
45 Yellow dent corn seeds
glass beads or gravel
volumeter with all the components
tray
100 ml graduate cylinder
3-150 ml beakers
eyedropper and bottle

(per class)

ascarite or sodium hydroxide
soap
food coloring

Procedure:

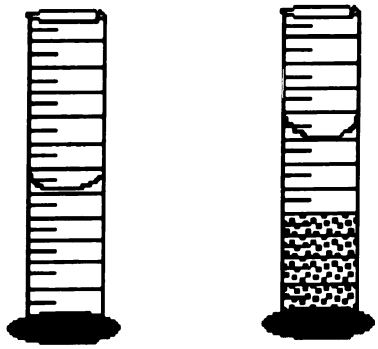
Day 1-

1. Using wet paper towels, layer pea and corn seeds in trays for germination.
2. Leave seeds in cabinet overnight.

Day 2-

1. Measure the volume of peas, and corn using the displacement method. Record data in table 1. See figure 1 below.
2. Fill volumeter with water and let it sit overnight.

Figure 1: How to Measure Volume by Displacement



The first graduated cylinder has just water in it. Find the volume of the water. Add the pea or corn seeds. Find the new volume. The difference between the first reading and the second is the volume of the seeds in the graduate.

Adapted by H. Krusenklaus

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Day 3-

1. Measure the volume of the peas and corn again. Record in table 1.
2. If the volume of the pea seeds is not equal to the corn seeds, then add gravel to the one that is less in volume until both are equal in volume.
3. Add the pea seeds and gravel to one test tube and the corn seeds and gravel to another test tube.
4. Measure an equal volume of gravel for the third test tube.
5. The third test tube is the thermobarometer.
6. Loosely pack cotton near the top of each test tube to a depth about 1 cm.
7. Add 4 pellets of ascarite or sodium hydroxide to the top of the cotton in each test tube.

CAUTION: Ascarite and sodium hydroxide are caustic. Be careful not to get any on you or your clothes.

8. Place stoppers on test tubes immediately and place test tubes in volumeter.
9. The stopper should have a short tube and a long tube attached to it.
10. Insert a capillary tube in each of the long tubing pieces coming from the stopper.
11. Insert a small drop of colored water into the capillary tubes using a syringe, or pipette. Position the bubble in the pea and corn tubes at the end of the capillary tubes. Position the bubble in the control in the middle of the capillary tube.
12. Tape the capillary tubes to a blank sheet of white paper.
13. Once the volumeter is completely assembled let it stand for five minutes.
14. If the bubble in the capillary tubes needs to be adjusted use a syringe in in the small tubing of the stopper.
15. After five minutes, clamp the small tubing on the stopper. Then mark the starting point of the bubble in each capillary tube.
16. Mark 10 measurements, at 2 minute intervals, of the distance the drop moves. Mark the position of each drop at each interval on the paper.
17. After 20 minutes stop taking readings. Record data in table 2.

Note- *If respiration is rapid, it may be necessary to readjust the drop using the syringe. If you do this, use both sets of readings to calculate the total change during the experiment.*

Sometimes the drop of dye will not move as expected; or will not move at all. This may be due to inactive ascarite or a system that is not airtight. Try using a smaller bubble or squeezing the rubber tubing to cut back on adhesion.

If the drop in the thermobarometer moves toward the test tubes, subtract the distance it moves from the distance the drop moves in each of the other pipettes. If it moves away from the test tubes, add the distance to that of each of the other drops. This corrects your readings based on changes that may have occurred in the entire system. (SEE TABLE 2)

APPENDIX D

18. The volume of oxygen used in each tube should be calculated using the the formula for the volume of a cylinder: $V=h \times \pi r^2$. The h is the total distance a drop moved during the 20 minute period of observation, r is the inner radius of the glass pipette.

12. Make a sketch of your apparatus. Include the contents of each test tube, and all parts of the volumeter. Make sure to label all parts of the sketch. This should be in the data section of your lab.

13. Make a line graph for the oxygen intake for peas, corn, and gravel. Put all three plots on the same graph and include a key.

14. Include the raw data sheet in the data section of the lab picked up.

Hypothesis: If peas and corn seeds are used to determine whether sugar or starch provides a better food source for cellular respiration, then oxygen intake and respiration rate will be greater.....

Data:

Table 1:

	24 Hours	48 Hours
Pea Seeds Volume (ml)		
Corn Seeds Volume (ml)		

APPENDIX D

Table 2:

Time (min.)	Oxygen Intake in (cm)													
	Peas						Corn						Gravel	Gravel
	Trial 1			Trial 2			Trial 1			Trial 2			Trial 1	Trial 2
	* uncorrected cm	corrected cm	ml	* uncorrected cm	corrected cm	ml	* uncorrected cm	corrected cm	ml	* uncorrected cm	corrected cm	ml	* uncorrected cm	* uncorrected cm
2														
4														
.														
.														
20														

Calculations:
Show all work for calculations. Use rules for significant digits.

Sketch:
Include the sketch with labels and a title.

Questions:

1. Is oxygen used for cellular respiration or is it released as a waste? What experimental evidence do you have to support your answer.
2. What was the control? What variable were controlled by using the control.
3. What is the NaOH (sodium hydroxide) were not used? Use the equation $C_6H_{12}O_6 + 6O_2 \rightarrow 6H_2O + 6CO_2$ to calculate how much, if any, the volume within the volumeter would change if the CO_2 were not removed. Explain.
4. What is the independant variable in this lab? What is the dependant variable?
5. Is the rate of respiration for the pea and corn seeds different?

Discussion: See "How to Write A Lab Report"

Conclusion: See "How to Write A Lab Report"

Source:

Biological Science: Interaction of Experiments and Ideas. 4th ed. New Jersey: Prentice-Hall, Inc., 1983.

La
Student
GENERA

LAB WR

DATA:

QUEST

DISC

CONC

Create

APPENDIX D

Lab Entry: 2-1 Measuring Rates of Respiration in Peas and Corn

Student I.D._____ Date:_____ Period:_____

GENERAL ITEMS:

_____ Neat and orderly (.5 pt.)
_____ Ink used (.5 pt.)
_____ Proper deletion used (.5 pt.)
_____ Entries underlined (.5 pt.)

LAB WRITE-UP:

_____ Heading (ID# / Date / Period #) (.5 pt.)
_____ Descriptive title (.5 pt.)
_____ Purpose: (organism/ variable [peas and corn] / problem (1 pt.)
_____ Hypothesis: (If organism / variable, then prediction (2pts)

DATA:

_____ Table 1: Team Vol. of Corn & Peas for 24 & 48 (2 pts.)
Title Column Headings (ml) corn, pea volume
_____ Table 2: Team Oxygen Intake in cm and ml (5 pts.)
Title Table set up corrected data(2 pts.) ml
_____ Calculations: (3 pts.) [MUST HAVE SIG FIGS]
Conversion equation table/peas calculations table/ corn calc.
_____ Raw data sheet (1 pt.)
_____ Sketch (3 pts.)
jar/water 3 t.t./contents rubber tubing/glass tubing
cotton/sodium hydroxide clamps Labels
_____ Graph (4 pts.)
Title/Key Scale/Spacing Labels/Units 2 Plottings Comp.Graph

QUESTIONS: (1 pt. for each question. Questions should be written out.)

_____1. Is oxygen used for cellular respiration or is it released as a waste? What experimental evidence do you have to support your answer.
_____2. What was the control? What variable(s) was (were) controlled?
_____3. What if the NaOH (sodium hydroxide) were not used? Explain.
_____4. What is the independent variable in this lab? What is the dependent variable?
_____5. Is the rate of respiration for the pea and corn seeds different?

DISCUSSION:

_____ (Sources of error / affect on results) (2 pts.)

CONCLUSION:

_____ Hypothesis (1 pt.)
_____ Reject or Accept (1 pt.)
_____ Data support (1pt.)
_____ Concluding relationship (1 pt.)

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APPENDIX D

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Student Comments:

Pre-Grade: Due Date:

ID#_____	Done	Corrections	Not Done	ID#_____	Done	Not Done
ID#_____	Done	Corrections	Not Done	ID#_____	Done	Not Done
ID#_____	Done	Corrections	Not Done	ID#_____	Done	Not Done

I agree to make the corrections disccussed with my team _____
(Initial)

Teacher Comments:

APPENDIX D

PRE-LAB EXERCISE 2-1:
Read section 4-3 on handout.
Answer the following questions.

1a. Fermentation is the process by which_____is broken down in the _____ of oxygen: It is also called _____ respiration.

b. Cellular respiration is the process by which _____ is broken down in the _____ of oxygen: It is also called _____ respiration.

2a. Write the equation for fermentation (include # of ATP molecules and omit the number of KCal or % of ATP stored).

b. Write the equation for cellular respiration (include # of ATP molecules and omit the number of KCal or % of ATP stored).

3a. How many ATP molecules are produced from the oxidation of one molecule of glucose in fermentation? _____

b. How many ATP molecules are produced from the oxidation of one molecule of glucose in cellular respiration? _____

c. What is the ratio of ATP produced in fermentation to ATP produced in cellular respiration? _____: _____

4. What type of organism is favored in an aerobic environment? Explain why.

5. Would a plant be a suitable organism to use to study cellular respiration? Explain your answer fully.

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APPENDIX D

Read section 4-4 on the handout.

1. What is the name of the apparatus that you will use to measure respiration rate?_____

2. Why does one of the tubes contain inert material (gravel)?
   _____

3. What two variables does this tube (thermobarometer) control?
   _____ _____

4. To maintain a controlled experiment the corn and peas will be equal in their:
   a. mass b. size c. volume d. density

5. The rate of respiration will be determined by measuring
   _____

6a. What gas needs to be removed from the tubes?_____
b. Explain why it needs to be removed?

c. How will it be removed?

Source:

Biological Science: Interaction of Experiments and Ideas. 4th ed. New Jersey: Prentice-Hall, Inc., 1983.

APPENDIX D

Chap. 9 : Respiration- How Cells Harvest Chemical Energy
Study Guide

Introduction:

1. The initial energy needed to start photosynthesis comes from the _____.
2. How do animal obtain fuel since they do not perform photosynthesis?

3. Organic molecules are needed for fuel, _____ and _____.
4. _____ is the process of breaking down glucose for energy in the presence of oxygen and _____ breaks down glucose in the absence of oxygen.
5. Draw figure 9.2 in the space provided. Label everything the way it is in the book. Then answer questions 6-10.

6. The chloroplast is the location of photosynthesis/respiration (Circle one)
7. What materials are needed in respiration?

8. What products (used and not used) are produced in photosynthesis?

9. What materials are needed in photosynthesis?

10. What products (used and not used) are produced in respiration?

How Cells Make ATP:

11. Draw the hydrolysis of ATP.

12. Does the above reaction produce energy or store energy? If it produces energy, how much?

An Overview of Cellular Respiration: p. 181

13. Complete the following chart:

Stage of Respiration:			
Location:			
Starting Materials			
Ending Materials			

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APPENDIX D

Fermentation: The Anaerobic Alternative:

14. What are two common forms of fermentation?

15. In _____ fermentation ethyl alcohol is produced. _____ and _____ can perform this kind of fermentation that is used in _____.

16. In _____ fermentation a product is produced that can make muscles fatigue. This type of fermentation can be carried out by _____ and _____ to make _____ and _____.

Comparison of Aerobic and Anaerobic Catabolism:

17. Compare strict aerobes, strict anaerobes, and facultative anaerobes. Make sure to include examples of each. (May be a good idea to make a chart for easy understanding)

18. Explain the difference in the making of wine, sparkling wine, and beer?

Catabolism of Other Molecules:

19. Humans obtain most or their calories from _____.

20. Explain the amount of energy produced by fat and why it is not recognized as the best respiration source.

Control of Respiration:

21. Define feedback inhibition:

22. How is cellular respiration controlled?

23. The rate of glycolysis is _____ by ATP and is _____ by ADP.

Thought Question:

24. -25. In the process of baking bread, an essential ingredient is yeast, which is uniformly distributed throughout the dough during mixing and kneading. Yeast is a facultative anaerobe. How would you expect the metabolism of yeast cells on the surface of the dough mixture to differ from the metabolism of yeast cells in the interior? What causes the bread to rise?

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APPENDIX D

Investigation 2-2: Respiration in Crickets

Questions:

1a. What two variables does the tube containing gravel control?
b. What was the experimental variable in this experiment?
c. What other variable(s) was (were) not controlled in this experiment?

2a. Write both the formula and work equations for both cellular respiration and fermentation. Include ATP produce in each process and indicate which equation is cellular respiration and which is fermentation.
b. Since cellular respiration requires oxygen, it is sometimes referred to by a different name. What is this name?
c. Why does a species that uses cellular respiration have an advantage (better survival odds) over a species that uses fermentation? Explain fully.

3a. How was the respiration rate measured in this experiment? Explain fully.
b. How and why was the carbon dioxide removed from the system?

APPENDIX D

Lab Entry: 2-2 Measuring Rates of Respiration in A Cricket

Student I.D._____ Date:_____ Period:_____

GENERAL ITEMS:

_____ Neat and orderly (.5 pt.)
_____ Ink used (.5 pt.)
_____ Proper deletion used (.5 pt.)
_____ Entries underlined (.5 pt.)

LAB WRITE-UP:

_____ Heading (ID# / Date / Period #) (.5 pt.)
_____ Descriptive title (.5 pt.)
_____ Purpose: (organism/ variable [cricket/ worm]
_____ Hypothesis: (If organism / variable, then prediction) (2pts.)

DATA:

_____ Table 1: Team Oxygen Intake in cm and ml (4pts.)
Title Table set up corrected data ml
_____ Calculations: [MUST HAVE SIG FIGS]
Conversion equation table/ cricket and worm calculations
_____ Raw data sheet
_____ Sketch
Statement
_____ Graph
Title/Key Scale/Spacing Labels/Units 2 Plottings Comp.Graph

QUESTIONS:

_____1a. What two variables does the tube containing gravel control?
_____ b. What was the experimental variable in this experiment?
_____c. What other variable(s) was (were) not controlled
_____2a. Write both the formula and work equations for both cellular respiration and fermentation. Include ATP produce in each...
_____b. What is a different name for cellular respiration.
_____ c. Why does a species that uses cellular respiration have an advantage over a species that uses fermentation? Explain
_____3a. How was the respiration rate measured in this experiment?
_____ b. How and why was the carbon dioxide removed ...?
_____ (pt. for each question. Questions should be written out.)

DISCUSSION:

_____ (Sources of error / affect on results) (pts.)

CONCLUSION:

_____ Hypothesis (1 pt.)
_____ Reject or Accept (1 pt.)
_____ Data support (1pt.)
_____ Concluding relationship (1 pt.)

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APPENDIX D

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Student Comments:

Pre-Grade: Due Date:

ID#_____	Done	Corrections	Not Done	ID#_____	Done	Not Done
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ID#_____	Done	Corrections	Not Done	ID#_____	Done	Not Done

I agree to make the corrections disccussed with my team _____
(Initial)

Teacher Comments:

APPENDIX D

RESPIRATION REVIEW

QUESTIONS:

1. What is the equation for respiration? Include the number of ATP molecules produced.
2. How is the equation for respiration different from the equation for fermentation?
3. What is the name of the apparatus used in lab exercises 2-1 and 2-2?
4. Why was water in that apparatus in both lab exercises?
5. What was the variable in lab exercise 2-1?
6. What was the variable in lab exercise 2-2?
7. Why was gravel placed in the third test tube?
8. Why was gravel mixed with the peas or corn?
9. What did the distance the bubble moved represent?
10. Why did the bubble move towards the system?
11. Give possible reasons the bubble could have moved away from the system.
12. What was the function of the sodium hydroxide?
13. What if the sodium hydroxide was not functioning properly? What would happen in either respiration lab exercise?
14. Give two examples of random errors from lab exercise 2-1 or 2-2.
15. Give two examples of systematic errors from either exercise.
16. Give two examples of discrete variables from either exercise.
17. Give two examples of continuous variables from either exercise.
18. What variable was introduced into the lab because of germination?
19. Which seed had a better respiration rate?
20. Which seed provides a better food source?
21. Why did you equalize the volumes of the pea seeds, corn seeds, and gravel?
22. What was the organism in lab exercise 2-2?
23. What variable(s) did you not control in lab exercise 2-2?
24. What was the variable in lab exercise 2-2?
25. What gas is used in cellular respiration?
26. What gas is given off as a waste in cellular respiration?
27. Which process, cellular respiration or fermentation, produces more energy?
28. Given another name for cellular respiration.
29. Give another name for fermentation.
30. Give an example of an organism that performs fermentation and cellular respiration?

APPENDIX E

APPENDIX E

Investigation 1-4: Enzyme Specificity and Digestive Disorders

Procedure:

1. Label centrifuge tubes: (One team only will do D, E, and F)
   A - Lactose D - Melibiose G - Yeast
   B - Lactose + Lactaid E - Melibiose + Lactaid
   C - Lactose + Beano F - Melibiose + Beano
   *ALSO INDICATE TEAM NUMBER AND PERIOD NUMBER
2. Put 8 ml of the lactose solution in tubes A, B, and C.
3. Add two drops of Lactaid® to tube B and two drops of Beano® to tube C.
5. Put 8 ml of the melibiose solution in tubes D, E, and F.
6. Add two drops of Lactaid® to tube E and two drops of Beano® to tube F.
7. Mix tubes by swirling then let the tubes stand for 10 minutes.
8. After 10 minutes, add enough yeast solution to each tube to completely fill the tube. There should be an overflow of solution so that when the parafilm (STEP 9) is placed on the tube the amount of gas in the tube is minimal.
9. Cover each tube with parafilm. Poke two holes in the parafilm with a pin provided by the teacher.
10. Invert each tube and place in your test tube holder in the water bath.
11. After 20 minutes mark the level of carbon dioxide.
12. Record results in table 1.
13. Make a bar graph to show the contents of each tube and the carbon dioxide production.

Data:

Make sure you include the following items in the data section of your lab:

1. Sketch of the apparatus used. Include title, contents of each tube, (include tests tubes D, E, and F even if your team did not set these tubes up.) temperature of the water bath and labels for equipment used.
2. Temperature during the experiment.

APPENDIX E

3. Table that includes the contents of each tubes used, and the amount of carbon dioxide produced. (Test tubes A - G)
4. Bar graph that shows the contents of each tube and how much carbon dioxide was produced. (Test tubes A - G)

Questions:

1. Did the Beano® drops breakdown both the lactose and melibiose?
2. If Beano® did not breakdown both sugars, explain why.
3. Did the Lactaid® drops breakdown both the lactose and melibiose?
4. If the Lactaid® drops did not breakdown both sugars, explain why.
5. What is in the drops that allows the breakdown of the sugars to occur?
6. What was the control in the experiment?
7. How does the temperature of this lab relate to human body temperature?
8. At what temperature were the drops designed to function in?

Discussion: See " How to Write A Lab Report"

Conclusion: See " How to Write A Lab Report"

Sources:

Campbell, Neil A, Biology 2nd ed., The Benjamin/Cummings Publishing Co., Inc., New York, 1990.

Reinking, Larry N., Jeffrey L. Reinking and Kenneth G. Miller. "Fermentation, Respiration & Enzyme Specificity: A Simple Device & Key Experiments with Yeast." The American Biology Teacher. vol. 56 (3), March 1994:164-168.

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APPENDIX E

TEACHER NOTES

Investigation 1-4: Enzyme Specificity and Digestive Disorders

Purpose: To observe the specificity of enzymes to sugars and learn how this can lead to digestive problems in humans.

Materials:

(per team)

7 plastic 15 ml centrifuge tubes
test tube holder-large enough to hold centrifuge tubes

(per class)

Lactaid® drops
Beano® drops
5% lactose solution- (Each team needs 24 ml)
5% melibiose solution - (Each team needs 24 ml)
7% yeast solution - (Each team needs 64 ml)
thermometer
tape
marking pen
water bath

Time Frame:

1 day

Teacher Prep:

Make lactose, melibiose, and yeast solutions the day of use.

Procedure:

1. Label centrifuge tubes: (One team only will do D, E, and F)

A - Lactose	D - Melibiose	G - Yeast
B - Lactose + Lactaid	E - Melibiose + Lactaid	
C - Lactose + Beano	F - Melibiose + Beano	

*ALSO INDICATE TEAM NUMBER AND PERIOD NUMBER

2. Put 8 ml of the lactose solution in tubes A, B, and C.
3. Add two drops of Lactaid® to tube B and two drops of Beano® to tube C.
5. Put 8 ml of the melibiose solution in tubes D, E, and F.
6. Add two drops of Lactaid® to tube E and two drops of Beano® to tube F.

APPENDIX E

7. Mix tubes by swirling then let the tubes stand for 10 minutes.
8. After 10 minutes, add enough yeast solution to each tube to completely fill the tube. There should be an overflow of solution so that when the parafilm (STEP 9) is placed on the tube the amount of gas in the tube is minimal.
9. Cover each tube with parafilm. Poke two holes in the parafilm with a pin provided by the teacher.
10. Invert each tube and place in your test tube holder in the water bath.
11. After 20 minutes mark the level of carbon dioxide.
12. Record results in table 1.
13. Make a bar graph to show the contents of each tube and the carbon dioxide production.

Organism: Saccharomyces cerevisiae - "yeast"

Hypothesis: If yeast is given melibiose and lactose sugars, then the sugars will not break down unless their proper enzyme, in Beano® or Lactaid®, is added, because yeast does not have the right enzymes to break down the two sugars.

Data:

Make sure you include the following items in the data section:

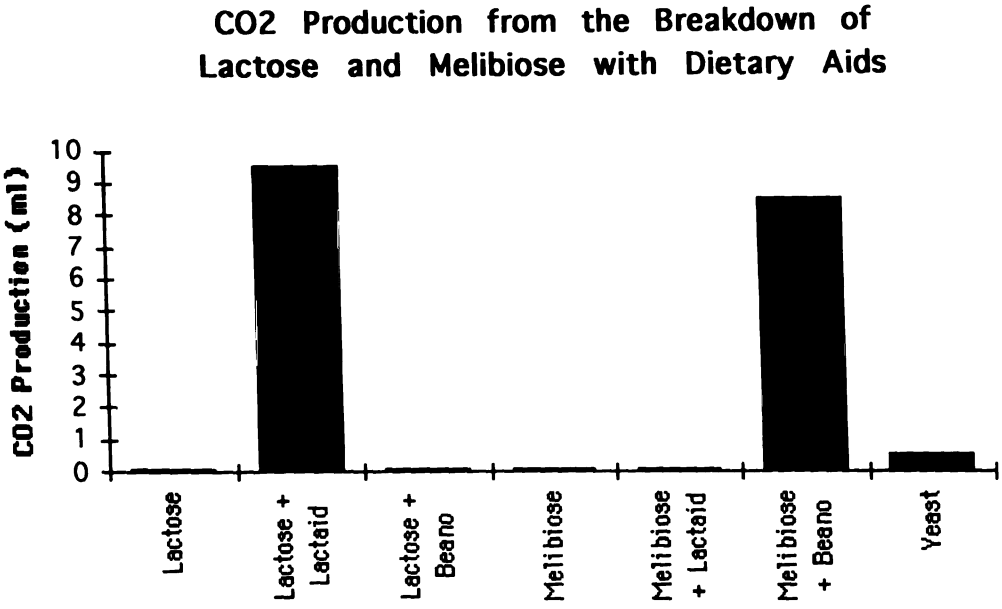
1. Sketch of the apparatus used. Include title, contents of each tube, (include tests tubes D, E, and F even if your team did not set these tubes up.) temperature of the water bath and labels for equipment used.
2. Temperature during the experiment. *Should be around 37° C*

Table 1: Carbon dioxide Production of Yeast with Two Different Sugars with added of Lactaid® drops and Beano® drops for 20 min.

Tube Letter	Contents	CO2 Produced
A	Lactose	trace
B	Lactose + Lactaid	9.5 ml
C	Lactose + Beano	trace
D	Melibiose	trace
E	Melibiose + Lactaid	trace
F	Melibiose + Beano	8.5 ml
G	Yeast	.5 ml

APPENDIX E

Sample Graph with 1996 Results



Questions:

1. Did the Beano® drops breakdown both the lactose and melibiose?
   They should only work with the melibiose.
2. Why didn't the Beano® drops breakdown both sugars?
   Beano® contains the enzyme necessary to break down one sugar, melibiose. Enzymes are specific.
3. Did the Lactaid® drops breakdown both the lactose and melibiose?
   They should only work with the lactose.
4. Why didn't the Lactaid® drops breakdown both sugars?
   Lactaid® contains the enzyme necessary to break down one sugar, lactose. Enzymes are specific.
5. What was the control in the experiment?
   The tube with just yeast.

APPENDIX E

6. How does the temperature of this lab relate to human body temperature?
   Human body temperature is around 37 C and the lab was suppose to be carried out between 37 C and 40 C.
7. At what temperature were the drops designed to function in?
   Human body temperature, which is around 37 C.

Discussion:
1. What problems did you encounter during the experiment?
2. What other factors contributed to your results?
3. What were sources of error? and how did they affect your data?

Conclusion: Restate your hypothesis. Explain whether or not you accept or reject the hypothesis and use actual observed data to support your statements. Last give a concluding relationship about enzymes and their specificity.

Note:
Melibiose is a costly sugar, so the concentration can be reduced to 1%, but the results will not be as dramatic.

Sources:

Campbell, Neil A, Biology 2nd ed., The Benjamin/Cummings Publishing Co., Inc., New York, 1990.

Reinking, Larry N., Jeffrey L. Reinking and Kenneth G. Miller. "Fermentation, Respiration & Enzyme Specificity: A Simple Device & Key Experiments with Yeast." The American Biology Teacher. vol. 56 (3), March 1994:164-168.

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APPENDIX E

Lab Entry: 1-4 Enzyme Specificity and Digestion Disorders

Student I.D._____ Date:_____ Period:_____

GENERAL ITEMS:

_____ Neat and orderly (.5 pt.)
_____ Ink used (.5 pt.)
_____ Proper deletion used (.5 pt.)
_____ Entries underlined (.5 pt.)

LAB WRITE-UP:

_____ Heading (ID# / Date / Period #) (.5 pt.)
_____ Descriptive title (.5 pt.)
_____ Purpose: (organism / variable / problem) (1 pts.)
(2 pts.)
_____ Hypothesis: (If organism / variable, then prediction [ideal T.T.'S]
_____ organism (1 pt.)

DATA:

_____ Sketch (4 pts.)
Title equipment/labeled temperature t.t contents
_____ Table 1 (3 pts.)
Title Column Headings CO_2 produced
_____ Table 2 (3 pts.)
Title Team data Averages
_____ Graph (4 pts.)
Title Scale/Spacing Labels/Units Plots

QUESTIONS:

_____1. Did the Beano® drops breakdown both? (1 pt.)
_____2. Why didn't the Beano® drops breakdown ..? (1 pt.)
_____3. Did the Lactaid® drops breakdown both? (1 pt.)
_____4. Why didn't the Lactaid® drops breakdown ...? (1 pt.)
_____5. What was in the drops...? (1 pt.)
_____6. What was the control? (1 pt.)
_____7. How does the temperature of this lab relate...? (1 pt.)
_____8. At what temperature were the drops designed for? (1 pt.)

DISCUSSION:

_____ (Sources of error / affect on results) (2 pts.)

CONCLUSION:

_____ Hypothesis (1 pt.)
_____ Reject or Accept (1 pt.)
_____ Data support (1pt.)
_____ Concluding relationship (1 pt.)

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_____ Extra	_____Extra	_____Extra	_____Extra
_____Score	_____Score	_____Score	_____Score
_____Grade	_____Grade	_____Grade	_____Grade

Student Comments:

Pre-Grade: Due Date:

ID#_____	Done	Corrections	Not Done	ID#_____	Done	Not Done
ID#_____	Done	Corrections	Not Done	ID#_____	Done	Not Done
ID#_____	Done	Corrections	Not Done	ID#_____	Done	Not Done

I agree to make the corrections disccussed with my team _____
(Initial)

Teacher Comments:

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APPENDIX E

Pre-Lab 1-4

Name:_____
ID#:_____Date:_____

Directions: Read pages 89-93 in the Green biology textbook. Then complete the following worksheet.

1. Explain the difference between exergonic and endogonic reactions.

2. Enzymes _____(increase/decrease) the activation energy needed for a chemical reaction. Why does this need to happen for reactions to occur?

3. Give two examples of what could go wrong in your body if your enzymes did not function properly.

4. Enzymes are made of _____.

5. Describe how an enzyme and substrate are like a lock and key.

6. Enzymes are specific. Give an example of their specificity in your body.

7. List the factors that affect the performance of enzymes. Explain what happens when the enzymes are not functioning under ideal conditions for each factor.

Lab 1-4 Background: Enzymes are involved in the digestion of sugars. Some humans lack the enzyme that is needed to break down the sugar lactose. Lactose is found in milk products. A person that cannot break down lactose sugar is said to be lactose intolerant. Now these people can find relief in an over the counter pill called Lactaid ® which contains the enzyme lactase to break down lactose sugar. The same situation exists for another sugar called

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melibiose. If a human does not have the enzymes to break it down they can take Beano ®which contains the enzyme melibiase. Yeast cannot break down lactose or melibiose very effectively. It lacks the proper enzymes. Design an experiment where yeast is given the two sugars to test for enzyme specificity. In other words, will adding Beano ® or Lactaid drops ® help the yeast break down the sugars, will Beano® break down lactose as well as melibiose and will Lactaid ® break down melibiose as well as lactose?

Title:

Purpose:

Organism:

Hypothesis:

Procedure: (Use labs 1-1, 1-2, and 1-3 to answer the following questions.)

1. At what temperature should this lab be conducted? What lab evidence do you have for your answer?

2. What concentration of sugar should be used? What lab evidence do you have for your answer?

3. Using the concentration % above calculate how many grams of lactose sugar will be needed to make a solution of 350 ml. SHOW ALL WORK

4. What kind of control should be set up? Explain your answer.

5. What can be measured to determine if yeast is breaking down lactose and melibiose? Explain your answer.

6. Explain how you would test your hypothesis. When possible give lab evidence for support.

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APPENDIX F

APPENDIX F

Investigation 4-4

Purpose:

Organism: *Raphanus sativa* "radish"
Phaseolus vulgaris "beans"
See respiration lab "corn"

Hypothesis:

Data:

Sketch: The Bean, Corn and Radish in the Light and Dark after 7 days. Include measurements on the drawing.

Table 1

Seven Days in the ___	Bean	Hypocotyle Length	Epicotyl Length	Angle of Cotyledon	Hypoctyl Color	Leaf Color	Expansion of Cotyledon	Radish	Hypocotyl Length	Cotyledon Width	Hypocotyl Color	Cotyledon Color	Corn	Leaf Height	Coleoptile Height	Leaf Width	Leaf Color
	1							1					1				
	2							2					2				
	3							3					3				

Table 2: Just like table 1 except the conditions of the light.

Sketch: The Bean, Corn and Radish in the Light and Dark after 9 days. Include measurements on the drawing.

Tables 3a-3c: (Summary tables) Record all data from all teams

APPENDIX F

Table 3a:

BEAN:																		
Measurement:	Hypocotyl Length						Epicotyl Lenght						Angle of Cotyledon					
Condition:	Light			Dark			Light			Dark			Light			Dark		
Time:	7 d	9 d	7 d 2 dk	7 d	9 d	7 d 2 Lt	7 d	9 d	7 d 2 dk	7 d	9 d	7 d 2 Lt	7 d	9 d	7 d 2 dk	7 d	9 d	7 d 2 Lt
Team#/Period																		

Table 3b:

CORN:																								
Measurement:	Leave Height								Coleoptile Height								Leaf Width							
Condition:	Light				Dark				Light				Dark				Light				Dark			
Time:	7 d	9 d	7 d 2 dk		7 d	9 d	7 d 2 Lt		7 d	9 d	7 d 2 dk		7 d	9 d	7 d 2 Lt		7 d	9 d	7 d 2 dk		7 d	9 d	7 d 2 Lt	
Team #/Period																								

APPENDIX F

Table 3c:

RADISH:												
Measurement:	Hypocotyl Length						Cotyledon Width					
Condition:	Light			Dark			Light			Dark		
Time:	7 d	9 d	7 d 2 dk	7 d	9 d	7 d 2 Lt	7 d	9 d	7 d 2 dk	7 d	9 d	7 d 2 Lt
Team#/Period												

APPENDIX F

Statistic Evaluation:

Do statistical evaluations on the above data. You should have two tests. Write out the null hypothesis, data box, statistic value, d.f. , p, accept or reject the null hypothesis and the conclusion. Record class data in the results table.

Questions:

1. Was there a significant difference between plants grown in light for 7 days vs. those grown in darkness for 7 days? Consider each characteristic measured separately, site t-test results to support your conclusions, and give reasons for any significant differences between the two groups.
    a. beans (3 characteristics)
    b. corn (3 characteristics)
    c. radish (2 characteristics)
2. Did placing plants grown in the light for 7 days into darkness for 2 days significantly effect their growth? Compare to plants grown in the light for 9 days. Consider each characteristic measured separately, site t-test results to support your conclusion, and give reasons for any significant differences between the two groups.
    a. beans (3 characteristics)
    b. corn (3 characteristics)
    c. radish (2 characteristics)
3. Did placing plants grown in the darkness for 7 days into the light for 2 days significantly effect their growth? Compare to plants grown in darkness for 9 days. Consider each characteristic measured separately, site t-test results to support your conclusion, and give reasons for any significant differences between the two groups.
    a. beans (3 characteristics)
    b. corn (3 characteristics)
    c. radish (2 characteristics)
4. In the germinating embryo, what is the function of:
    a. the cotyledon
    b. the hypocotyl in beans
    c. the coleoptile in corn

APPENDIX F

Statistical Results Table:
Results of Statistic Comparison of Characteristics of Bean, Corn, and Radish Plants Grown in Varying Amounts of Light

Characteristic	Comparison	PD/GD	T=	df	p=	Conclusion
Beans:						
Hypocotyl length	7 d.l. vs 7 d.l.					
Hypocotyl length	9 d.l. vs 9 d.d.					
Hypocotyl length	9 d.l vs 7 d.l. & 2 d.d.					
Hypocotyl length	9 d.d vs 7 d.d. & 2 d.l.					
Epicotyl lenght	7 d.l. vs 7 d.l.					
Epicotyl lenght	9 d.l. vs 9 d.d.					
Epicotyl lenght	9 d.l vs 7 d.l. & 2 d.d.					
Epicotyl lenght	9 d.d vs 7 d.d. & 2 d.l.					
Corn:						
Leaf Height	7 d.l. vs 7 d.l.					
Leaf Height	9 d.l. vs 9 d.d.					
Leaf Height	9 d.l vs 7 d.l. & 2 d.d.					
Leaf Height	9 d.d vs 7 d.d. & 2 d.l.					
Coleoptile Height	7 d.l. vs 7 d.l.					
Coleoptile Height	9 d.l. vs 9 d.d.					
Coleoptile Height	9 d.l vs 7 d.l. & 2 d.d.					
Coleoptile Height	9 d.d vs 7 d.d. & 2 d.l.					
Leaf Width	7 d.l. vs 7 d.l.					
Leaf Width	9 d.l. vs 9 d.d.					
Leaf Width	9 d.l vs 7 d.l. & 2 d.d.					
Leaf Width	9 d.d vs 7 d.d. & 2 d.l.					
Radish:						
Hypocotyl lenght	7 d.l. vs 7 d.l.					
Hypocotyl lenght	9 d.l. vs 9 d.d.					
Hypocotyl lenght	9 d.l vs 7 d.l. & 2 d.d.					
Hypocotyl lenght	9 d.d vs 7 d.d. & 2 d.l.					
Cotyledon Width	7 d.l. vs 7 d.l.					
Cotyledon Width	9 d.l. vs 9 d.d.					
Cotyledon Width	9 d.l vs 7 d.l. & 2 d.d.					
Cotyledon Width	9 d.d vs 7 d.d. & 2 d.l.					

APPENDIX F

5a. Write the formula and word equation for photosynthesis.
b. What evidence do you have that plants germinated in the dark do not perform photosynthesis?

Discussion:

1. What problems did you encounter during the experiment?
2. What other factors contributed to your results?
3. What were sources of error? and how did they affect your data?

Conclusion: Restate your hypothesis. Explain whether or not you accept or reject the hypothesis and use actual observed data to support your statements. Last propose a concluding relationship between light and the growth and development in three different plant species.

Sources:

Biological Science: Interaction of Experiments and Ideas. 4th ed. New Jersey: Prentice-Hall, Inc., 1983.

Campbell, Neil A, Biology 2nd ed., The Benjamin/Cummings Publishing Co., Inc., New York, 1990.

Hopkins, William G. Introduction To Plant Physiology. John Wiley & Sons, Inc. New York, 1995.

Developed by H. Krusenklaus with consultation with Dr. Ken Nadler

APPENDIX F

TEACHER NOTES

Investigation 4-4: The Effects of Light on Three Different Plants.

Purpose: To observe the differences between plants grown in the dark and light.

Materials:

(per team)

20 barley seeds or corn seeds
20 radish seeds
20 bean seeds
trays
12 coffee cups
vermiculite or sterile soil
metric rulers

Time Period:

15 min. day one
20 min. day two
20 min. on day seven

Teacher Prep:

Day one and two procedures could be done by the teacher.
Need to make bleach solution.

Procedure:

Day One: Disinfect Seeds and Soak

1. Disinfect the surface of the seeds with a 1% NaOCl solution. (Household bleach is 5.25% NaOCl. Dilute 1 volume bleach to 4 volumes water for an approximate 1 % NaOCl solution). Seeds should not be in the solution for more than two minutes.
2. Wash seed several times until the odor is gone.
3. Soak seeds overnight in a container with water running over them to thoroughly hydrate the seeds.

Day Two: Plant Hydrated Seeds

1. Fill coffee cups 2/3 full of vermiculite.
2. Poke 3 holes in the bottom of the cups with a pen.
3. Water each cup until the water starts to drain.
4. Plant 5 seeds of one species in each cup.
5. Put a little more vermiculite on top of the seeds and water again.
6. Place two cups of each seed type in a tray in the dark and place the other cups in a tray under grow lights.
7. Leave cups in this location for seven days.

APPENDIX F

Day Eight:

1. Take the following measurements for each plant, then calculate averages.
   In Beans - the hypocotyl length and epicotyl length
   In Barley - the leaf height and coleopile height
   In radish - the hypocotyl length and cotyledon width
   (See figure 1)
2. Observe color differences, expansion of cotyledons, and angle of cotyledons between treatments and record in table 1.
3. Compare your measurements of light and dark grown plants, then make a prediction as to what would happen if the plants that were in the dark are now put under grow lights for 48 hours. Prediction should include all characteristics measured on all three plants.
4. Place all plants under the grow lights for 2 days, except one cup of each kind of plant that was in the dark for the first 7 days. Put them back in the dark. Make sure you label the plants that were in the dark that are now being placed in the light.

Day Ten:

1. Remeasure plants in the dark and light and then measure plants that were in the dark for 7 days then placed in the light for two days.
2. Make sketches of each plant. Label measurements and use colored pencils.

Organism:	*Raphanus sativa*	"radish"
	Phaseolus vulgaris	"beans"
	Hordeum sative	"barley"

Hypothesis: If radish, bean, and barley seeds are placed in light and dark conditions, then the plants in the light will _____.

APPENDIX F

Data:

Sketch: The Bean, Corn and Radish in the Light and Dark after 7 days. Include measurements on the drawing.

Table 1

Seven Days in the ___	Bean	Hypocotyle Length	Epicotyl Length	Angle of Cotyledon	Hypoctyl Color	Leaf Color	Expansion of Cotyledon	Radish	Hypocotyl Length	Cotyledon Width	Hypocotyl Color	Cotyledon Color	Corn	Leaf Height	Coleoptile Height	Leaf Width	Leaf Color
	1							1					1				
	2							2					2				
	3							3					3				

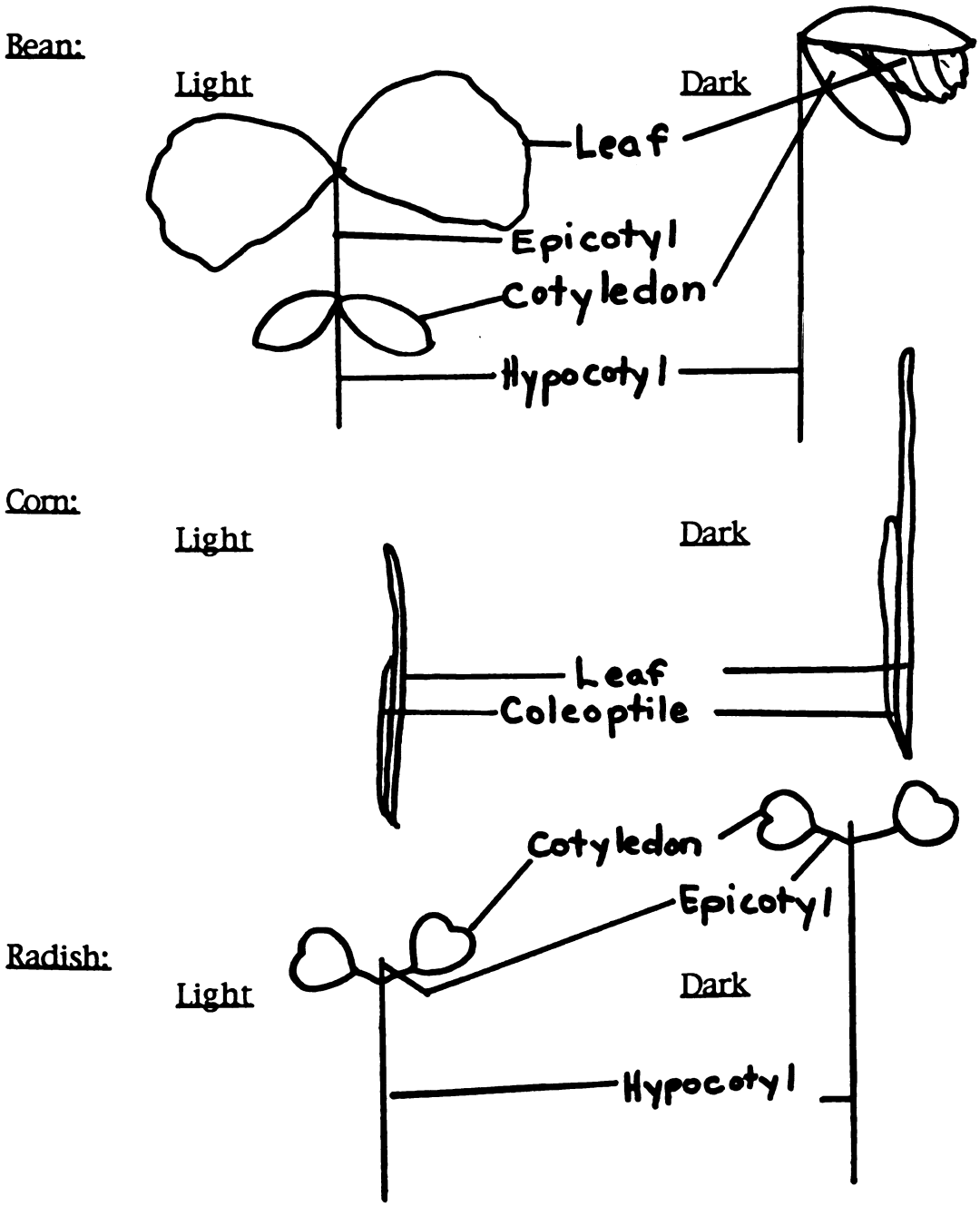
Table 2: Just like table 1 except the conditions of the light. *Students need to be assigned different conditions for the two days after the plants were in the dark for seven days.*

Sketch: The Bean, Corn and Radish in the Light and Dark after 9 days. Include measurements on the drawing.

Tables 3a-3c: (Summary tables) Record all data from all teams. SEE TABLES IN THE STUDENT LAB PROTOCOL.

APPENDIX F

Sample Sketches: Sketches of Bean, Barley and Radish Plant under Light Conditions and Dark Conditions for Seven Days



APPENDIX F

Data:

Sample Data : Structure Differences Between Three Different Seeds Germinated in the Light and Dark.

Condition	Light	Light	Dark	Dark	Light for 7
	For 7 Days	For 9 Days	For 7 Days	For 9 Days	Days Then Days,Dark for 2 Days
Seed Type/Measurement					
Beans:					
Hypocotyl Length	7.0 cm	7.0 cm	15.0 cm	20 cm	15 cm
Epicotyl Length	2.0 cm	3 cm	0 cm	1.5 cm	1 cm
Hypocotyl Color	green	green	white	white	green
Leaves Color	green	green	yellow	yellow	green
Expansion of Cotyledon?	expanded	expanded	not expanded	not expande d	expanded
Angle of Cotyledon	0	0	180	180	0
Barley:					
Leave Height	11.0 cm	12 cm	15.5 cm	17 cm	16 cm
Coleoptile Height	1.5 cm	3 cm	4 cm	4 cm	5 cm
Leave Width	.6 cm	.7 cm	.1 - .2 cm	.3 cm	.6 cm
Leave Color	green	green	yellow	yellow	green
Radish:					
Hypocotyl Length	4 cm	4 cm	-	8 cm	-
Cotyledon Width	1.5 cm	1.5 cm	-	1 cm	-
Hypocotyl Color	green	green	yellow	yellow	yellow
Cotyledon Color	green	green	yellow	yellow	yellow

Do statistical evaluations on the above data. You should have two tests. Write out the null hypothesis, data box, statistic value, d.f. , p, accept or reject the null hypothesis and the conclusion. Record class data in the results table.

APPENDIX F

Statistical Results Table:
Results of Statistic Comparison of Characteristics of Bean, Corn, and Radish Plants Grown in Varying Amounts of Light

Characteristic	Comparison	PD/GD	T=	df	p=	Conclusion
Beans:						
Hypocotyl length	7 d.l. vs 7 d.l.					
Hypocotyl length	9 d.l. vs 9 d.d.					
Hypocotyl length	9 d.l vs 7 d.l. & 2 d.d.					
Hypocotyl length	9 d.d vs 7 d.d. & 2 d.l.					
Epicotyl lenght	7 d.l. vs 7 d.l.					
Epicotyl lenght	9 d.l. vs 9 d.d.					
Epicotyl lenght	9 d.l vs 7 d.l. & 2 d.d.					
Epicotyl lenght	9 d.d vs 7 d.d. & 2 d.l.					
Corn:						
Leaf Height	7 d.l. vs 7 d.l.					
Leaf Height	9 d.l. vs 9 d.d.					
Leaf Height	9 d.l vs 7 d.l. & 2 d.d.					
Leaf Height	9 d.d vs 7 d.d. & 2 d.l.					
Coleoptile Height	7 d.l. vs 7 d.l.					
Coleoptile Height	9 d.l. vs 9 d.d.					
Coleoptile Height	9 d.l vs 7 d.l. & 2 d.d.					
Coleoptile Height	9 d.d vs 7 d.d. & 2 d.l.					
Leaf Width	7 d.l. vs 7 d.l.					
Leaf Width	9 d.l. vs 9 d.d.					
Leaf Width	9 d.l vs 7 d.l. & 2 d.d.					
Leaf Width	9 d.d vs 7 d.d. & 2 d.l.					
Radish:						
Hypocotyl lenght	7 d.l. vs 7 d.l.					
Hypocotyl lenght	9 d.l. vs 9 d.d.					
Hypocotyl lenght	9 d.l vs 7 d.l. & 2 d.d.					
Hypocotyl lenght	9 d.d vs 7 d.d. & 2 d.l.					
Cotyledon Width	7 d.l. vs 7 d.l.					
Cotyledon Width	9 d.l. vs 9 d.d.					
Cotyledon Width	9 d.l vs 7 d.l. & 2 d.d.					
Cotyledon Width	9 d.d vs 7 d.d. & 2 d.l.					

APPENDIX F

Questions:

1. Was there a significant difference between plants grown in light for 7 days vs. those grown in darkness for 7 days? Consider each characteristic measured separately, site t-test results to support your conclusions, and give reasons for any significant differences between the two groups.
   a. beans (3 characteristics)
   b. corn (3 characteristics)
   c. radish (2 characteristics)
2. Did placing plants grown in the light for 7 days into darkness for 2 days significantly effect their growth? Compare to plants grown in the light for 9 days. Consider each characteristic measured separately, site t-test results to support your conclusion, and give reasons for any significant differences between the two groups.
   a. beans (3 characteristics)
   b. corn (3 characteristics)
   c. radish (2 characteristics)
3. Did placing plants grown in the darkness for 7 days into the light for 2 days significantly effect their growth? Compare to plants grown in darkness for 9 days. Consider each characteristic measured separately, site t-test results to support your conclusion, and give reasons for any significant differences between the two groups.
   a. beans (3 characteristics)
   b. corn (3 characteristics)
   c. radish (2 characteristics)
4. In the germinating embryo, what is the function of:
   a. the cotyledon
   b. the hypocotyl in beans
   c. the coleoptile in corn

5a. Write the formula and word equation for photosynthesis.

b. What evidence do you have that plants germinated in the dark do not perform photosynthesis?

APPENDIX F

Discussion:

1. What problems did you encounter during the experiment?
2. What other factors contributed to your results?
3. What were sources of error? and how did they affect your data?

Conclusion: Restate your hypothesis. Explain whether or not you accept or reject the hypothesis and use actual observed data to support your statements. Last propose a concluding relationship between light and the growth and development in three different plant species.

Sources:

Biological Science: Interaction of Experiments and Ideas. 4th ed. New Jersey: Prentice-Hall, Inc., 1983.

Campbell, Neil A, Biology 2nd ed., The Benjamin/Cummings Publishing Co., Inc., New York, 1990.

Hopkins, William G. Introduction To Plant Physiology. John Wiley & Sons, Inc. New York, 1995.

Developed by H. Krusenklaus with consultation with Dr. Ken Nadler

APPENDIX F

Lab Entry: 4-4 The Effects of Light On Three Different Plant Species
Student I.D._____ Date:_____ Period:_____

GENERAL ITEMS:

_____ Neat and orderly (.5 pt.)
_____ Ink used (.5 pt.)
_____ Proper deletion used (.5 pt.)
_____ Entries underlined (.5 pt.)

LAB WRITE-UP:

_____ Heading (ID# / Date / Period #) (.5 pt.)
_____ Descriptive title (.5 pt.)
_____ Purpose: (organisms/variable) (1pt.)
_____ Hypothesis: (If organisms /variable, then prediction) (2pts)
_____ Organisms: *Scientific name* (all three)(1 pt.)

DATA:

_____ Sketch- 7 days: (3 pts.) Title Pictures Labeled
_____ Table 1: (3 pts.) Title data units/headings
_____ Sketch - 9 days: (3 pts.) Title Pictures Labeled
_____ Table 2: (3 pts.) Title data units/headings
_____ Table 3: (2 pts.) Title data
_____ Statistical calculations 1 (2 pts.)
null/ t formula/ t/ d.f./ p/ accept or reject/ conclusion
_____ Statistical calculations 2 (2 pts.)
null/ t formula/ t/ d.f./ p/ accept or reject/ conclusion
_____ Statistical Results Table (1 pts.) Title data

QUESTIONS:

_____ 1. 7 days light vs. 7 days dark....beans,corn,radish (3 pts.)
_____ 2. 7 days dark 2 light vs. 9 days light....beans,corn,radish (3 pts.)
_____ 3. 7 days light 2 dark vs. 9 days dark....beans,corn,radish (3 pts.)
_____ 4. What is the function of the cotyledon,hypocotyl, and coleoptile? (1)
_____ 5. Write the formula and word equation for photosynthesis and give evidence for no photosynthesis in the dark. (2 pts.)

DISCUSSION:

_____ (Sources of error / affect on results) (2 pts.)

CONCLUSION:

_____ Hypothesis (1 pt.)
_____ Reject or Accept (1 pt.)
_____ Data support (1pt.)
_____ Concluding relationship (1 pt.)

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APPENDIX F

ID #	ID #	ID #	ID #
35 Possible	35 Possible	35 Possible	35 Possible
Missed	Missed	Missed	Missed
Extra	Extra	Extra	Extra
Score	Score	Score	Score
Grade	Grade	Grade	Grade

Student Comments:

Pre-Grade:

Due Date:

ID#_____	Done	Corrections	Not Done	ID#_____ Done	Not Done
ID#_____	Done	Corrections	Not Done	ID#_____ Done	Not Done
ID#_____	Done	Corrections	Not Done	ID#_____ Done	Not Done

I agree to make the corrections disccussed with my team _____ (Initial)

Teacher Comments:

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APPENDIX F

Campbell Reading Assignment:
Read p.748-751

1. Explain why seed germination is not the beginning of life.

2. List as many ways as you can the seeds break their dormancy.

3. Explain why seed dormancy is considered an adaptation.

4. Explain why after an area of land has been burned the vegetation can come back stronger than it was before the fire.

5. Define imbibition-

6. Why do the foliage leaves turn green?

7. Why are cotyledons needed? Why does the plant dispose of them?

8. How does a seed know that it has grown above ground?

9. Explain etiolation and relate it to the current lab.

10. Draw and label a corn and bean plant the is above ground and has foliage leaves. Label the foliage leaves, epicotyl, hypocotyl, cotyledon, and coleoptile.

APPENDIX F

Campbell Reading Assignment:
Read p.748-751

1. Explain why seed germination is not the beginning of life.
   Seed contains miniature plant
   During seed germination growth resumes

2. List as many ways as you can the seeds break their dormancy.
   water fire rocks intense heat light cold
   digestion of animals

3. Explain why seed dormancy is considered an adaptation.
   Seeds have different factors that break their dormancy based on their environment.

4. Explain why after an area of land has been burned the vegetation can come back stronger than it was before the fire.
   Seeds are durable enough to last a year or two until conditions are favorable for germinating. Therefore a pool of seeds can accumulate.
5. Define imbibition-
   Absorption of water by a dry seed

6. Why do the foliage leaves turn green?
   The green color is needed to absorb sunlight convert to sugar. (Photosynthesis)
7. Why are cotyledons needed? Why does the plant dispose of them?
   They serve as food reserves. Plants dispose of them after food has been consumed.
8. How does a seed know that it has grown above ground?
   When it reaches the light.

9. Explain etiolation and relate it to the current lab.
   Make a seed think it is still below ground by keeping it in the dark. (That is what we are doing in the lab exercise)
10. Draw and label a corn and bean plant the is above ground and has foliage leaves. Label the foliage leaves, epicotyl, hypocotyl, cotyledon, and coleoptile.
    See textbook page 750 or lab protocol

APPENDIX F

Investigation 4-5: The Effects of Light on Radish Cotyledons

Purpose: To determine if light will effect the color and growth of cotyledons from dark - grown radish plants.

Materials:
(per team)
2 small petri dishes
2 pieces of filter paper (or 4 layers of paper towel)
30 radish seedlings - 7 days old
razor blade
forceps

Time Frame:
2 days

Teacher Prep:

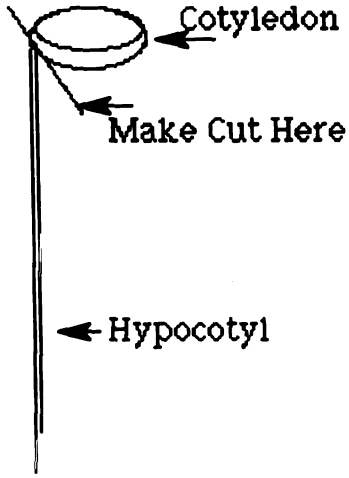
1. Plant radish seeds in the dark seven days before lab experiment is started. Leave planted seeds in the dark until the experiment begins. Seeds should be soaked overnight then planted in vermiculite. Leave the seeds in a dark cabinet for seven days.

Procedure Day I:

1. Work in a dim light room or under "true " green lights.
2. Remove seed coats from cotyledon. (Most will have fallen off.)
3. Gently cut cotyledon at the point of attachment to the stem. (See figure 1).
4. With forceps, pull two halves of the cotyledons apart.
5. Determine the weight of 25 cotyledons then place them in a petri dish lined with filter paper and place it under a light source. The light source should be between 20-24 cm. Weigh another 25 cotyledons and place them in the other petri dish lined with filter paper in the dark. Make sure you label each dish and set up a table to record data. See table 1.
6. Add 1.5 ml of water to each petri dish. Filter paper should be wet with very little excess.
7. Leave dishes in this placement for 48 hours.

APPENDIX F

Figure 1: Diagram of Two Halves to Cotyledon and Where to Make Cut.



Procedure Day III:

1. Pull out the petri dishes and record observations.
2. Blot dry the cotyledons grown in the light and weigh. Blot dry the cotyledons grown in the dark and weigh.
3. Calculate changes in weight on team data table, then record team data in class data table.

Organism: *Raphenus sativa* " radish "

Hypothesis: If radish leaves are used to study the effects of light on the cotyledon development, then the cotyledons placed in the dark will _____.

Data:

Table 1: Mass of Radish Cotyledons Before Experiment and After Exposure to the Light and Dark Conditions for 48 Hours

Radish Cotyledons	Cotyledons in the Light	Cotyledons in the Dark
Weight Before		
Weight After		
Difference (+/-)		

APPENDIX F

Table 2: Class Data on Weight of Radish Cotyledons Before Experiment and After Exposure to Light and No Light for 48 Hours

Color of Light	Light	Dark
Team #		
1		
2		
3		
4		
5		
6		
7		
Total		
Average		

Statistic Evaluation:
Do statistical evaluations on the above data. You should have four tests. Write out the null hypothesis, data box, statistic value, d.f. , p, accept or reject null hypothesis and the conclusion.

Questions:
1. What effect does light have on the radish cotyledons?
2. Why do you think it "make sense" for cotyledons to respond to light in this manner?

Discussion:
1. What problems did you encounter during the experiment?
2. What other factors contributed to your results?
3. What were sources of error? and how did they affect your data?

APPENDIX F

Conclusion: Restate your hypothesis. Explain whether or not you accept or reject the hypothesis and use observed data to support your statements. Propose a concluding relationship between Cotyledon growth and the presence of light

Sources:

Biological Science: Interaction of Experiments and Ideas. 4th ed. New Jersey: Prentice-Hall, Inc., 1983.

Campbell, Neil A, Biology 2nd ed., The Benjamin/Cummings Publishing Co., Inc., New York, 1990.

Hopkins, William G. Introduction To Plant Physiology. John Wiley & Sons, Inc. New York, 1995.

Developed by H. Krusenklaus with consultation with Dr. Ken Nadler

APPENDIX F

Investigation 4-6: The Effects of Different Wavelengths on Radish Cotyledons

Purpose: To determine if different wavelengths of light will effect the color and growth of radish cotyledons.

Materials:

(per team)

4 small petri dishes
6 pieces of filter paper (or 4 layers of paper towel)
30 radish seedlings - 7 days old
red cellophane-need enough layers to block all wavelengths but red
green cellophane-need enough layers to block all wavelengths but green
blue cellophane-need enough layers to block all wavelength but blue
razor blade
forceps

(per class)

cups
vermiculite
radish seeds
grow lights

Time Frame:

2 days

Teacher Prep:

1. Plant radish seeds in the dark seven days before lab is started. Leave seeds in the dark until the experiment begins. Seeds should be soaked overnight then planted in vermiculite. Leave the seeds in a dark cabinet for seven days.

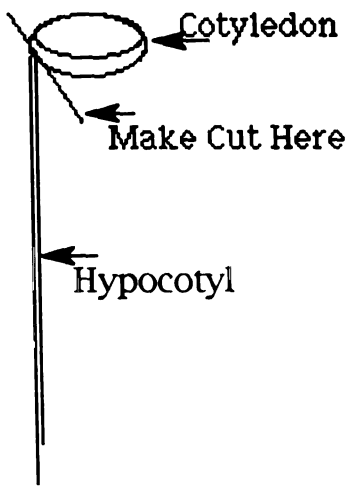
Procedure Day I:

1. Work in a dim light room or under "true " green lights.
2. Remove seed coats from cotyledon. (Most will have fallen off.)
3. Cut cotyledon at the point of attachment to the stem. See figure 1. You need to be very careful when handling the cotyledons. It you cut or damage one, do not use it.
4. With forceps, pull the two halves of the cotyledons apart.

APPENDIX F

5. Weigh a group of 10 cotyledons and place in a petri dish lined with filter paper and cover the dish with red cellophane repeat the procedure for the blue cellophane and green cellophane and a petri dish with no cellophane. Set up a table to record weight of each set of cotyledons. (See table 1).
6. Add 1.5 ml of water to each petri dish. Filter paper should be wet with very little excess.
7. Place each petri dish under grow lights for 48 hours.

Figure 1: Diagram of Two Halves to Cotyledon and Where to Make Cut.



Procedure Day III:

1. Pull out the petri dishes and record observations.
2. Blot dry the cotyledons and weigh.
3. Record your data on team data table and calculate averages.

Organism: *Raphanus sativa* " radish "

Hypothesis: If radish leaves are used to study the effects of different wavelengths of light on the cotyledon development, then the cotyledons placed in the light will _____, in the blue will _____, in the green will _____, and the red will _____.

APPENDIX F

Data:

Table 1: Mass of Radish Cotyledons Before Experiment and After Exposure to Different Wavelengths of Light for 48 Hours

Radish Cotyledons	Cotyledons in the Red	Cotyledons in the Green	Cotyledons in the Blue	Cotyledons in the Light
Mass Before				
Mass After				
Difference (+/-)				

Table 2: Class Data on Weight of Radish Cotyledons Before Experiment and After Exposure to Different Wavelengths of Light for 48 Hours

Color of Light	Red	Blue	Green	Light	Dark
Team #					
1					
2					
3					
4					
5					
6					
7					
Total					
Average					

Statistic Evaluation:

Do statistical evaluations on the above data. You should have four tests. Write out the null hypothesis, data box, statistic value, d.f. , p, accept or reject null hypothesis and the conclusion.

Do a chi square for red and light, green and light, and blue and light.

APPENDIX F

Questions:

1. What effect did the different wavelengths of light have on the color of the cotyledons?
2. What effect did the different wavelengths of light have on the weight of the cotyledons?

Discussion:

1. What problems did you encounter during the experiment?
2. What other factors contributed to your results?
3. What were sources of error? and how did they affect your data?

Conclusion: Restate your hypothesis. Explain whether or not you accept or reject the hypothesis and use actual observed data to support your statements. Last give a concluding relationship between radish cotyledons grown under different wavelengths of light.

Sources:

Biological Science: Interaction of Experiments and Ideas. 4th ed. New Jersey: Prentice-Hall, Inc., 1983.

Campbell, Neil A, Biology 2nd ed., The Benjamin/Cummings Publishing Co., Inc., New York, 1990.

Hopkins, William G. Introduction To Plant Physiology. John Wiley & Sons, Inc. New York, 1995.

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APPENDIX F

Lab Extension: Can Different Wavelengths of Light Cause Fruit To Ripen?

Purpose: To use information gained from radish wavelength lab and design a lab to cause an apple to ripen.

Materials:

(per team)

4 pieces of black construction paper
blue cellophane-enough to block all wavelengths except blue
green cellophane-enough to block all wavelengths except green
red cellophane-enough to block all wavelengths except red
2 unrip apples or tomatoes (Need light sensitive fruits)
[Jonathan, Rome Beauty Apples (Green) or Green tomatoes]

Time Frame:

30 min. to set up
results may not be seen for 10 days

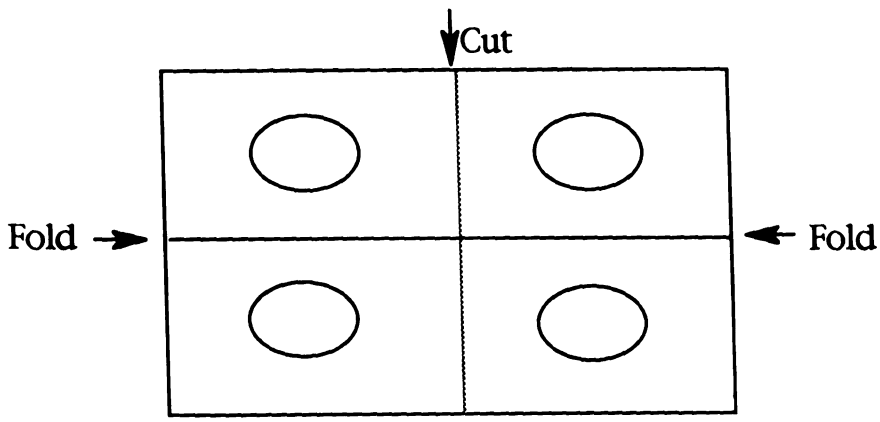
Teacher Prep:

None

Procedure:

1. Construct two boxes out of the black construction paper. One serves as the control and should be all black. The other should have windows with different colored cellophane.
2. Cut a piece of construction paper in half in the wide direction. See figure 1.

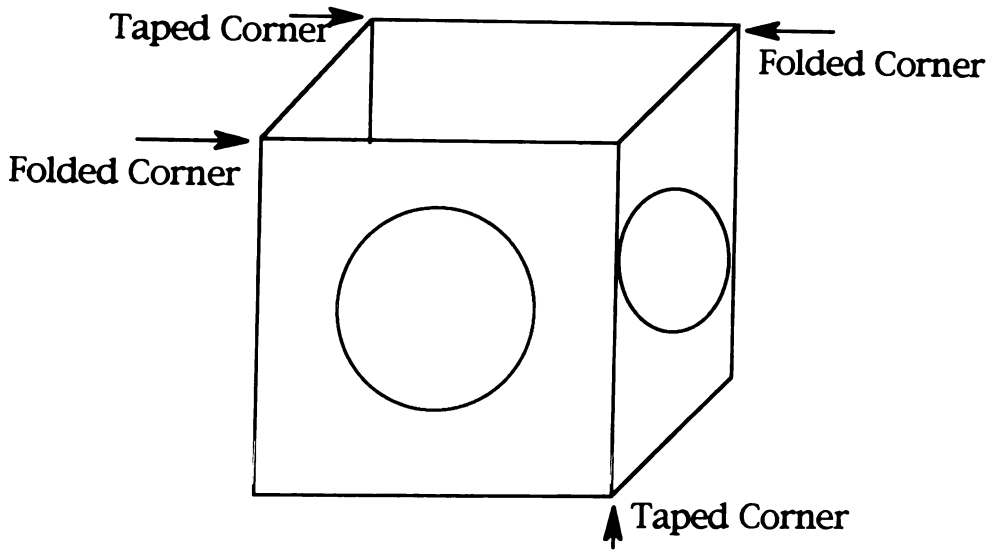
Figure 1: Diagram to Construct Box



APPENDIX F

3. Fold each piece in half to make corners.
4. Using a small petri dish for a pattern, cut out circles.
5. Cover each window with a different color of cellophane.
6. Tape the two pieces of construction paper together. See figure 2.

Figure 2: Attachment of Two Construction Pieces to Make Box



7. Cut out a square piece of construction paper that will cover the top of the box with some overhang. Use the extra overhang to tape the lid to the sides of the box, so light does not get in.
8. Construct another box with no windows. This box will serve as the control.
9. Put an apple or tomato under each box. Make sure the fruit is level with the windows.
10. Let the experiment stand for at least ten days or until any color changes occur.
11. Lights could be place around each window, but do not put them too close or else heat will be an unwanted variable.

APPENDIX F

Organism: "apple"

Hypothesis: If an apple is placed under a box which allows different wavelengths of light to pass through, then the side of the apple facing the ____red____ cellophane will turn red first.

Data:
Record observations

Questions:
1. What color of cellophane did you predict would cause the fruit to ripen? Why did you choose this color?
2. Where you right?
3. Why do you think you got the results you obtained?
4. Could there be other factors that effect the ripening of fruit? Explain.

Discussion:
1. What problems did you encounter during the experiment?
2. What other factors contributed to your results?
3. What were sources of error? and how did they affect your data?

Conclusion: Restate your hypothesis. Explain whether or not you accept or reject the hypothesis and use actual observed data to support your statements. Last give a concluding relationship between fruit ripening and different wavelenghts of light.

Sources:
Biological Science: Interaction of Experiments and Ideas. 4th ed. New Jersey: Prentice-Hall, Inc., 1983.
Campbell, Neil A, Biology 2nd ed., The Benjamin/Cummings Publishing Co., Inc., New York, 1990.
Hopkins, William G. Introduction To Plant Physiology. John Wiley & Sons, Inc. New York, 1995.

Developed by H. Krusenklaus 1996

APPENDIX F

Lab 4-1: Comparison of Two Seed Viability Tests

Purpose: To statisitcally compare two seed viability tests.

organisms- get organisms from other labs

Hypothesis: If (organisms) (variable, experiment), then prediction.

Procedure: See figure 1

1. Get 100 soaked seeds of the seed type you are assigned. (Most teams will be assigned corn while others will have corn.)
2. Put 50 seeds in boiling water for ten minutes.
3. Place 25 soaked seeds in wet paper towel in your germination tray. Label the seeds " not boiled."
4. Place 25 soaked/boiled seeds in wet paper towel on top of the " not boiled" seeds. Label the seeds "boiled."
5. Label the tray: Team #, Period # and store in the cabinets for three days.
6. Using a razor blade cut 25 soaked seeds in half through the embryo.
7. Place 25 halves in the petri dish lid. (Throw the other halves away.)
8. Using a razor blade cut 25 boiled seeds in half through the embryo.
9. Place 25 halves in the petri dish bottom plate. (Throw the other halves away.)
10. Add enough tetrazolium to each petri dish to cover the cut half of the seeds.
11. Wait 30 minutes and record tetrazolium results in table 1. If the seeds are viable the cut side of the seeds will turn pink.

Day 3:

1. Complete table 2 for the germination test.

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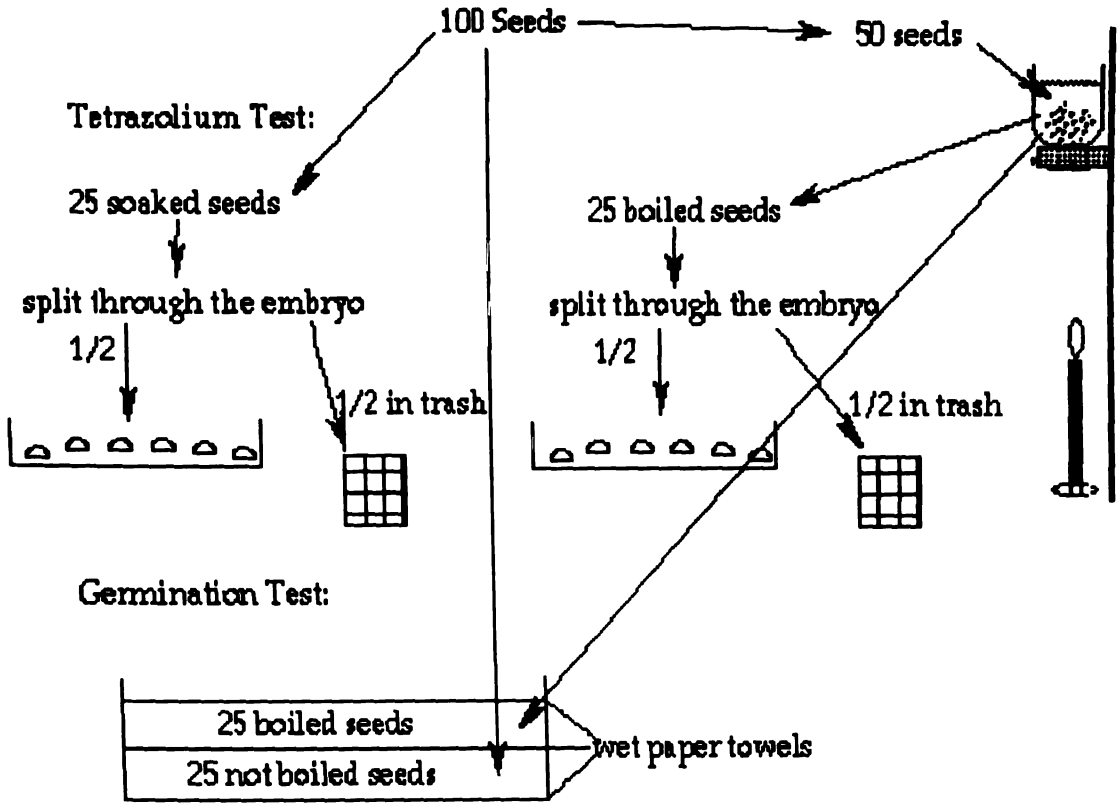
Figure 1 - Flow chart for lab procedure.



Data:

Table 1:

Seed Type	Tetrazolium Test	
	not boiled	boiled
Total Number of Seeds		
Number of Viable Seeds		
% of Viable Seeds		

Table 2:

Seed Type	Germination Test	
	not boiled	boiled
Total Number of Seeds		
Number of Viable Seeds		
% of Viable Seeds		

APPENDIX F

Table 3:

Tetrazolium Test:								
Corn not boiled	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Total	Average
Total Number of Seed								
Number of Viable Seeds								
% of Viable Seeds								
Corn boiled								
Total Number of Seed								
Number of Viable Seeds								
% of Viable Seeds								
Tetrazolium Test:								
Peas not boiled	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Total	Average
Total Number of Seed								
Number of Viable Seeds								
% of Viable Seeds								
Peas boiled								
Total Number of Seed								
Number of Viable Seeds								
% of Viable Seeds								

APPENDIX F

Table 4:

Germination Test:								
Corn not boiled	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Total	Average
Total Number of Seed								
Number of Viable Seeds								
% of Viable Seeds								
Corn boiled								
Total Number of Seed								
Number of Viable Seeds								
% of Viable Seeds								
Germination Test:								
Peas not boiled	Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Total	Average
Total Number of Seed								
Number of Viable Seeds								
% of Viable Seeds								
Peas boiled								
Total Number of Seed								
Number of Viable Seeds								
% of Viable Seeds								

Statistic Evaluation:

Apply a test of significance to your viability test results. One test should be done on the two viability tests for corn and another for the viability tests for peas. Show the null, data box, all calculations, d.f., p, accept/reject null hypothesis, and conclusion.

Questions:

1. What does viable mean?
2. What was the control in this experiment?
3. In what part of the seeds you examined was the chemical action of the tetrazolium greatest?
4. How did the percentages of viability in the two tests compare?
5. What test of significance was used to evaluate the difference between the two viability tests? Why?
6. After doing the statistic evaluation, did you find the differences to be significantly different? at what level of confidence? (Hint: What probability could you be wrong?)

APPENDIX F

Discussion: See "How to Write a Lab Report"

Conclusion: See "How to Write a Lab Report"

Sources:

Biological Science: Interaction of Experiments and Ideas. 4th ed. New Jersey: Prentice-Hall, Inc., 1983.

Adapted by H. Krusenklaus 1996

APPENDIX G

Lab 12-2: Meiosis with Insect Chromosomes

Objectives:

1. Manipulate chromosomes models to demonstrate the events of meiosis I and II.
2. Use chromosome models to demonstrate segregation and independent assortment in the process of meiosis.
3. Calculate gamete possibilities.
4. Construct offspring phenotype based on parent genetics.

Background:

A newly discovered insect has six chromosomes in its genome. All genes on the chromosomes have been mapped, so that the patterns of inheritance and relationships between genotypes and phenotypes can be studied. You will use models of insect's chromosomes to study the process of meiosis.

Procedure For Lab:

Manipulate the provided chromosomes according to the following directions. Answer all "data" question on a piece of paper separate from the actual lab write up. Your data section should include figures 1-7 and one table.

Interphase I:

1. Place one copy of each chromosome (6 total)in the center of your lab station.
2. Surround the chromosomes with a circle of string.
3. Take a larger piece of string and make a circle around the first circle.

Data:

1. *What does the first circle around the chromosomes represent?*
2. *What does the circle around the inner circle represent?*
3. *What is the diploid number of chromosomes for this insect?*
4. *What would be the haploid number of chromosomes?*
5. *How many chromosomes came from the mother?*
6. *How many chromosomes came from the father?*
7. *How many homologous pairs are in your cell?*

Figure 1 - Draw the homologous pairs and illustrate the genes. Label each pair with their chromosome number (See Key) or as sex chromosomes. (Colors should match paper chromosomes.) [Sketch should have a title including - Figure 1]

APPENDIX G

Key to Gene Symbols and Genomes

Chromosome #1	Chromosome #2	Sex Chromosome
D = resistant to DDT	A = long abdomen	X = female
d = not resistant to DDT	a = short abdomen	Y = male
H = large head	B = blue body	B = black eyes
h = small head	b = yellow body	b = blue eyes
R = round eyes	Bb = green body	F = fertile
r = oval eyes	L = six legs	--- = no coding
S = straight wings	l = four legs	
s = crumpled wings	S = black spotted body	
P = antennae present	s = no spots	* = chromosome
p = antennae absent	P = high pitch mating	from mother
L = long legs	p = low pitch mating call	(egg)
l = short legs	W = walk on water	
C = compound eyes	w = cannot walk water	# = chromosome
c = simple eyes	T = long thorax	from father
B = wide stripes (Body)	t = short thorax	(sperm)
b = narrow stripes	I = long wings	
W = four wings	i = short wings	
w = two wings	O = salvia with poison	
T = bristles on body	o = salvia with no poison	
t = no bristles on body		

4. Add a copy of each chromosome to the circle to simulate replication. Copies would be connected to the original copies in actual cell.

APPENDIX G

Prophase I:

1. Put the homologous chromosomes side by side.
   Data:.

Figure 2 - Draw the three tetrads that are formed, and illustrate genes. Label tetrads, homologous chromosomes, chromosomes, chromatids, centromeres. (Colors should match paper chromosomes.)
[Sketch should have a title including - Figure 2]

2. Cut the right chromatid of chromosome 1 below the S gene (wing shape gene) and cut the left chromatid of the homologous chromosome in the same location. Exchange pieces between the two chromosomes and tape the new pieces to their new chromosome. [This represents crossing over.]

3. Cut the right chromatid of chromosome 2 above the T gene (thorax gene) and cut the left chromatid of the homologous chromosome in the same location. Exchange pieces between the two chromosomes and tape the new pieces to their new chromosome. [This represents crossing over.]

Figure 3 - Draw the three tetrads with their genes after crossing over has occurred. Label tetrads and chromosome numbers or sex chromosomes. (Colors should match paper chromosomes.)
[Sketch should have a title including - Figure 3]

Metaphase I:

1. Take the inner circle of string away.
2. Line all chromosomes up so that their centromeres line up on a straight line in the center of the cell.
   Data:
   8. Why did you take the inner circle of string away?

Anaphase I:

1. Pull homologous chromosomes to opposite poles in the cell.
   Data:
   9. What structures move chromosomes to the poles?

APPENDIX G

Telophase I:

1. Put a string circle around each set of chromosomes to simulate the appearance of nuclear membranes.
2. Cytoplasm splits down the middle to produce two daughter cells.
3. Use string to create the cell membrane of the new cell produced.

Data:

Figure 4 - Draw two daughter cells, illustrate genes on the chromosomes and include all the contents of the cells. Label cell membrane, nuclear membrane, and chromosomes. (Colors should match paper chromosomes.) [Sketch should have a title including - Figure 4]

10. Can the two cells formed be identical?
11. How many homologous pairs are in each cell?

Interphase II:

1. Leave the cells the way they are.

Data:

12. Why doesn't replication occur in interphase II?

Prophase II:

1. Remove the circles that represent the nuclear membranes.

Metaphase II:

1. Line chromosomes up at the center of each cell.

Anaphase II:

1. Pull sister chromatids to opposite poles in their cells.

Telophase II:

1. Put a string circle around each set of chromosomes to simulate the appearance of nuclear membranes.
2. Cytoplasm splits down the middle to produce four daughter cells.
3. Use string to create the cell membrane of the new cells produced.

Data:

13. How many gametes have been formed?
14. How many chromosomes are in each gamete?
15. How many homologous chromosomes are in each gamete?
16. Gametes in a female would be called ____?
17. Gametes in a male would be called ____?

APPENDIX G

Figure 5- Draw the four gametes that you produced and illustrate genes on the chromosomes. Include the cell membrane, nuclear membrane and the chromosomes. Label the parts that are drawn. (Colors should match paper chromosomes.)
[Sketch should have a title including - Figure 5]

18. Are there other possible gametes that could have formed?

Sexual Fusion:

1. Pick one gamete from your four and combine it with a gamete that is randomly given to you from another team.

Data:

Figure 6 - Draw the cell produced by combining your gamete with that of another team and illustrate genes on the chromosomes. Label homologous chromosomes, chromatids, and cell membrane. (Colors should match paper chromosomes.)
[Sketch should have a title including - Figure 6]

19. How many chromosomes are in the offspring?
20. How does this number compared to the number of chromosome in a cell during interphase before replication in this insect?

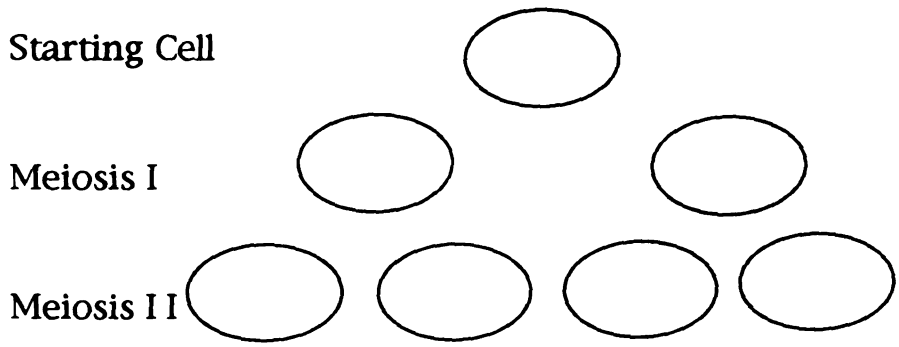
Table 1 - Create a table for each chromosome number to list the genotypes and phenotypes of each characteristic in the insect produced. Use Key chart for phenotypes.
[table should have a titles including - Table 1]

Figure 7 - Draw the insect produced according to the phenotypes listed in your table 1. [Sketch should have a title including - Figure 7]

APPENDIX G

Questions: **(Include these in lab write up.)**

1. How many genes for a single trait are found in each gamete?
2. What mechanism separates linked genes during meiosis?
3. Why doesn't crossing over occur in mitosis?
4. How does crossing over create genetic diversity?
5. Why does meiosis require twice as many stages as mitosis?
6. Make a diagram showing a starting cell with 10 chromosomes. Illustrate the cell product of meiosis I and meiosis II with the numbers of how many chromosomes would be in each cell.



Discussion: Discuss at least one problem that could go wrong in meiosis and lead to a specific genetic disorder.

Conclusion: Discuss what type of cells that go through meiosis and why they go through meiosis and not mitosis. Also explain the importance of crossing over.

Take a Step Ahead: (Earn up to 20 pts. extra credit.)
Design a 3-D model of your insect based on all phenotypes listed in tables 1-3 in your lab write-up.

APPENDIX G

Campbell, Neil A, Biology 2nd ed., The Benjamin/Cummings Publishing Co., Inc., New York, 1990.

Cordero, Robert E. and Cynthia A. Szewczak. " The Developmental Importance of Cell Division." The American Biology Teacher. vol. 56(3), March 1994:176-179.

McKean, Heather R. and Linda S. Gibson. "Hands - on Activities that Relate Mendelian Genetics to Cell Division." The American Biology Teacher. vol. 51 (5), May 1989:294-300.

Rindos, David and J.W. Atkinson. "Pizza Chromosomes: A Method for Teaching Modern Genetics." The American Biology Teacher. vol. 52 (5), May 1990:281-287.

Stencel, John. " A String & Paper Game of Meiosis that Promotes Thinking." The American Biology Teacher. vol. 57 (1), January 1995: 42-45.

Taylor, Mark F. "Hands - on Activity for Mitosis, Meiosis, and the Fundamentals of Heredity." The American Biology Teacher. vol. 50 (8), November/December 1988:509-512.

Lab Developed by H. Krusenklaus 1996

APPENDIX G

Lab Exercise 12- 2: Meiosis with Insect Chromosomes

Interphase I:

1. What does the first circle around the chromosomes represent? nuclear membrane
2. What does the circle around the inner circle represent? cell membrane
3. What is the diploid number of chromosomes for this insect? six
4. What would be the haploid number of chromosomes? three
5. How many chromosomes came from the mother? three
6. How many chromosomes came from the father? three
7. How many homologous pairs are in your cell? three

Metaphase I:

8. Why did you take the inner circle of string away? The nuclear membrane starts to disappaer in prophase and is completely gone in metaphase.

Anaphase I:

9. What structures move chromosomes to the poles? Spindle fibers

Telophase:

10. Can the two cells formed be identical? no
11. How many homologous pairs are in each cell? none (they split up)

Interphase II:

12. Why doesn't replication occur in interphase II? The cell is reducing the genetic information in half. Replication would go against this.

Telophase II:

13. How many gametes have been formed? four
14. How many chromosomes are in each gamete? three
15. How many homologous chromosomes are in each gamete? none
16. Gametes in a female would be called _eggs____?
17. Gametes in a male would be called _sperm____?
18. Are there other possibilities of gametes that could have been formed? yes

APPENDIX G

Sexual Fusion:

19. How many chromosomes are in the offspring? six
20. How does this number compared to the number of chromosomes in a cell during interphase before replication in this insect? same

Table 1: Genotypes and Phenotypes Produced in Offspring

Genotype	Phenotype
Dd	resistant to DDT
HH	large head
Rr	round eyes
Ss	straight wings
pp	antennae absent
LL	long legs
CC	compound eyes
bb	narrow banding
Ww	four wings
Tt	bristles on body

Questions

1. How many genes for a single trait are found in each gamete? one
2. What mechanism separates linked genes during meiosis? crossing over
3. Why doesn't crossing over occur in mitosis?
   Mitosis produces new cells from existing cells. The genetic information needs to be identical in the existing cell and the new cell.
4. How does crossing over create genetic diversity?
   When crossing over occurs it combines genes from different linkage groups, which in turn creates many different gamete possiblities which creates genetic diversity.
5. Why does meiosis require twice as many stages as mitosis?
   Meiosis reduces the genetic information in half. A cell must go through the stages twice to reduce the genetic information in half.
6. Make a diagram showing a starting cell with 10 chromosomes. Illustrate the cell product of meiosis I and meiosis II with the numbers of how many chromosomes would be in each cell.

APPENDIX G

Starting Cell	10			
Meiosis I	10	10		
Meiosis I I	5	5	5	5

Discussion: Discuss at least one problem that could go wrong in meiosis and lead to a specific genetic disorder.

Conclusion: Discuss what type of cells that go through meiosis and why they go through meiosis and not mitosis. Also explain the importance of crossing over.

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Lab Entry: Lab 12-2: Meiosis with Insect Chromosomes

Student I.D._____ Date:_____ Period:_____

GENERAL ITEMS:

_____Neat and orderly (.5 pt.)
_____Ink used (.5 pt.)
_____Proper deletion used (.5 pt.)
_____Entries underlined (.5 pt.)

LAB WRITE-UP:

_____Heading (ID# / Date / Period #) (.5 pt.)
_____Descriptive title (.5 pt.)
_____Purpose: (1 pt.)

DATA:

_____Figure 1 - Homologous Chromosomes (Three pairs) (2pt.)
Title Color/Genes Labeled: Numbers
_____Figure 2 - Three Tetrads in Prophase. (2 pt.)
Title/Color/Genes/Labeled:tetrads, homo. chromo.,chromo. chromatids, cent.
_____Figure 3 - Three Tetrads after Crossing Over (2 pt.)
Title Color/Genes Labeled: tetrads and chromosome numbers
_____Figure 4 - Two Daughter Cells (2 pt.)
Title/Color/Genes Labeled: cell mem, nuclear mem.,chromo.
_____Figure 5 - Four Gametes (2 pt.)
Title/Color/Genes Labeled: cell mem., nuclear mem.,chromo.
_____Figure 6 - Cell produced from the Egg and Sperm cells. (2 pt.)
Title/Color/Genes Labeled:homo.chromo., chromatids, cell mem.
_____Figure 7 - Insect Produced from Genome (3pt.)
Title Color Correct phenotypes
_____Table 1: Key to Insect Genotype and Phenotype (4 pt.)
Ch1 Geno/Pheno Ch2 Geno/Pheno SexCh Geno/Pheno

QUESTIONS: (1 pt. each)

_____ 1. How many genes for a single trait are found in each gamete?
_____ 2. What mechanism separates linked genes during meiosis?
_____ 3. Why doesn't crossing over occur in mitosis?
_____ 4. How does crossing over create genetic diversity?
_____ 5. Why does meiosis require twice as many stages as mitosis?
_____ 6. Make a diagram showing a starting cell with 10 chromosomes.
_____ Line between answer and next question (1 pt.)

DISCUSSION:

_____Discuss at least one problem (2 pts.)

CONCLUSION:

_____Discuss what type of cells, why, crossing over (3pts.)

Pre-Grade Date Post Grade Date

Grader ID#_____ Done Corrections Not Done Grader ID#_____Done N/Corrected N/Done
Grader ID#_____ Done Corrections Not Done Grader ID#_____Done N/Corrected N/Done
Grader ID#_____ Done Corrections Not Done Grader ID#_____Done N/Corrected N/Done

I have discussed this lab with all members of my group signed above and agree to make all corrections indicated before the post grade date.

Owner ID# _____ Initial _____

CREATED BY H. KRUSENKLAUS 1997

APPENDIX G

Group:_____ **Period:**_____ **Date:**_____

ID#_____	ID#_____	ID#_____	ID#_____
Total__35__	Total__35__	Total__35__	Total__35__
X-Cre ±_____	X-Cre ±_____	X-Cre ±_____	X-Cre ±_____
Missed -_____	Missed -_____	Missed -_____	Missed -_____
Score_____	Score_____	Score_____	Score_____

Lab Entry: Lab 12-2: Meiosis with Insect Chromosomes

_X_ - Indicates areas of concern

GENERAL ITEMS:

_____ Neat and orderly (.5 pt.)
_____ Ink used (.5 pt.)
_____ Proper deletion used (.5 pt.)
_____ Entries underlined (.5 pt.)

LAB WRITE-UP:

_____ Heading (ID# / Date / Period #) (.5 pt.)
_____ Descriptive title (.5 pt.)
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_____ Figure 1 - Homologous Chromosomes (Three pairs) (2pt.)
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Title Color/Genes Labeled: tetrads and chromosome numbers
_____ Figure 4 - Two Daughter Cells (2 pt.)
Title/Color/Genes Labeled: cell mem, nuclear mem.,chromo.
_____ Figure 5 - Four Gametes (2 pt.)
Title/Color/Genes Labeled: cell mem., nuclear mem.,chromo.
_____ Figure 6 - Cell produced from the Egg and Sperm cells. (2 pt.)
Title/Color/Genes Labeled:homo.chromosomes, chromatids, cell mem.
_____ Figure 7 - Insect Produced from Genome (3pt.)
Title Color Correct phenotypes
_____ Table 1: Key to Insect Genotype and Phenotype (4 pt.)
Ch1 Geno/Pheno Ch2 Geno/Pheno SexCh Geno/Pheno

QUESTIONS:

_____ 1. How many genes for a single trait are found in each gamete?
_____ 2. What mechanism separates linked genes during meiosis?
_____ 3. Why doesn't crossing over occur in mitosis?
_____ 4. How does crossing over create genetic diversity?
_____ 5. Why does meiosis require twice as many stages as mitosis?
_____ 6. Make a diagram showing a starting cell with 10 chromosomes.
Two daughter cells? Four gametes?
_____ Line between answer and next question (1 pt.)

DISCUSSION:

_____Discuss at least one problem (2 pts.)

CONCLUSION:

_____Discuss what type of cells that go through meiosis and why they go through meiosis and not mitosis. Also explain the importance of crossing over. (3 pts.)

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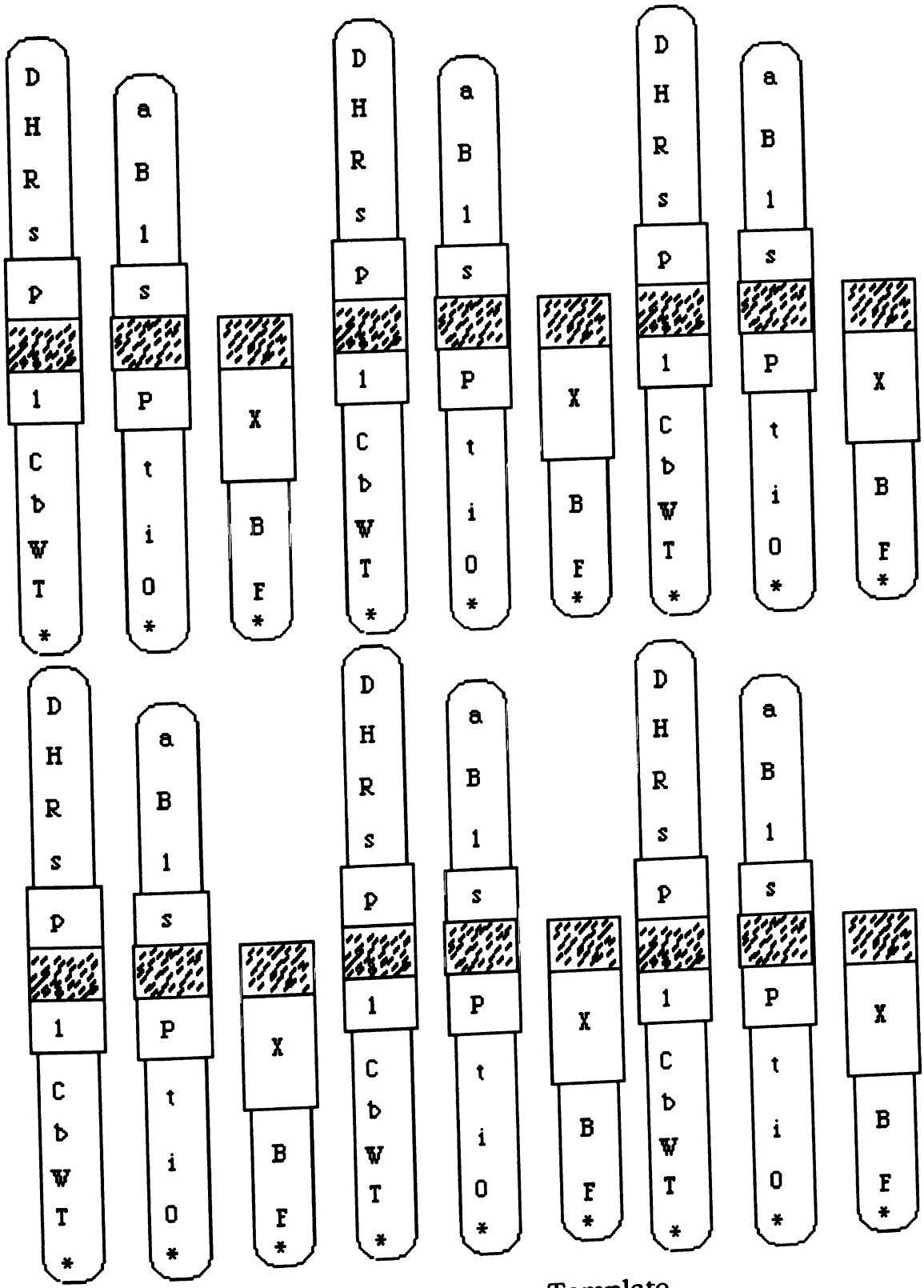

Female Chromosomes Template

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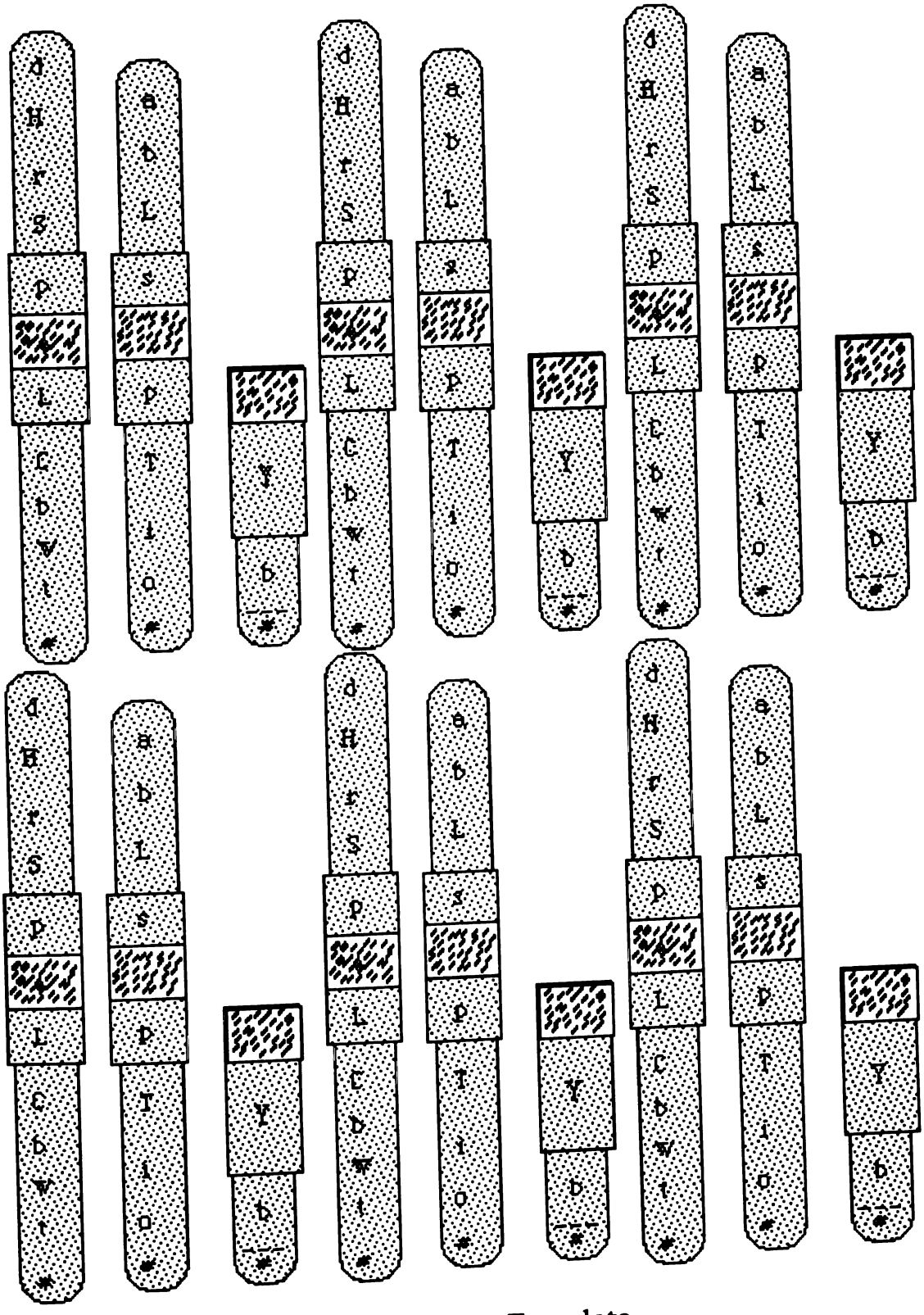

Male Chromosomes Template

APPENDIX G

CHANGES TO IMPROVE LABORATORY EXERCISE 12-2

1) The directions for crossing over confused many students, so they should be clarified.
2) If the procedure is followed accurately all students are given a male insect genome. Therefore when students are instructed to combine gametes to simulate sexual fusion, they are being asked to reproduce with two sperm cells. We corrected this by having students come to the teacher to receive their egg.
3) In the key to genes table(in the lab protocol), I included a walking on water trait found on chromosome number two that was not included on the template chromosomes used by the students. This allele should be added to the templates or removed from the key.
4) Students should label the gamete in figure five that they chose for figure six. This notation will be helpful when grading the report.
5) In figure six of the lab protocol, students should not label the chromatids (they are not there!).
6) Students should be provided with drawings to choose from when they make their sketch for figure seven. Students needed to know what the characteristics look like otherwise it was impossible to accurately grade the students' interpretations.

APPENDIX H

APPENDIX H

LAB REPORT PROCEDURE FOR
INITIAL AND FINAL EVALUATIONS

BACKGROUND: This class is designed to teach you how to problem solve, organize data, design experiments, use laboratory equipment, work on a team to achieve a common goal, and compose scientific reports. The Initial and Final Evaluations are set up for students to use their team members for constructive feedback on their progress with the items listed above in addition to what the teacher gives. The Initial and Final Evaluation sessions are also set up to insure that each member is writing their own report and understands the material in the report.

EXTRA CREDIT:

1.) If you type the lab report. The only parts that may be done by hand are the sketches and calculations. If you type your lab you will receive 3 points towards your lab grade.

2.) If one lab is turned in for the whole team. If a team works well together, communicates well, stays on task, and comes to class prepared, then only one lab should need to be turned in. Each member of the team needs to be done or done with corrections for the Initial Evaluation and done for the Final Evaluation. Each member will receive 5 points toward the lab.

3.) If one lab is turned in for the whole team, but not everyone is done for the Initial Evaluation. The Initial Evaluation is major component in understanding the labs reports. If team members are not done for the Initial Evaluation and they ask questions of their team and their team thoroughly makes comments on the grade sheet, then only one lab should need to be turned in. Each member of the team will receive 3 points toward the lab.

LOSE POINTS:

1.) If your station, sink, tray or cabinet is not kept clean at all times. If I see or the next hour team points out that your team left a mess, then everyone on your team will lose 2 points.

2.) You are not done on due dates. See below for points.

INITIAL EVALUATION PROCEDURE:

1.) Your lab should be checked for completion by everyone on your team. Each member signs his class ID and circles **DONE, NOT DONE, OR CORRECTIONS, then comments should be clearly stated on the grade sheet for individuals that are not done or have corrections to make.**

2.) Each team member should sign the top of their grade sheet to make a contract that the lab report will be corrected and complete the day of Final Evaluation.

3.) Any person that is not done for Initial Evaluation loses 25% (8 points).

4.) Any team that is caught circling done or corrections on a lab that is clearly not done will lose 25% (8 points).

APPENDIX H

5.) If a person is absent from the group, request to evaluate the lab report the day the individual returns. If at all possible give your lab report to your group or me if you know you are going to be gone. If the lab report is not Initially Evaluated then the team and individual could lose 25%.

6.) If you are absent the day of the Initial Evaluation, pick up a grade sheet from me the day you return and have your team evaluate your lab.

FINAL EVALUATION PROCEDURE:

1.) Check everyone's lab report for completion and corrections made. Circle **Done or Not Done** on the grade sheet. Decide which team members will be in the drawing for a team grade. If all team members are in the drawing and no one lost points, then the whole team will receive extra credit.

2.) If a person was not done for Initial Evaluation and they are not done for Final Evaluation, 50% (16 points) will be taken off their lab grade.
*This lab will be graded separately.

3.) If a person needed to make corrections and they did not make them, 25% (8 points) will be taken off their lab grade. [*Graded separately.]

4.)If a person was not done or needed to make corrections and on Final Evaluation day the team feels there are too many differences in this lab, then the team may decide to have the teacher grade two lab reports. Keep in mind no extra credit will be earned for the team.

5.) IF A PERSON IS ABSENT:

-If you know in advance, like a field trip, appointment or school meeting, then you must turn your lab report into me or your team before the hour it is due.

-If you have an unplanned absence and it is excused, your lab report is due the day you return. The team will evaluate the lab report and then we will draw.
(I will draw from present students the day of Final Evaluations)

-If you have an unplanned absence and it is unexcused, you will receive a zero on the lab report.

CHEATING:

1.) If a team is caught with similar answers to questions, discussions, and/or conclusions, then

1st time --- whole team receives a zero on the parts that are similar
2nd time ---whole team receives a zero on the lab
3rd time---whole team will be in jeopardy of failing the nine weeks

2.)Any team that is caught circling done on a lab that is not done will:

1st time ---whole team lose 25% (8 points)
2nd time---whole team lose 50% (16 points)
3rd time ---whole team receives a zero

NO LATE LABS WILL BE ACCEPTED

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APPENDIX H

Lab Format Below:

ID#
Investigation # and Title period
date due

Purpose: States what the lab is supposed to do or why you are doing the lab. States organism and variable.
organism: Scientific name "common name"

Hypothesis: States your prediction of what you expect to happen using words If(organism).....[condition/variable]....then (prediction)....because....(reason)."

Data: Includes all your observations including tables, graphs, and sketches. **Organize data tables before the lab.** Title all tables. Title should include organism, condition and variable. All graphs should be titled and labeled indicating variables and units. The title should include organism, condition and variable. The independent variable goes on the horizontal axis. Select units of scale for each axis so that the graph will fill the page. Except in special cases the intercept should be labeled zero. Show all calculations done during the lab including equations used. Labeled drawings should be used to show apparatus setups.

Questions: Copy the question and, answer in complete sentences. Leave a blank line after each answer.

Discussion: List any errors or problems and what affect it had on your results.

Conclusion: Should be a brief summary of what was learned. Always refer back to your hypothesis. It's important that you can relate to the teacher your understanding of the lab by explaining **Why** the results turned out the way they did. This is scientific writing and should not include emotional reactions or feelings. Include a discussion of your findings supported by data to support your conclusions. Attempt to explain your results based upon the data you collected.

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APPENDIX H

Lab Report Write- Up Directions

Guidelines to Follow in Write - up:

1. All entries are to be done in blue or black ink (use same color throughout). Entries must be accurate, orderly and neat. To make a correction, draw a single line through the error and neatly make the correction above the error. When a large area needs correction use the "Void" method.
2. You are required to keep your rough labs, pre-lab notes, etc. in a three ring notebook. The lab section should have a table of contents of all labs in order of completion.
3. You are required to keep all final labs in a science spiral notebook The first three pages should be left blank for a table of contents.
4. Only write on one side of the paper in the science notebook. (Should be the right side when notebook is opened all the way.)
5. During certain labs tables, graphs, pictures, etc. may be permitted to be taped or glue (use glue stick) into your lab book. Be careful to avoid hiding any information underneath.
6. Never use first person (I....we....you...etc.). The exception is in the discussion and conclusion sections.
7. Typed labs will receive 3 extra credit points. They should be stapled into the science notebook.

Organization of Science Notebook:

1. Tape in the front cover the "Lab Format" sheet.
2. Tape in the back cover this page.
3. First three pages should be set aside for table of contents.
4. The fourth page should have the "Pre-Grade/Post- Grade Procedure" sheet taped or stapled to it.
4. Labs should be written into notebook in the order they are assigned.
5. Labs that are due should have a paper clip marking the first page of the lab.

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APPENDIX H

Closing Team Procedure

Directions for all students:

1. Take out a sheet of paper and put your name in the top right hand corner.
2. Write "Team Comments" at the top of your paper in the middle.
3. Divided the sheet into two columns. At the top of the left column write "Did Well" and at the top of the right column write "Work On."
4. Circulate your paper to all your teammates.
5. Each teammate should write at least two positive comments in the left column and one positive suggestion in the right column about each team members behavior in the team. Use words below to guide your comments.
6. Each team member should sign their name in top left hand corner of each comment sheet to which they added their feedback.

When each student gets their comment sheet back:

1. Turn your comment sheet over.
2. Divided it into two columns with the same headings on the front side.
3. Write what you think you did well in your team and what you will work on with the new team.

Communication	Helping
Listening	Staying
Equal participation	On task
Asking	Praising

APPENDIX H

Team Assessment Scale

1	2	3
•little interaction	•some interaction	•enthusiastic interaction
•conversations not always focused	•conversation usually focused	•involved conversation on topic
•one person dominates	•two people are involved	•whole group contributes
•several students off task	•one student off task	•all students on task

Team	1	2	3	4	5	6	7	
Date								

Adapted by H. Krusenklaus from Model Instruction Unit

APPENDIX H

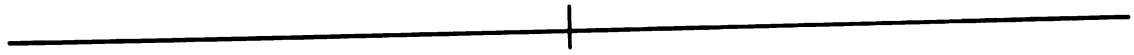
Student Evaluation of Cooperation in Their Team

Directions: Circle the word that most agrees with the statement.

ID#_____Period_____

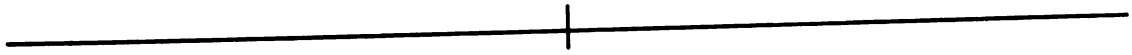
1. Same as number 6.

2. I asked others for their ideas and information.



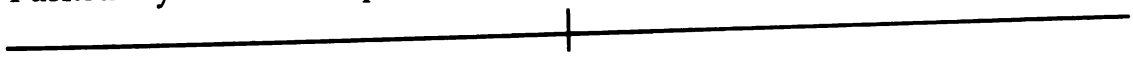
Always Sometimes Never

3. I summarized all our team ideas and information.



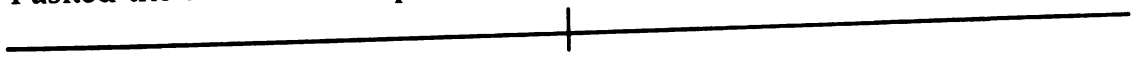
Always Sometimes Never

4. I asked my team for help when I needed it.



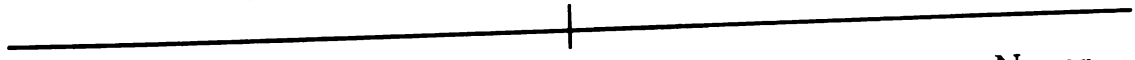
Always Sometimes Never

5. I asked the teacher for help when I needed it.



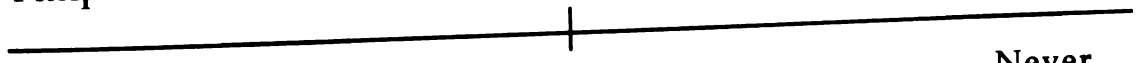
Always Sometimes Never

6. I contributed my ideas and information.



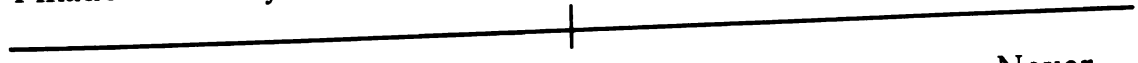
Always Sometimes Never

7. I helped the other members of my group learn.



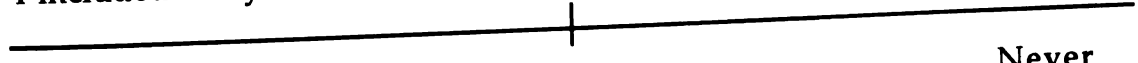
Always Sometimes Never

8. I made sure everyone in my group understood how to do the lab work.



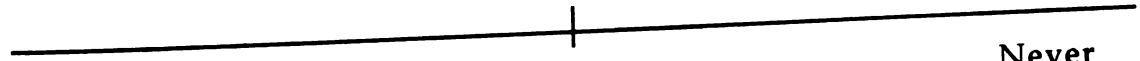
Always Sometimes Never

9. I included everyone in team discussions.



Always Sometimes Never

10. I worked hard to be done for pre-grade and post grade dates.



Always Sometimes Never

Adapted from Handout on Cooperative Learning

APPENDIX H

Portfolio Outline

I. Table of Contents
- Should include the following items with item numbers. (Put everything in your portfolio, number each item (not each page), then complete the item number for the table of contents.
- Items should be in the order given below.
- If you do not have one of the following items, write it on the table of contents and write "not present" under item number.

II. Lab 1-1
Lab 1-2
Lab 1-3
Lab 2-1
Lab 2-2
Lab 1-4
Lab 4-4
Lab 4-5

- On the table of contents include lab titles.
- Staple Initial and Final Evaluation sheets to each lab report

III. Selected Lab: Pick a lab that most reflects you. Write an essay about the following questions.
- State the lab number and title.
- Why did you pick this lab?
- If you could work further on this lab, what would you do?
- What I still don't understand is.....
- You may want to include rough draft lab notes to make a point.

IV. Concept Map Using the following words:
- fermentation, respiration, carbon dioxide, oxygen, sugar, aerobic, anaerobic, yeast, peas, corn, cricket, earthworm, temperature, different food sources, sodium hydroxide, ethyl alcohol, energy, systematic error, random error, discrete variable, continuous variable, t-test, chi-square test.
- Must use all words.
- Link words with phrases.
- May add more words

V. Fermentation Quiz
VI. Respiration Quiz
VIII. Final
IX. First team closing remarks
X. Second team closing remarks
XI. Self evaluation
XII. Team Grade

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APPENDIX H

PORTFOLIO GRADE SHEET

ID#_____Period_____

_____Table of Contents (2 pts.) [Neat, organized, all items with #]
_____Order (2 pt.)
_____Items numbered (1 pt.)
_____Lab 1-1 (1 pt.)
_____Lab 1-2 (1 pt.)
_____Lab 1-3 (1 pt.)
_____Lab 1-4 (1 pt.) Should include evaluation grade sheets
_____Lab 2-1 (1 pt.)
_____Lab 2-2 (1 pt.)
_____Lab 4-4 (1 pt.)
_____Lab 4-5 (1 pt.)
_____Selected lab: (5 pts.)
- State the lab number and title.
- Why did you pick this lab?
- If you could work further on this lab, what would you do?
- What I still don't understand is.....
- You may want to include rough draft lab notes to make a point.

_____Concept Map: (10 pts.)
- fermentation, respiration, carbon dioxide, oxygen, sugar, aerobic, anaerobic, yeast, peas, corn, cricket, earthworm, temperature, different food sources, sodium hydroxide, ethyl alcohol, energy, systematic error, random error, discrete variable, continuous variable, t-test, chi-square test.
- Must use all words.
- Link words with phrases.
- May add more words

_____Fermentation Quiz (1 pt.)
_____Respiration Quiz (1 pt.)
_____Final
_____First team closing remarks (1 pt.)
_____Second team closing remarks (3 pt.)
_____Self evaluation (1 pt.)

_____/ 35 Total

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APPENDIX H

	A	B	C	D	E	F	G	H
1	TABLE 1							
2	Observed	Expected #	Genotype	Observed %	Expected %	Obs. Geno.	Exp. Geno. Freq.	
3	52	34	TT	43%	28%	0.43	0.28	
4	55	60	Tt	46%	50%	0.46	0.50	
5	13	26	tt	11%	22%	0.11	0.22	
6	120							
7						TABLE 2		
8							Observed Gene Freq.	
9						159.00	p=	66%
10						81.00	q=	34%
11						CALCULATIONS		
12							Expected Gene Freq.	
13						12720%	p=	53%
14	TABLE 3					11280%	q=	47%
15	Observed	Expected #	Genotype	Observed %	Expected %	Obs. Geno.	Exp. Geno. Freq.	
16	81	69	TT	51%	43%	0.51	0.43	
17	68	73	Tt	43%	46%	0.43	0.46	
18	11	17	tt	7%	11%	0.07	0.11	
19	160							
20						TABLE 4		
21							Observed Gene Freq.	
22						230.00	p=	72%
23						90.00	q=	28%
24	TABLE 5							
25	Observed	Expected #	Genotype	Observed %	Expected %	Obs. Geno.	Exp. Geno. Freq.	
26	50	85	TT	30%	51%	0.30	0.51	
27	106	71	Tt	63%	43%	0.63	0.43	
28	11	11	tt	7%	7%	0.07	0.07	
29	167							
30						TABLE 6		
31							Observed Gene Freq.	
32						206.00	p=	62%
33						128.00	q=	38%
34	TABLE 7							
35	Observed	Expected #	Genotype	Observed %	Expected %	Obs. Geno.	Exp. Geno. Freq.	
36	76	52	TT	44%	30%	0.44	0.30	
37	81	110	Tt	47%	63%	0.47	0.63	
38	17	11	tt	10%	7%	0.10	0.07	
39	174							
40						TABLE 8		
41		*The shaded areas represent					Observed Gene Freq.	
42		where data was entered.				233.00	p=	67%
43		All other numbers were calculated by the				115.00	q=	33%
44		spreadsheet.						

APPENDIX H

	A	B	C	D	E	F	G	H
49	**TABLE 9**	Go	G1	G2	G3	G4		
50	TT	28%	43%	51%	30%	44%		
51	Tt	50%	46%	43%	63%	47%		
52	tt	22%	11%	7%	7%	10%		
53								
54		Go	G1	G2	G3	G4		
55	T	53%	66%	72%	62%	67%		
56	t	47%	34%	28%	38%	33%		
57								
58						G4		
59	**Question 1**					44%		
60		Go	G4			47%		
61		28	44			10%		
62		50	47					
63		22	10			G4		
64						67%		
65		X2	8.77874	0.23781213	6.79864039	33%		
66								
67		X2	15.81519					
68		d.f.	2					
69		p	0.001					
70		REJECT						
71		THERE IS A DIFFERENCE BETWEEN THE GO AND G4						
72								
73								
74	**Question 2**							
75		Go	G4					
76		53	67					
77		47	33					
78								
79		X2	3.673863	4.14286718				
80								
81		X2	7.816731					
82		d.f.	1					
83		p	0.001					
84		REJECT						
85		THERE IS A DIFFERENCE BETWEEN THE GO AND G4						
86								
87	**Question 4**							
88	a	qn=	0.16					
89	b	p	0.84					
90	c	TT (p2)	0.70					
91		Tt (2pq)	0.27					
92		tt (q2)	0.03					
93	d				X2	20.487167		
94		Obs	exp		d.f	1		
95		67	84.		p	0.9		
96		33	16.			Strongly accept		

APPENDIX H

Research Survey

Grade Level:_____

First Semester Bio 3 Teacher:_____ Semester 1 Grade: _____

Second Semester Bio 4 Teacher: _____ Current Grade: _____

Directions: Circle the number or answer that best describes your feelings for each statement.

1= strongly disagree 2= disagree 3= neutral 4= agree 5= strongly agree

1 2 3 4 5: 1. I understood the Initial and Final Evaluation procedures.

1 2 3 4 5: 2. I accurately evaluated each lab report during Initial Evaluation each member of my team. **If you disagree, please explain:**

1 2 3 4 5: 3. I accurately evaluated each lab report during the Final Evaluation for each member of my team? **If you disagree, please explain:**

1 2 3 4 5: 4. Peer pressure is a factor when circling done or not done.

Yes or No: 5. Did you ever circle done on a lab that was not done? (Either during Initial or Final Evaluations?)

If yes, please give an approximate number of times:_____

If yes, please circle one of the following reasons:

thought they were done peer pressure wanted extra credit other:

1 2 3 4 5: 6. I made corrections that my team told me to make on my labs.

1 2 3 4 5: 7. It is fair that everyone on the team gets the same lab grade if the lab evaluation process is followed.

If you strongly disagree, explain:

1 2 3 4 5: 8. Having the opportunity to correct mistakes improved my grade.

1 2 3 4 5: 9. It was easy to get along with team members for a nine week period.

1 2 3 4 5: 10. In general, working on teams to complete labs is helpful.

1 2 3 4 5: 11. In general, working alone on the labs would be better than teams.

1 2 3 4 5: 12. I prepared for a lab exercises before starting the lab procedure, by reading background material, asking questions, and completing pre-lab activities.

1 2 3 4 5: 13. I helped set up labs, record results, measure data and clean.

1 or >1: 14. Did you write up each lab once or more than once?

15. How do you best learn a concept in science? Rank the following ways to learn form 5 to 1. A 5 should be given to the most effective teaching method and a 1 should be given to the least effective.

Lecture	Worksheets	Presentations	Group Work	Labs
_____	_____	_____	_____	_____

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ADDITIONAL RESOURCES

Additional Resources

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