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Teaching An Introductory Unit To Genetics Using An Investigative Approach With Wisconsin Fast Plant

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TEACHING AN INTRODUCTORY UNIT TO GENETICS USING AN INVESTIGATIVE APPROACH WITH WISCONSIN FAST PLANTS

By

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ABSTRACT

TEACHING AN INTRODUCTORY UNIT TO GENETICS USING AN INVESTIGATIVE APPROACH WITH WISCONSIN FAST PLANTS

By

Colleen Raye Pringle

I designed a genetics unit in which the students conducted an investigation using Wisconsin Fast Plants ® to discover how the characteristics of living things are passed on through generations. I employed a constructivist approach so that the students' learning was a process of personal and intellectual construction of knowledge based on their activity in the classroom. After observing, identifying, comparing and contrasting traits, collecting data and drawing conclusions, students were able to explain why organisms within a species showed similarities and differences from one another. The Gibberellic acid experiment applied to the Wisconsin Fast Plants demonstrated this idea. The students explored the role environment plays in the development of living things and considered whether environment affects an organism as strongly as heredity. The results of the item analysis showed improvement in the students understanding of the genetics concepts assessed. The unit concluded with a discussion and activity demonstrating what can happen when something goes wrong with the genetic code.

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I would like to thank God for the guidance in my life and for blessing me with such great family and friends. I appreciate the support my parents have given me and the valuable tools to persevere. Thanks to my husband, Doug, for all of the help and support he has given me. And finally, thanks to all of my friends. I love you all.

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

I developed and implemented a genetics unit to address three main problem areas in our 8th grade science curriculum at Haslett Middle School: 1) the science curriculum made few attempts to provide any connections between the ideas that were being taught; 2) the existing heredity unit had no laboratory component to help the students in understanding the concepts; and 3) there was no teaching and awareness for the students of biomedical issues and genetic engineering advancements.

The development of this unit started during my research in 1996 when I was looking for new methods of teaching as well as activities for the students to do. A typical unit in my integrated science class consisted of lecturing, introducing new concepts, assigning homework, conducting a laboratory experiment or two, and finishing with a test at the end of the unit. This was a very teacher-centered approach to transmitting the science knowledge to the students. It was difficult to keep the students interested and motivated and their achievement was low. The students that missed class at the beginning of the unit often missed the objective of the lesson, did the laboratory experiment incorrectly, or were trying to catch up. A new teaching approach was required in order for my students to correct these problems. It was stated by Matthews (1994), that Jean Piaget's original work proposed that, "children's learning is a process of personal, individual, intellectual construction arising from their activity in the world." Inspired by this and other constructivist beliefs, this unit, as well as others, are based on the constructivist approach. The overarching principles of a constructivist pedagogy are: posing problems that are important to the learner; structuring learning around big concepts; getting students' points of view; adapting curriculum to address students needs; and assessing student learning in the context of teaching. Some of the constructivism-based strategies currently used are (Brooks and Brooks, 1993):

*using open-ended questions;

*increasing wait-time;

*accepting all student responses without confirming or rejecting their answers;

*giving students a chance to pursue their own questions. (Rita, 1998)

*starting units by asking what students think about a topic before giving input. By unearthing student preconceptions, activities can be designed to dispel false ideas and to promote student inquiry and debate, (Brooks and Brooks, 1993); and

*using hands-on activities instead of lectures to start units. This gives the students something mentally to refer to during lecture, (Lawson, 1995).

In developing the genetics unit, I wanted activities that connected new ideas with the ideas that the students already had and those isolated bits of information that they were getting from the 8th grade science curriculum within my class. As Smith (1984) states the criteria for understanding is two fold: connectedness and usefulness in the social world. The first part deals with the learner appropriately identifying the concept and connecting it with other ideas. I wanted to help connect the basic ideas in the genetics unit for the students through a wide variety of activities that would focus on the three types of learners: audio, visual, and kinesthetic. These activities included journal writing, laboratory work, videos, guest speakers, small group projects and science sleuths.

The type of learner will determine what adaptations will be needed in the curriculum to meet student needs. The learner types are: logical/mathematical, body/kinesthetic, visual/spatial, interpersonal, verbal/linguistic, intra personal intelligence and musical/rhythmic. David Lazear (1993) talks about Howard Gardner's categories of learning styles and said, "students have different intelligent wavelengths and all are gifted. We must get all kids to be as intelligent as we possibly can." He discussed the importance of the teacher knowing their learners and valuing all abilities on more levels so that all students can succeed.

This was one reason that I felt the need for implementing a variety of activities, to insure that I was reaching all types of learners.

In the new unit, the students will set daily goals and long term goals to help them solve problems. Allowing students to help set these goals and objectives, gives them a feeling of empowerment and investment. By involving them in this process, it has been recognized to increased interest, commitment, and effort (Long, 1991 and Frymier,1985). Of course, students cannot decide what should be taught, but they should be involved in the decision process.

The Wisconsin Fast Plant ® lab was implemented for the investigation of the inheritance of gene(s) controlling a mutant trait. The students were to learn about the principle of unit characters, principle of dominance and the principle of segregation. Each lab group would determine what genetic trait they would be studying. The students would also decide what observations were important to record in order to reach these objectives. As the students performed the Wisconsin Fast Plant lab®, they were to make some of their own decisions in the lab such as what data to collect, what to graph and even how to do the steps to the scientific method. Students eventually should become proficient enough to complete an investigation given only basic materials and an objective, similar to the MEAP investigations that they will do this year. The MEAP investigations are a simple form of inquiry based learning for experiments. Using the Wisconsin Fast Plants®, I would expect that the students would be excited about learning, asking the "why" questions, resolving discrepancies, representing ideas, discussing information and solving problems.

Basic to inquiry, George DeBoer (1991), conveys the significance of this idea in his assertion:

> "If a single word had to be chosen to describe the goal of science education during the 30-year period that began in the late 1950's it would have to be inquiry."

According to the National Science Education Standards (1996), "inquiry into authentic questions generated from student experiences is the central strategy for teaching science." The standards encourage teachers to focus on inquiry because it relates to real-life experiences and guides students to design their own investigations.

At the start of the genetics unit, my students had conceptions which did not match those of other students. In order for learners to change their previous alternative misconceptions about a particular idea, they have to be confronted with other phenomenon that challenge their misconceptions and allow them to formulate a new belief. According to Smith (1991), in order for conceptual change to occur, we simply can not tell students that their ideas are wrong and expect them to change them. They have to engage in hands-on activities and laboratory experiments so that they experience a better scientific explanation. "Hands on learning by experience are powerful ideas, and we know that engaging students actively and thoughtfully in their studies pays off in better learning," says Rutherford (1993).

I also agree with Rutherford in his earlier works that science should be taught as a process rather than as content. He said that science is often taught as a body of content or as a set of techniques that would resemble scientific inquiry. Rutherford (1964) stated that the conclusions of science are closely related with the inquiry which produced them; that is why we must consider the close organic connections between process and content in science.

Many times in the classroom, I am guilty of trying to teach too much content and not focusing on process. As I worked on constructivist-based labs, I noticed that they seemed to take a bit longer than the traditional ones because I took the time to revisit ideas a lot more frequently than I had before. Dempster (1993), says that educators need to recognize that "less is more," and that presenting less content to students and reviewing it frequently has significantly positive effects on their recall and retention.

Another constructivist technique that I continued to work on was allowing sufficient wait time after posing a question. Cooper (1980), implied that the importance of wait time is necessary for those students who are not prepared to respond to questions or other stimuli immediately. He says that they process the world in different ways. Another reason to have some wait time is that the questions posed by the teacher are not always those heard correctly by the students.

Lastly, it was critical to incorporate authentic assessment that relates to real concerns and problems that the students encounter or have. It is unreasonable to assess students in a traditional manner. After teaching in a manner that fostered individual construction of knowledge. In addressing this problem, Mayer (1961) discussed the rush of weekly quizzes and tests, class work and homework, recitations and catechisms. Especially in America, students are made to prove that they have learned their lessons. If the child cannot give back the information on demand, then it is assumed that they have not learned it. Therefore, this unit was assessed through teaching, participating in student/teacher interactions, observing student/student interactions, and watching students work with ideas and materials. In all activities, I was assessing whether or not they understood the "big idea" or main concept being taught. In discussing what they call "assessment while teaching," Newman, Griffin, and Cole (1989) profess:

> "Many instructional units do not decompose themselves into a neat sequence of levels to be mastered in an invariant sequence with a single correct route to mastery. In fact, appropriable child behaviors come in great variety, requiring flexible expertise on the teacher's part to weave them into a productive instructional interaction."

Before working on this unit, I did not know how to grade open-ended problem-solving labs and open-ended essay questions. However, after reading an article by Lundberg (1997), I was willing to make the change to student generated scoring rubrics. The students would help devise the criteria for each of the six test questions on how to "hit a target" or answer the question correctly. Authentic assessment through teaching seems natural, but not particularly easy like a multiple choice test. The biggest advantage to meaningful assessment is that learning continues while assessment occurs.

The genetics unit discussed in this thesis was taught to an eighth grade class of 30 students. The ability of these students in my class ranged from gifted to at-risk to learning disabled to basic classroom students. It is the largest range of students that I will taught in my eight years at Haslett Middle School. I had confidence that this unit was the best one to encompass all of the learning styles. The school is in a suburban area in mid-Michigan, made up of mostly middle class Caucasian pupils. The school is average in size, rated class B for its athletic programs. The middle school has approximately 700 students and is growing rapidly.

IMPLEMENTATION

IMPLEMENTATION

Overview

The new genetics unit, taught to the eighth grade students in the Science Plus curriculum, was a five week unit developed in the summer of 1996 during research. Laboratory experiments and activities were developed to enhance the genetics unit and resources were collected to implement the constructivist teaching method. The unit taught before genetics was the Photosynthesis unit and the unit following was the Weather unit. I taught the new and improved genetics unit in 1997 as a trial run and then again in 1998. In the second year, the unit flowed much more smoothly and the data in this thesis are taken from my 1998 teaching experience.

Although, the students worked on a variety of activities in this unit, the ongoing project was the Wisconsin Fast Plant ® lab. The students were provided with seeds of the *Brassica rapa* plant with different traits to study, such as wild type and a mutant, rosette (short), anthocyanin and anthocyaninless, and hairy and hairless. Students were to form a hypothesis about the inheritance of a trait and test that hypothesis by collecting phenotypic data through two generations. The genetics unit began in April and continued for six weeks. However, the study of the second generation of plants extended into the weather unit.

Objectives of Unit

The overarching objective of this genetics unit was to have the students become "knowers" of science. What we know about genetics is constantly changing. As students encounter new information through reading, personal experience, or active investigation they should have the desire to understand the world around them, (Michigan Essential Goals and Objectives, 1991). The students should master the Michigan Essential Goals and Objectives for Science Education about genetics/inheritance and demonstrate what they have learned through embedded assessment, as well as pre and post tests.

The student objectives for the genetics unit were:

1. Genetics MEGOSE Objectives

   *How are characteristics of living things passed on through generations?

   *Why are organisms within a species different from one another?

   *How can new traits be established by changing or manipulating genes?

The teacher objectives for the genetics unit were:

2. Constructivism Objectives

   *Posing problems that are important to the learner.

   *Constructing learning around big concepts.

*Obtaining students point of view.

*Adapting curriculum to address the students needs.

*Assessing student learning in the context of teaching.

3. Students will demonstrate what they have learned by written work, (essays, book questions, lab analysis & conclusions) and oral discussion with the whole class and in individual interviews and the end of the unit survey.

Weekly Outline of Unit

Note: All activities are referenced to a specific Appendix;

All activities new to the unit are noted with *.

Week One:

Two weeks before starting the genetics unit I interviewed six of my eighth grade science students. I choose the students by the grades that they had received in previous units and picked two students who received excellent grades, two students that received average grades and two students that scored really low. The interview questions that I asked came from the pre-test but if the students had incorrect answers then I inquired further to find out about their misconceptions.

At the start of the genetics unit, the eighth grade students took a pre-test. They wrote the answers in their science journals, titled *"For Your Journal", (Appendix

A). At the end of the unit they reflected on their answers to the journal questions and rewrote the answers to correct any misconceptions and included knowledge and terminology gained throughout the unit. The students *set short-term, daily goals and long range, unit goals for themselves and their small working groups. The students started the *Wisconsin Fast Plant lab ®, (Appendix B), in order to observe and conduct some of the genetics experiments in the new unit. Then the students did a Family Likeness activity (Appendix C), to help them recognize common traits among family members and observe how

they were passed on from one generation to the next. From here, the students looked at characteristics shared by members of their eighth grade class in a survey, (Appendix D), distributed, collected, and analyzed by them to determine how many members of their class share specific physical traits.

Week Two:

In the second week of the Wisconsin Fast Plant ® Lab, day 6 to 11 of the grower's calendar (Appendix B) reminded the students to check the plants and reservoir water level each day and observe growth and development. On day eight, and every other day until the plants flowered (about day 16) the students applied one drop of Gibberellic acid or water (see Appendix E), according to the treatment labels, to each leaf on their plants. They also recorded plant height (distance along the stem from the point of cotyledonary attachment to the very tip of the plant).

The students made a list and studied the characteristics that are necessary for organisms to live. They focused on the cell as being the basic unit of all living things. They learned structures and functions of organelles in both plant and animal cells, (Appendix F). In studying that all processes in a living cell are controlled by the cell's nucleus, the students interpreted what happens as cells divide to make new cells in mitosis and meiosis, (Appendix G). These activities helped students distinguish sexual reproduction and asexual reproduction. The students were assessed after these two weeks of the genetics unit with a short quiz, (Appendix H).

Week Three:

During this time of the Wisconsin Fast Plant ® growth, the buds on the plants are open and the students cross-pollinated for three consecutive days. On the last day of pollination, the students removed unopened flower buds. In this part of the unit, the students analyzed one of Gregor Mendel's genetic experiments with pea plants. They performed an activity that demonstrated how predictable ratios of dominant to recessive traits can occur in the offspring of hybrid plants

(Appendix I). Later in the lesson, the students worked through Punnett squares, and concluded that inherited traits appeared in predictable mathematical patterns in the offspring of a specific cross. Students were then ready to learn more about the genes and chromosomes that are responsible for carrying the traits.

Week Four:

The Wisconsin Fast Plants ® developed seed pods so the students observed and made drawings of the changes that took place in their plants. The students continued the chromosome study from week three, by making a *karyotype to better understand an individual's genetic make-up, (Appendix J). Then, they studied disorders that are a result of chromosome abnormalities, developmental errors and abnormal or lethal genotypes. Once students had learned about many of these disorders, they chose to put eight of the defects on the chromosomes of the karyotype they were working on. This step helped with the students understanding in the possibility of passing on an abnormality when a new offspring is made. The week ended with a genetic counselor speaking to the class about specific key encounters and jobs they must perform. The students were allowed to ask questions about genetics to the geneticist.

Week Five:

The last week of the Wisconsin Fast Plant ® study, the seed pods matured. The students removed the plants from the watering system and allowed the plants to dry in order to harvest the seeds from the pods. The students had a second chance to work on Punnett squares when they learned *blood typing and looked at the blood type of possible offspring. They conducted a lab to determine the ABO and Rh factors for blood types of four unknown simulated blood samples, (Appendix K). The class read two articles on identical twins: one dealing with environmental influences on twins raised in different locations and the other article on twins conjoined at birth. This prepared students for the upcoming sleuth activity. The *science sleuth mystery, (Appendix L), using the video disc is about twins that read a will and find out that there is a third sibling, a triplet, with whom they must share their inheritance. Three people claim to be the lost sibling. The sleuths must analyze the evidence to identify the true triplet. Finally, at the end of the unit, the students looked at Environment vs. Heredity. Which plays a bigger role in the development of living things?

The *unit test (Appendix M), included true/false, multiple choice, completion, completing Punnett squares, and six essay questions that appeared on the pre-test. The students were given as much time as needed to answer the questions because the team block-scheduled the test for that day.

EVALUATION

EVALUATION OF ACTIVITIES

New Techniques

My subjective overall evaluation of the use of several new methods in this genetics unit is that it raised the interest level and motivated more students in my class to get started working each day, actively participate in the activities and achieve a desirable grade in the class. The following are primarily subjective evaluations of specific new activities that were implemented into the new genetics unit.

Goal Setting -

Each class, in 1997 and 1998, started the unit by setting short-term and long range goals for themselves and their small working groups. It was important for them to determine what needed to be accomplished each day and what they should have completed at the end of the unit. I listened to the students say that they felt like they were making their own list of things to do instead of the teacher instructing them on what they had to complete. It was the first time I tried student goal setting and I saw better focus and organization out of the majority of the class. The students were required to turn in their goals and reflect on them to see if they were reached at the end of the unit.

Wisconsin Fast Plant® Lab -

The Wisconsin Fast Plant ® lab, which included the Gibberellic acid experiment, was the major change to the existing curriculum. This project was to be monitored daily and gave the students a focus at the beginning of the hour each day. There was no question about what was expected because each of them had a grower's calendar to follow and measurements to record. This procedure was very different from the traditional style of reporting to the class and taking your seat while the teacher took attendance. The students independently got started on their own and solved problems together in their lab groups. The Wisconsin Fast Plant ® lab also had added another aspect to the original genetics unit; we now not only studied how traits are passed on in animals but plant species too.

Survey -

The eighth grade genetics students were excited to go to their classmates home room and present the survey about human characteristics. They were also in charge of collecting and tallying the results. The survey results were observed by all on the overhead to see how some of the traits are shared by a large majority and others may be shared by only two or three people, and still other traits may not appear at all.

Karyotype -

The human chromosome karyotype activity was implemented to help students learn what a karyotype looks like, understand meiosis better, locate genes on chromosomes, learn about genetic disorders and their location in the 23 pairs of chromosomes, how sex is determined and have fun by playing a game. The concepts in this part of the unit are difficult ones for eighth graders to grasp but the karyotype activity provides a visual piece for the learners.

Blood Typing -

The blood typing lab is an activity reintroduced to our curriculum. We used to type our student's blood when I did my student teaching at Haslett in the 1980's. Now, students can see the obvious results once again with WARD's simulated blood typing activity. They will also determine the Rh factor of these same unknown blood samples. The lab is a one day experiment and very easy for the students to perform and observe. They work on Punnett squares for predicting the blood type of possible offspring.

Science Sleuth -

The "Twins or Not?" science sleuth mystery is an activity that was published with our Science Plus text book. This laser disc game was a new activity where students worked in cooperative groups to try to solve the case, using knowledge they had learned in the unit.

The students' mission was to determine which applicant, if any, was the true remaining triplet. This was a great way to review concepts learned throughout the entire genetics unit. The students thought this activity was hard work and required a lot of clue writing. However, after two days of critical thinking and scientific problem solving they were ready to hear the solution to the sleuth mystery and the evidence that supported the solution.

<u>Pre & Post Tests</u> -

The pre and post tests essay questions,(Appendix A & M), described in the implementation, were identical questions and were left open ended so the students could explain their reasoning and write as many examples as they felt necessary. The pre-test was written in the students' science journals so that any time throughout the unit they could reflect back on them and add important terms or ideas to them in order to make them complete answers. The students did not know that the same essay questions were going to appear on the post test at the end of the unit. After the post test, the students generated rubrics in groups and then combined them in a class discussion, to form one good, three point rubric, for each essay question on the test, (Appendix N). Even during this process, real learning was going on amongst the students as they carefully considered what constituted quality work.

Interviews -

I interviewed six students before the unit and asked them questions about genetics. I wanted to hear what they already knew before the unit and see if they had any misconceptions. I interviewed the students during prime time, at lunch or on my planning hour and it took approximately 20 minutes per student. At the conclusion of the unit, I interviewed the same six individuals and asked them the same questions.

Student Self-Assessment & Unit Evaluation -

This unit and self-evaluation was given after the entire unit had been taught. The students were asked to give their opinion of what activities helped them learn most to least in the unit. It also asked them what they liked, what concept was hardest and how this unit was different from other units taught this year. The students evaluated their effort and participation in the unit to help determine their success. And finally, I had them write a goal for the upcoming unit.

EVALUATION

I evaluated the 1998 genetics unit primarily by pre and post test results but also implemented were other activity and lesson assessment techniques which are reported in this document. The 1997 genetics unit was a preliminary trial run and data was neither compiled nor incorporated in this thesis. The assessment throughout the unit was ongoing and measured performance in every area. The quality of the students home work, class work, lab work, journal entries and performance on quizzes and tests were all factors in assigning grades.

The students were provided with realistic problems to solve and assessment relied on performance-based strategies, instead of recall-based assessment. The pre and post test items were consistent with the pursuit of scientific knowledge. They also encompassed the scientific method: gathering data, hypothesizing, experimenting, inferring, observing, analyzing data and concluding. The post test assessed the students' mastery of these skills.

The unit test consisted of true and false, multiple choice, short answer completion and essay questions. There was no length requirement for the essay questions and no time limitations for the test. The concepts assessed were those that had been identified as problem areas for previous students. The concepts assessed were: 1) how characteristics of living things are passed on through generations, 2) why organisms within a species are different from one another, 3) how manipulating genes can produce new traits. The topics of the questions were passing of genetic traits, diversity within species, environmental influences on traits, chromosomal abnormalities and genetic technology and manipulation.

Based on responses to the six pre and post test essay questions, students were scored on a basic rubric developed by students of three points per question (Appendix N), in an attempt to keep the evaluation as objective as possible. A score of a three on an individual question showed complete proficiency while a score of 0 reflected an answer that was totally incorrect. The average student score from 1998, for all questions on the pre-test was 39.8% (7.17 points earned out of 18 points possible). On the post test with the same six essay questions and rubric, the average student score, for all questions was 70.1% (12.63 points earned out of 18 points possible). These averages show an increase in class performance and individual growth of students for one class (Tables 1 and 2). The median for the pre-test was 7 and the median for the post-test was 13.5. The mode on the pre-test scores were 4 and 5, and the mode on the post-test scores as 16. The pre-test standard deviation was 3.97 and the post test standard deviation was 4.28.

Analysis of Individual Essay Questions

The six pre and post test response for the essay questions were compared and presented as histograms (Figures 1-6). Each question was evaluated using the assessment rubric in Appendix N. For all test items there were 30 subjects assessed in 1998. Some of the sample responses of the subjects tested are included for a subjective assessment. The names of these students have been changed to protect anonymity.

Table 1: Students pre-test scores for the six essay questions (3 points possible per question).

PRE-TEST SCORES

Student Number	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Total
1	2	1	1	2	1	2	9
2	2	0	2	1	1	1	7
3	3	1	1	2	2	3	12
4	2	2	1	1	2	2	10
5	1	2	0	0	1	1	5
6	2	0	2	1	1	2	8
7	1	2	1	0	0	1	5
8	1	2	0	0	1	0	4
9	1	0	2	0	0	1	4
10	0	1	1	0	1	1	4
11	1	1	0	0	1	1	4
12	2	0	2	1	2	2	9
13	0	1	0	0	1	0	2
14	2	1	2	1	1	0	7
15	3	1	1	2	3	3	13

Table 1 (cont.): Students pre-test scores for the six essay questions (3 points possible per question).

PRE-TEST SCORES							
Student Number	**Question 1**	**Question 2**	**Question 3**	**Question 4**	**Question 5**	**Question 6**	**Total**
16	0	1	1	0	0	1	3
17	2	1	2	1	2	2	10
18	1	0	1	0	0	1	3
19	2	1	2	3	3	3	14
20	2	2	1	1	1	1	8
21	1	0	1	0	0	1	3
22	2	3	1	1	2	2	11
23	2	1	1	1	2	2	9
24	1	2	1	0	0	1	5
25	3	1	3	2	3	3	15
26	2	1	1	0	2	2	8
27	2	1	3	3	3	3	15
28	0	1	0	0	0	1	2
29	2	0	1	1	1	0	5
30	0	1	0	0	0	0	1

Table 2: Students post-test scores for the six essay questions (3 points possible per question).

POST-TEST SCORES

Student Number	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Total
1	3	2	2	3	3	3	16
2	3	2	2	3	3	3	16
3	3	3	3	3	3	3	18
4	3	3	2	3	2	3	16
5	3	2	2	2	2	1	12
6	3	1	2	3	2	2	13
7	3	2	2	3	1	2	13
8	3	2	2	2	2	0	11
9	3	2	2	2	1	2	12
10	2	1	2	1	1	1	8
11	2	2	2	2	2	2	12
12	3	2	2	3	2	2	14
13	1	2	1	1	1	0	6
14	3	2	2	3	2	2	14
15	3	2	2	3	3	3	16

Table 2 (cont.): Students post-test scores for the six essay questions (3 points possible per question).

POST-TEST SCORES

Student Number	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Total
16	1	1	1	0	1	1	5
17	3	3	2	3	3	2	16
18	2	0	2	2	1	1	8
19	3	3	3	3	3	3	18
20	3	2	2	3	2	2	14
21	2	0	2	1	1	1	7
22	3	3	3	3	2	3	17
23	3	3	3	3	2	2	16
24	2	2	2	2	1	1	10
25	3	3	3	3	3	3	18
26	3	2	2	3	2	3	15
27	3	3	3	3	3	3	18
28	1	1	1	0	1	1	5
29	3	2	2	3	2	0	12
30	0	1	1	0	1	0	3

The item analysis shows the scores in the form of histograms for the six pre and post test essay questions.

Question 1:

Explain how traits are passed on from one generation to the next.

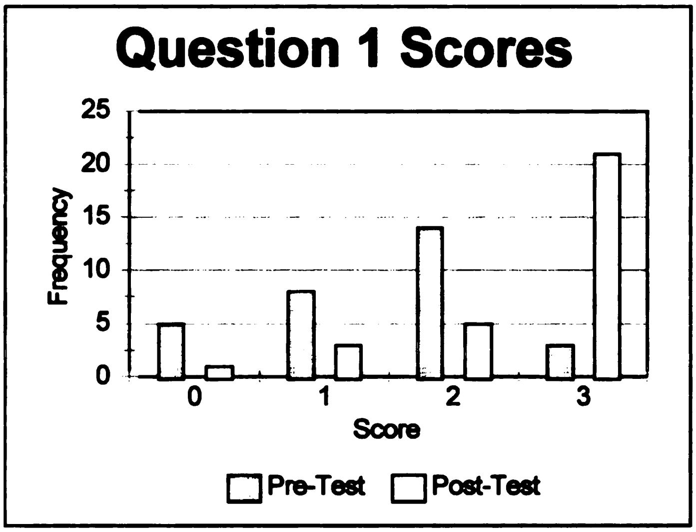


Figure 1: Histogram of pre and post test scores for Question 1.

The overall performance for question one was that the average score for the pre and post test was 1.5 and 2.53 (Fig. 1). One student in the class, "Sue", subject #5 and an eighth grade student, answered Question 1 on the pre-test, "Our parents give us our traits so we tend to look and act like them." For her prior knowledge, "Sue" received one point because she did mention where we get our traits but was not specific enough to earn 2 or 3 points. On the post-test "Sue" answered, "Traits are passed on from one generation to the next when the fathers sperm, that has 23 chromosomes, with genes on them, that contain traits, fertilizes the mothers egg, that has 23 chromosomes, with genes on them, that contain traits, to make a baby with 46 chromosomes. "Sue" received 3 points for this answer because she showed that the traits originated from the parents, told the correct number of chromosomes, discussed the process by which a new offspring is made and mentioned the new count of chromosomes in the young.

Three students, subjects # 3,15, and 25, all knew the number of chromosomes in egg and sperm cells, the process of fertilization and the resulting number of chromosomes after meiosis, prior to the unit. They received a score of 3 points on both the pre and post test.

Question # 2:

Why are organisms within a species different from one another?

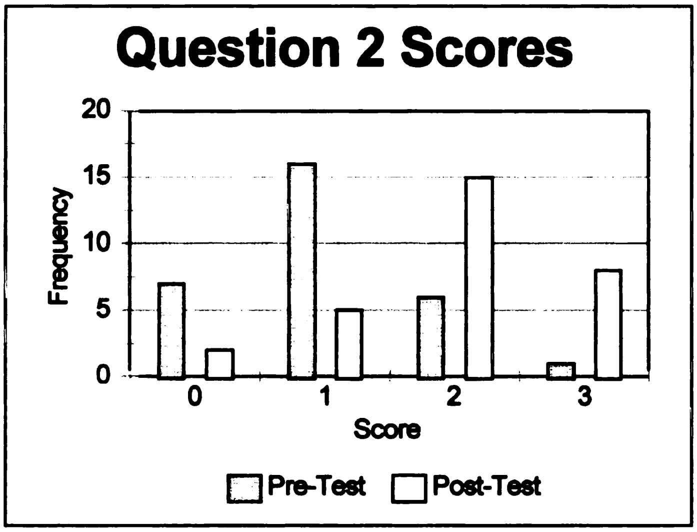


Figure 2: Histogram of pre and post test scores for Question 2.

The students scored the lowest on this question on the pre-test. The class average score was 1.03 on the pre-test and 1.96 on the post-test, (Fig. 2). Most students realized that there is diversity but couldn't explain why. It was not uncommon for them to answer like "John", subject #11: "Organisms are different because they look different, move differently; like fish, birds, humans, and sound or communicate differently." These are all considered traits that are different in organisms so "John" received 1 point. On the post-test "John" received 2 points and answered, "Organisms are different because they have different parents or if they are related, then like all other organisms, they have different genes on their chromosomes."

On the post-test, only eight students earned a perfect score of 3 points on this question. Combinations and recombinations of genetic material was covered in class for one lesson, as was the structure of DNA. Students did not feel that they needed to know about combinations and recombinations for the test. They were very interested in making their models of DNA and discussing ways that the environment could lead to diversity of traits. Many of the students receiving 0 and 1 point on this post-test question were the learning disabled students that have reading and comprehension disabilities and struggle with vocabulary.

Question # 3: **Where in the living body, does the passing on of traits take place? Be specific.**

The analysis of this question, prior to teaching this unit, showed that a high number of students knew that the passing on of traits takes place in the cells of the organisms but did not know the process by which this happens. The students studied the process of mitosis which showed how the passing of traits takes place in body cells. The study of meiosis showed the students how sex cells pass on their traits through the process of reduction division. As a result of conducting the chromosome line-up project, the students learned the process of cell division and chromosomal activity. The average score for question three pre and post test was 1.17 and 2.07, (Fig. 3).

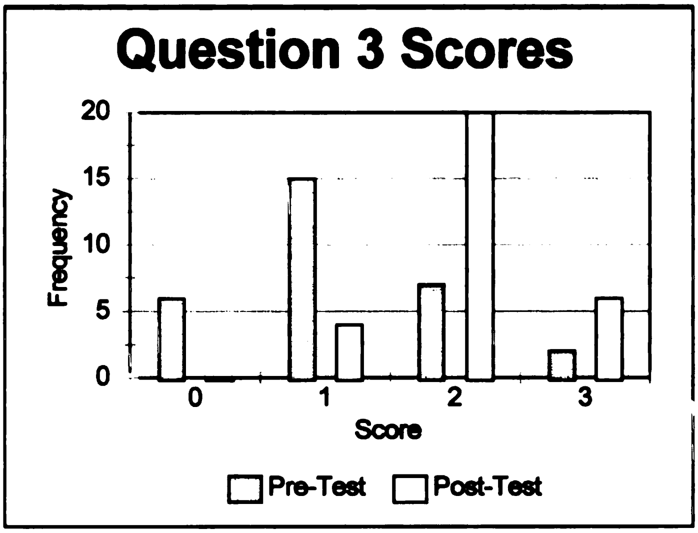


Figure 3: Histogram of pre and post test scores for Question 3.

"Julie" subject # 3, mentioned the helpfulness of the chromosome activity. She earned 1 point on the pre-test and 3 points on the post-test. Her post-test answer was: "We learned that chromosomes are found in the nucleus of cells and even got to see them pictured in our books and in the chromosome activity.

They had dark bands of color across them that were different thicknesses and those were the genes. The chromosomes are made of DNA and proteins and the make-up of these determines what type of traits that individual has in order to pass them on to the next generation."

<u>**Question # 4**</u>:

Does environment play a role in the development of living things? Explain.

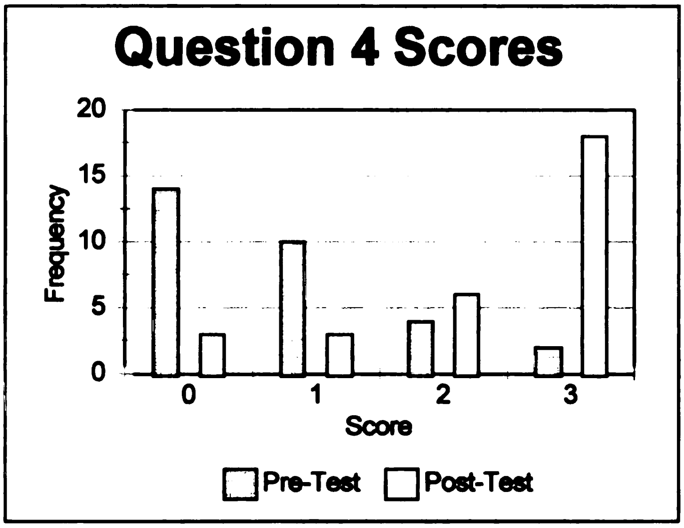


Figure 4: Histogram of pre and post test scores for Question 4.

The class average score for the pre and post test for question 4 was 0.80 and 2.3, (Fig. 4). A large portion of the class answered the question incorrectly on the pre-test. One example was "Pat", subject # 7, who answered the pre-test question, "No, Humans cannot change the genetic makeup that they inherit from their parents. " After reading the section in the <u>Science Plus</u> textbook called "Environment or Heredity?" and conducting the "Gibberellic Acid" experiment on the Wisconsin Fast Plants ®, the students were more familiar with environmental factors that can change the appearance of some particular traits. "Pat" earned the 3 points on the post-test for question # 4. This was her answer, "Yes, Environment can change the development of living things and the way they look. Take your weight, for example, it depends on how much you exercise, what your diet is and the condition of your overall health. Another example is your hair style, and that depends on if you color treat your hair, leave it natural, cut it short or let it grow long."

<u>**Question # 5**</u> **:**

What happens if there is something wrong with the traits? Give an example.

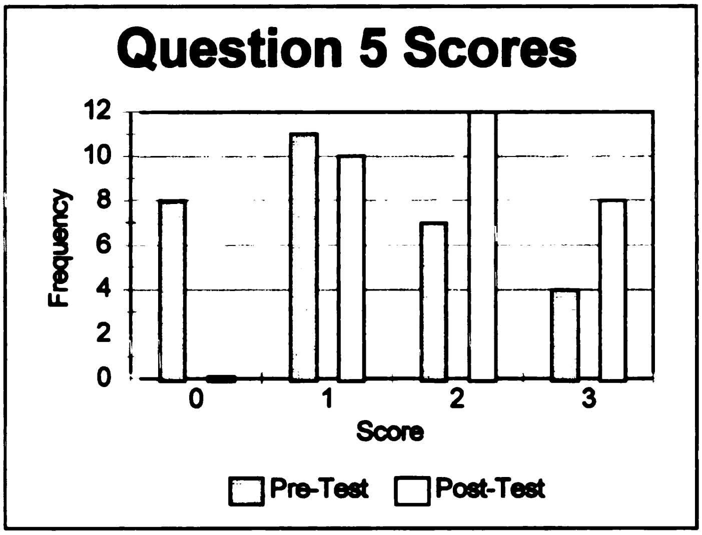


Figure 5: Histogram of pre and post test scores for Question 5.

The overall performance of the students for Question 5 was a mean score of 1.23 on the pre-test and 1.93 on the post test, (Fig. 5). There were no students with a score of 0 on the post-test which was an improvement from 8 students with a zero on the pre-test. The most touching answer came from one of my

Down's syndrome students in this class, who had a very good idea about the story of her genetic make-up. "Shelly" said, "I have an extra 21st chromosome and it made me look different than everyone else in my grade. I am not as smart either. I have Down's Syndrome." "Shelly" earned 3 points on this question because she knew the name of her genetic disease, identified the chromosome abnormality and told us about her developmental errors, (she just couldn't use the terminology that the other students had learned).

Question # 6 :

How can new traits be formed from manipulating or changing genes?

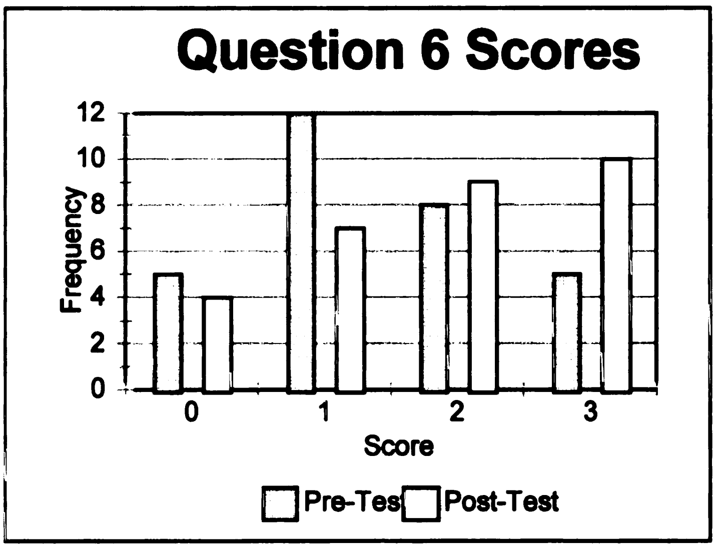


Figure 6: Histogram of pre and post test scores for Question 6.

The results for question 6 were that the mean score on the pre-test was 1.43 and 1.83 for the post test. The scores on the pre-test show that there was not a lot of prior knowledge on this topic. One student, "Ted", subject # 2, responded to question # 6 on the pre-test: "I know that scientists can change the way living things are by playing around with their genes." "Ted" scored only 1 point for that answer because he knew that scientists can change the genetic material in a cell. After studying this concept in the unit, "Ted" answered the following on the post-test: "Geneticists are the scientist that either add sections or change the DNA in a cells nucleus to alter the characteristics of the living organism." "Ted" scored 3 points for demonstrating how new traits can be formed by manipulating genes.

Analysis of Data:

The distribution of scores on the pre and post tests shows an improvement of understanding of the genetics concepts assessed. Some students did not improve on individual questions from pre-test to post-test, (like subjects # 3, 15, 19, 22, 27), as indicated by Table 1 because they were already proficient, scoring 3 points on both tests. Other students were not proficient, scoring a 0 on a pre-test question, and didn't improve on their score for the post-test, (subjects # 8, 13, 28, 30). Some, in fact, gave an entirely different answer for their post-test answer that an incorrect response.

The students' mean scores showed improvement from the pre-test to the post-test at the end of the genetics unit. The mean improved from 7 to 13. The means for questions 1: Explain how traits are passed on from one generation to the next and question 4: Does environment play a role in the development of living things?, showed the largest improvement from pre-test (1.5 and 0.80) to the post-test (2.53 and 2.3). The median, the score which shows the middle of distribution of scores increased from 4 and 5 to 13. The standard deviation for the pre and post test was 4. The pre-test scores deviated 4 points from the mean of 7, and the post-test scores deviated 4 points from the mean of 13, (Figure 7).

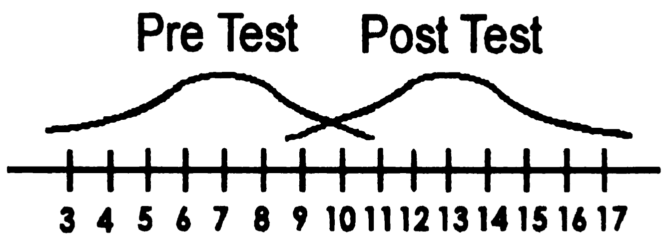


Figure 7: Pre and post test standard deviation.

The scores on the class and lab work and homework were very high; 90%, 77%, and 82% respectively. There were 10 assignments not turned in during the genetics unit or 93% turn-in rate. This was higher than the prior Photosynthesis unit where the students had an 84% homework turn-in rate.

DISCUSSION

What was effective?

I was pleased with all of the new activities implemented into this unit. They included: goal setting, the Wisconsin Fast Plant®, the genetic traits survey, karyotype chromosome activity, blood typing lab, the science sleuth, pre and post tests, students writing rubrics, interviews and self evaluation and unit survey.

The students wanted to be part of the lesson planning and decision making in class and it was the goal setting at the beginning of the unit that got them engaged. I will use this strategy again to give the students an opportunity to investigate questions that they have and are interested in.

The two laboratory experiments (Wisconsin Fast Plants® and Blood Typing lab), implemented in the genetics unit involved all of the students. It also instilled in them excitement about the topics they were investigating and provided them with a sense of achievement when they discovered the correct blood type and harvested the seeds from the Wisconsin Fast Plants®. In the self assessment at the end of the unit, 24 of the 30 students rated the laboratory experiments as the most helpful tool in their learning and understanding of the material.

The genetic traits survey allowed the students to compare different physical characteristics and abilities amongst themselves. They enjoyed the peer teaching as they distributed and administered the survey. When the surveys were completed the students took great pleasure in reporting the scores that they tallied. As a whole class we analyzed the data to understand the outcome of the results.

The chromosome karyotype activity was very challenging for the students and took a full class period for them to map the chromosomes into the 23 pairs. The students enjoyed picking out eight disorders to place on the genes of the chromosomes and completing the activity with a game to make a new offspring. One student wrote in the unit evaluation, "I thought it was cool how we got to roll the dice and move the chromosomes. We watched our offspring receive the trait for breast cancer. The most exciting roll was the 23rd pair, which determined if we had a boy or a girl."

The science sleuth is not one of the students favorite activities because they have to do a lot of writing. However, they are focused and determined to solve the problem in the mystery. It also piques their interest because I have offered extra credit for any student who resolves the case.

The interviews before the unit began were a great place to start because one of the students I interviewed did not answer question 4 on the pre-test in detail and

I was not sure how much he knew about the topic. The question was: Where in the living body does the passing on of traits take place? He answered: "The passing on of traits takes place in the cells of living things." In the interview, I asked him which cells and specifically where in the cells. He replied: "Traits are passed on in all of your cells that you get when you are formed at birth. And the traits are found in the nucleus inside a cell." I was glad that I took the opportunity to interview some students because I really got a better understanding of exactly what scientific information some of the students knew and what concepts I needed to teach them.

I feel that the post-test at the end of the unit was a good tool in assessing student understanding in genetics. The students generated their own class rubrics for each test question by brainstorming ideas on the chalkboard and then together we decided what parts of the answer would be worth points. I then used these rubrics for grading the test. The process of working together to create the scoring rubrics led us to many class discussions that involved more learning from their peers. The students often remarked about answers that they had not thought of themselves and we discussed them as possible answers. The students were very successful in designing the rubrics and they knew what was expected of them in order to score a full three points on each test question.

Conclusion

I read a book on constructivist teaching and I really agreed with the title of one of the chapters of this book: "Coming to Know Ones World" through constructivism. Based on teaching this unit, I feel that the students learned more about their world as it relates to heredity by constructing their knowledge. They were more motivated and interested in their results or outcomes that they got in this unit than the prior genetics unit that I taught. The old unit had no laboratory experiments and had paper/pencil activities and lecture style approach. In the new unit, the groups set their goals and knew what to do each day without my lead in instruction and they would enter class and begin gather data and measuring plant height without hesitation. It was nice for me because I was able to walk around the classroom to help individuals or groups when the need would arise.

The most challenging part of constructivist teaching for me is allowing student responses to drive lessons, shift instructional strategies and alter content. I improved on the wait time after asking questions to the students. I found that when I would repeat the question a second time and count to five that I had more volunteers and students that had time to formulate a good answer.

"BIBLIOGRAPHY"

BIBLIOGRAPHY

Brooks, J.G., and M.G. Brooks. (1993). "In Search of Understanding: The Case for Constructivist Classrooms," Alexandria, Va.

Cooper, L., D. Johnson, R. Johnson, and F. Welderson. (1980). "The Effects of Cooperative, Competitive, and Individualistic Experiences in InterPersonal Attractions Among Heterogeneous Peers," *The Journal of Social Psychology*, 111:243-252.

DeBoer, G.E.. (1991). "A History of Ideas in Science Education," New York: Teachers College, Columbia University.

Dempster, F.N. (1993). "Exposing Our Students to Less Should Help Them Learn More," Phi Delta Kappan 73, November.

Frymier, J.R.. (1985). Motivation To Learn. West Lafayette, Ind.: Kappa Delta Pi.

Goldstein, Philip. (1967). Genetics Is Easy. Lantern Press, Publishers, N.Y.

Lawson, A.E.. (1995). "Science Teaching and the Development of Reasoning," Wadsworth Publishing Co., Belmont, CA.

Long, S.H.. (1991). Educational Psychology. New York: McGraw-Hill.

Lundberg, Ramona. (1997). "Student-Generated Assessment," *The Science Teacher*, January.

Matthews, M.R.. (1994). "Science Teaching: The Role of History and Philosophy of Science," Routledge, New York.

Mayer, M. (1961). *The Schools*, New York: Doubleday and Company.

Milunsky, Aubrey. (1992). Heredity and Your Family's Health. The Johns Hopkins University Press, Baltimore.

"Multiple Intellengences" - VHS. (1993). David Lazear, Director from New Demensions in Learning Brains, producer: Agency for Instructional Technology.

National Research Council. (1996). "National Science Education Standards," Washington D.C.: National Academy Press.

Newman, D., P. Griffin, and M. Cole. (1989). *The Construction Zone, Working for Cognitive Change in School*, Mass: Cambridge University Press.

Rita, Ronald D. (1998). "Integrated Constructivism," *The Science Teacher*, Vol. 65 no. 5, May.

Rutherford, F. J. (1964). "The Role of Inquiry in Science Teaching," *Journal of Research in Science Teaching*, 2:80-84.

Rutherford, F. James. (1993). "Hands-on: A Means to an End," *Project 2061 Today*, Washington, DC: American Associations for the Advancement of Science, vol. 3, no. 1, March.

Smith, E.L. & Anderson, C.W.. (1984). "The Planning and Teaching Intermediate Science Study: Final Report", (Research Series No. 147). East Lansing, MI: Institute for Research on Teaching, MSU.

Smith, M.U. (1991). "Toward a Unified Theory of Problem Solving: Views from the Content Demains," Hillsdale, NJ: Lawrence Erlaum.

"APPENDICES"

APPENDIX A

"For Your Journal"

In your science journal, answer the follow questions to the best of your ability. If you do not know an answer, make the best educated guess that you can. You must have an answer to each question.

1. What is a trait?

2. How are traits passed on from one generation to the next?

3. Name a trait that all of the human species share?

4. Why are organisms within a species different from one another?

5. What is a gene?

6. What is a chromosome?

7. Where at, in the living body, does the passing on of traits take place?

8. Does environment play a role in the development of living things? Explain.

9. What happens if there is something wrong with the traits? Give an example.

10. How can new traits be formed from manipulating or changing genes?

APPENDIX B

"Wisconsin Fast Plants®"

Background: Wisconsin Fast Plants®, *Brassica rapa*, belong to the mustard or cabbage family, (also known as Cruciferae). They are used for research and education because of their rapid developing life cycle. The principles and methods formulated by Gregor Mendel provide the basis for studies of inheritance in higher organisms.

Mendel chose garden pea plants that bred true for one or more easily recognizable and widely contrasting traits. The Brassica rapa also express strong contrasting traits.

Mendel's pea plants lend themselves to controlled crosses because of the flower structure. Left to themselves, peas will only self-pollinate because both anther and pistil are enclosed completely by petals. Mendel could cross-pollinate any two plants by prying open the buds and removing the anthers before self-pollination. Pollen from another plan is transferred to the stigma of the first plant via a brush.

Thus, in peas, self-pollination is a certainty and cross-pollination involves manipulation. In Brassica rapa, these conditions are reversed.

The Brassica rapa plants do not self-pollinate. The Brassica flower structure is open with the anthers and pistil exposed, but self-pollination is prevented by a pollen-stigma incompatibility mechanism that inhibits self-pollen germination on the stigma. Brassica does not have wind-borne pollen. Cross-pollination occurs naturally by insects carrying pollen from plant to plant. Self-pollination can be accomplished only by bud pollination. One to three days before the young buds open, they are pried open and pollen is transferred from a mature anther on the same plant to the immature stigma. The incompatibility mechanism is not operational for a short time, and self-fertilization can take place. Thus, in Brassica rapa, cross-pollination is a certainty and self-pollination involves manipulation.

Objectives: In this lab you will investigate the inheritance of the gene(s) controlling a mutant trait. You will cross-pollinate F1 plants to produce F2 seeds. Then you will grow F2 plants and observe segregation.

I. Principle of unit characters- each trait or phenotype is conditioned by a single gene that occurs in pairs.

2. Principle of dominance- one of the pair of genes may differ in its expression and be masked by the other.

3. Principle of segregation- during the formation of gametes, the two factors for a trait must separate.

Materials:

* soil with vermiculite
* 100% polyester felt
* film canisters
* tupperware containers
* F1 seeds Rosette (Ros/ros)
* copper sulfate
* fertilizer pellets
* bee wands

Pre-Lab Questions:

I. How can you distinguish whether the mutant trait is inheritable or is the result of environmental effects?

2. If a single gene controls the mutant trait, how will you determine the dominant and the recessive expression of the gene?

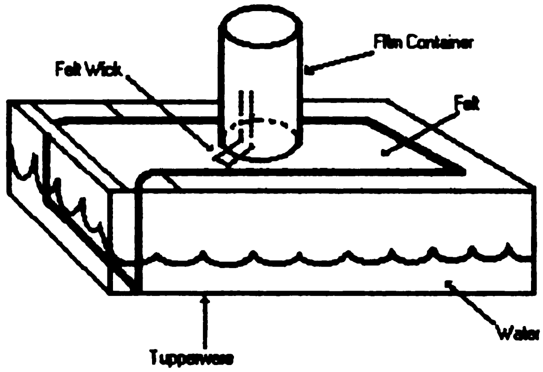
3. What is your hypothesis about the inheritance of the mutant trait?

Procedures and Observations:

First Generation (F1 Hybrid)

I. Always begin a planting cycle on Monday or Tuesday. This allows three consecutive school days for watering from above.
2. Prepare the felt water mat for use by soaking it in water and simply lay it on the top of the tupperware container. A piece should be long enough to extend down into the reservoir to soak up water. (This watering system is based on capillary action). Now fill the reservoir half to 3/4 full.
3. Moisten the potting mix until it is slightly damp.
4. Place the 1 ½ in. pre-cut felt strips (wicks), into the holes of the film containers so that half of it is inside and the other half is sticking out, (Figure 8).

Figure 8: Apparatus for growing Wisconsin Fast Plants®.



5. Fill each container half full with potting mix.
6. Add three fertilizer pellets to each cell.
7. Add more potting mix to fill each cell to the top. Do not pack the soil down. Use the end of a pencil to make a 4 mm depression in the potting mix in each cell
8. Drop three seeds into each depression.
9. Cover the seed with just enough soil so that they are no longer visible.
10. Label each container with the date and type of seed, (Use a waterproof pen).
11. Water gently with a pipet until the water drips from the wick at the bottom of the container.
12. Be sure to water gently from the top with pipets for the first three days to insure adequate moisture during germination.

* Follow the grower's calendar for the remaining life cycle of the plants, (see next page).

** Hint - Wash all materials before each planting with a bleach/water solution to sterilize them.

*** Note - If there appears to be a lot of algae on the felt or in the reservoir, drop into the water a small amount of copper sulfate.

Second Generation (F1) Seedlings

Date	Age of Plants	Your # Wild Type	Class # Wild Type	Your # Mutant	Class # Mutant

Second Generation (F2)

The mutant traits, like rosette, are recognizable at the seedling stage. Place one filter paper disc in the lid of a petri dish. Write your name and the type of seed in pencil on the filter paper. Add water until the paper is wet and then pour off the excess water. Place 20 seeds in four neat rows on the upper two-thirds of the filter paper. Place the cover on the dish and stand the dish in about 2 cm of water in a reservoir. Tilt the dish slightly so that water collects at the bottom and place the dish under the light bank. Seed should all be above the water line. On day three to five, observe and record the number of mutant and wild-type plants.

Third Generation (F2) Seedlings

Date	Age of Plants	Your # Wild Type	Class # Wild Type	Your # Mutant	Class # \Mutant

Discussion Questions:

I. Describe the plants in the F1. What does this suggest about the inheritance pattern of the mutant trait?

2. What do the combined class data for the F2 suggest about the inheritance of the mutant trait?

3. Are the deviations from a 3:1 ratio in the F2 significant? Explain your answer.

4. Do the results agree with your original hypothesis? If not, what is your modified hypothesis?

5. What additional cross(es) would you do to verify your hypothesis?

Extensions

I. Students can take the F2 seeds and instead of germinating them, actually plant them and take them home for the entire life cycle.

2. Students can do other experiments with the fast plants to prove or disprove theories that they may have, such as, starch in the soil or water, pollen studies plants responding to certain stimuli, etc.

* This lab was adapted from the Wisconsin Fast Plant manual published by Carolina Biological Supply Company.

Grower's Calendar

Calendar Date	Day of Cycle	Activities
__________	Prep	*Assemble light bank and rack. *Saturate water mat according to instructions and set up reservoirs. *Arrange all planting materials.
__________	Day 1	*Plan to start the life cycle on a Mon. or Tues. *Plant, water from above, label, and set on water mat, leaving 5 cm from top of Quads to lights.
__________	Day 2 to 3	*Water from top with pipet.
__________	Day 4 to 5	*Thin plants to one plant per cell. *Transplant, if necessary, to obtain one plant in every cell. *Check the water level in the reservoir.
__________	Day 6 to 11	*Check plants and reservoir water level daily throughout the rest of the cycle. *Observe growth and development.
__________	Day 12	*Make bee sticks. (Flower bud begin to open.)
__________	Day 13 to 18	*During this time, cross-pollinate for 3 consecutive days. *On the last day of pollination, remove unopened flower buds.
__________	Day 17 to 35	*Observe seed pod development and embryos maturing.
__________	Day 36	*Remove plants from the watering system and allow plants to dry for five days.
__________	Day 40	*Harvest seeds from dry pods and store appropriately. *Remove plants, potting mix, and wicks from quads. *Clean all equipment and prepare for the next planting.

APPENDIX C

"Family Likeness"

Now it is time to begin a history of a family of your choice. You may use your family, a neighbors family, a soap opera family or even a famous family. The family history will feature a diagram like the one drawn for Juan's family in our Science Plus textbook on page 441. You must have at least four generations, however, you should include as many generations as possible. Have a key to represent male, female, and marriages. Ask questions of family members and look through family records and photos to assist you in constructing your family tree.

1. What is meant by a generation of a family?

2. How many generations are included in your family tree?

3. What two members look most alike? How are they related?

4. What two members look least alike? How are they related?

5. Who has more ancestors, a person in the third or fourth generation? Explain.

APPENDIX D

"Genetics Survey"

Mrs. Pringle's 8th grade science class is studying a unit on genetics. They would like to determine how many members of their entire 8th grade class share specific physical traits.

Fill out the survey by answering "yes" or "no" and circle the correct response. Please return these to Mrs. Pringle or to the Genetics student that attended your Prime Time.

yes no I. Can you see the figure in the picture? This is a test for colorblindness.

yes no 2. Can you roll up the edges of your tongue?

yes no 3. Do you have free ear lobes? If you don't, then yours are called attached ear lobes.

yes no 4. Is the last segment of your thumb straight? This is sometimes called hitch hickers thumb.

yes no 5. Do you have dimples? Not creases.

yes no 6. Do you have hair on the middle digits of you fingers?

yes no 7. When you fold your hands naturally, does your left thumb cross over your right?

yes no 8. Is your fifth finger (pinky) straight? If not, they usually curve away from each other to make a "Y".

yes no 9. Do you have an indentation in the middle of your chin? (cleft chin)

yes no I0. Do you have a widow's peak in your hair line?

yes no II. Can you wiggle your ears without touching them?

yes no I2. Is your second toe longer than your big toe? (Morton's toe)

yes no I3. Are you right handed?

yes no l4. Do you naturally, fold your left arm over your right?

yes no l5. Do you have naturally curly hair?

* Other interesting genetically linked traits:

- long eyelashes
- baldness (male - pattern)
- tune deafness (inability to distinguish tones)
- asthma
- eye color
- hair color
- ability to roll tongue (folding up the tip)
- hairy ear rims
- cat eye syndrome
- acute alcohol intolerance

and many more!

APPENDIX E

"Environment or Heredity?"

Background: In this lesson, you will explore the role environment plays in the development of living things. After identifying a number of factors contributed by the environment to the development of living things, you will see the effects of gibberellic acid on a short rossette plant.

The effects of gibberellic acid were first investigated when rice plants infected with a fungus grew very rapidly, became much taller than normal, and fell over. This was known as the "foolish seedling disease". The effect was due to the fungus producing a large amount of a chemical which is normally present in plants in small amounts as a growth-regulating hormone. The chemical, gibberellic acid, causes many dwarf or bushy plants to grow tall.

Objective: To treat dwarf plants with gibberellic acid (GA) and observe the results.

Materials:

* 24 rosette seeds (ros/ros)
* 8 film canisters
* potting soil
* fertilizer pellets
* l00% polyester felt
* 2 disposable pipets
* gibberellic acid (GA)
* metric rulers

Pre-Lab Questions:

l. What do you predict will happen to those rosette plants treated with GA?

2. What part of the plant will be effected?

Procedures:

l. Follow the procedures for planting Wisconsin Fast Plants®.

2. Plant eight containers of rosette type and label four "rosette, water", and label four "rosette, GA".
3. Also, label one pipet "water" and the other one "GA".
4. On day eight, and every other day until flowering (about day 16). Record plant height (distance from the stem from the point of cotyledon attachment to the very tip of the plant). Measure in cm to the nearest mm and record. According to the labels, apply one drop of GA or water to each leaf on your plants, using the proper pipet.

Observations: Measure and record your data.

Date	Plant Age	Water/ Yours	Water/ Class Avg	GA/ Yours	GA/ Class Av

Discussion Questions:

1. What is the effect of GA on the rosette mutant?

2. What is the effect of water on the rosette mutant?

3. Compare the water treated plant and the GA treated plant. Do your results prove that the rosette is a gibberellic acid-deficient mutant? Explain.

* This lab was adapted from the Wisconsin Fast Plant manual, published by WARF and Carolina Biological Supply Company.

APPENDIX F

"Plant & Animal Cells"

I. Define the following vocabulary terms for the plant and animal cell:

*cell wall -

*cell membrane -

*chloroplast -

*vacuole -

*cytoplasm -

*mitochondrion -

*nucleus -

*nuclear membrane -

*ribosome -

*endoplasmic reticulum -

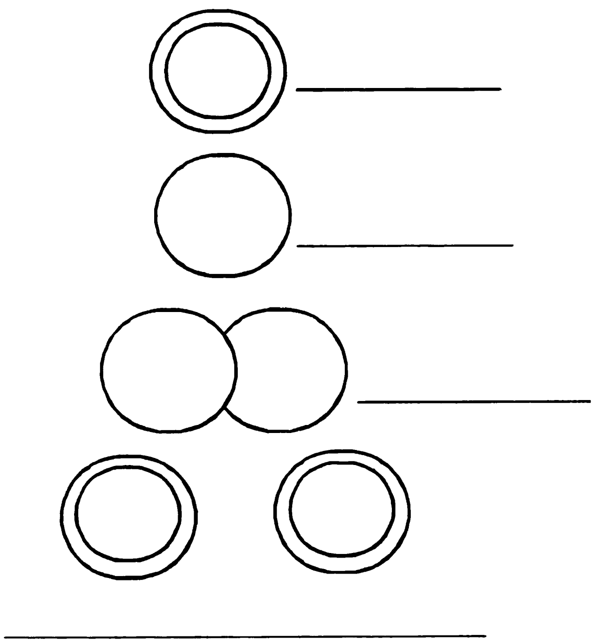
II. Draw, color and label the plant and animal cell.

APPENDIX G

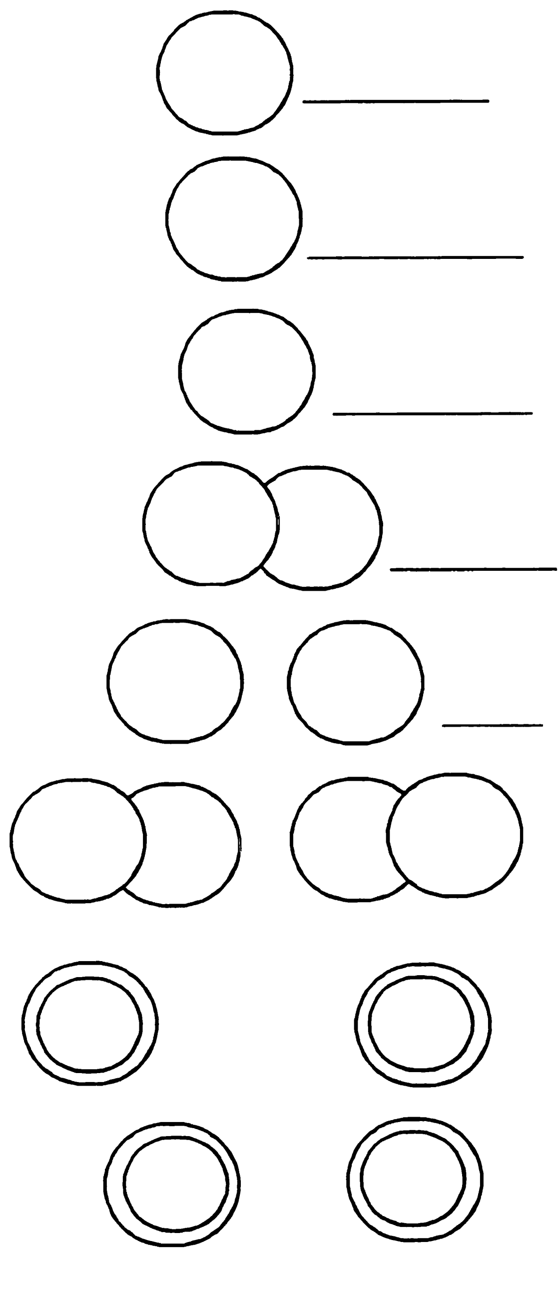
"Mitosis and Meiosis"

Draw the chromosomes and label the following diagrams:

Mitosis



Meiosis



APPENDIX H

Name________________
Hour_____
Quiz - Unit 8, sec. 1-3

"Genetics Unit"

I. What is heredity? Use some examples that we have studied so far in this unit.

2. Who are Watson and Crick?

Matching:

____3. trait	a. a type of cell division that produces sex cells.
____4. genes	b. the division of a single cell into two new cells.
____5. chromosomes	c. structures in the nucleus of a cell that carry the hereditary factors.
____6. Mitosis	d. a type of cell division that produces body cells.
____7. Meiosis	e. individual sections of chromosomes that control hereditary traits.
____8. sexual reproduction	f. two cells unite and become parents of the next generation.
____9. asexual reproduction	g. characteristics of a person, i.e. hair color, eye color, dimples, etc.

10.-11. Draw and label both a plant cell and an animal cell, include the following structures: nucleus, nuclear membrane, cytoplasm, cell wall, cell membrane, mitochondrian, endoplasmic reticulum, ribosomes, vacuole,

12.-13. Summarize the processes of mitosis and meiosis. Include diagrams to make the information as clear as possible.

14. How are mitosis and meiosis similar?

15. How are mitosis and meiosis different?

APPENDIX I

"Punnett Square Worksheet"

1, A cattle ranch owner wants to cross a longhorn steer (HH) with a shorthorn cow (hh). Draw a Punnett square to show the possible offspring. Describe what the offspring will look like, both phenotype and genotype. What is the ratio?

2. A pheasant breeder takes a healthy brown rooster carrying a recessive trait for black neck feather Bb, and crosses this bird with a black neck hen bb. Draw a Punnett square and show both the phenotype and genotype. What is the ratio?

3. What happens when you cross a brown-eyed girl carrying a recessive trait for blue eyes (Ee) with an eligible bachelor having the same characteristics? Draw a Punnett square and show both the phenotype and genotype. What is the ratio?

4. Explain how a man having (XY) chromosomes can expect a 50% chance of having a male baby when married to a woman having (XX) chromosomes. Draw a Punnett square and show both the phenotype and genotype. What is the ratio?

5. Cross a tall, round pea plant (TtRr) with a short, round pea plant (ttRr). Tall is dominant over dwarf. Round seed is dominant over wrinkled. Draw a Punnett square and show both the phenotype and genotype. What is the ratio?

6. Cross a tall, round pea plant (TtRr) with another tall, round pea plant (TtRr). Make a Punnett square and show both the phenotype and genotype. What is the ratio?

APPENDIX J

"Chromosome Line-up"

I. Have each student look at the metaphase spread in their textbook on page 462. Ask the students how they would arrange the chromosomes so they could be studied more easily.

2. Pass out the Human Karyotype form with attached velcro for the students to group the chromosomes in pairs. Then give them an envelope filled with the cut out chromosomes (with velcro on the back) and have them match the pairs according to

   * size of the chromosome (largest to smallest)
   * banding of the chromosomes (to form pairs)
   * position of the centromere (to assure correct groups

Group	Chromosomes	Characteristics...............
A	l - 3	Very long with metacentric (median) centromeres.
B	4 + 5	Long with submetacentric (set off from the middle) centromeres.
C	6-12, X	Medium length with submatacentric centromeres.
D	13 - 15	Medium length with acrocentric (at or very near to end) centromeres.
E	16 - 18	Somewhat short with submetacentric centromeres.
F	l9 - 20	Short with metacentric centromeres.
G	2l-22, Y	Very short with acrocentric centromeres.

3. Show the students how to locate the genes on the chromosomes in their karyotypes, (ex. p and q quadrants).

4. Give each student the gene locations for different human genetic disorders

and briefly discuss each trait. Ask them to put 8 of the disorder traits from the list on their chromosomes so that they are carriers for each of these traits. Do this with overhead transparency pens.

5. Pair off the students that have pink karyotypes (female) with the students that have blue karyotypes (male).

6. Now the game begins, to determine what chromosomes will be passed on to the baby's karyotype. Tell the students to do the following:

   A.) Roll the die to determine which chromosome from a given pair will be passed on to the offspring, (odd= one chromosome and even= the second chromosome). This is meiosis I.

   B.) Cut the doubled chromosome selected in half and place one of the halves on the new karyotype form (with velcro). This is meiosis II.

   C.) Carry out this process for every pair of chromosomes.

7. While your students are working on the karyotype for their baby you can create other types of chromosomal mutations by walking around and adding whole chromosomes or bits of chromosomes or by removing chromosomes from their karyotypes.

8. Journal entry: As the parents of this child, what questions would you have for your doctor and/or your genetic counselor?

* This was a modification of a Ball State Activity.

APPENDIX K

Name ________________________
Hour _______

"Blood Typing"

Background: Around 1900, Karl Landsteiner discovered that there are at least four kinds of human blood based on the presence or absence of specific agglutinogens on the surface of red blood cells. These antigens have been designated as A and B. Antibodies against antigens A or B begin to build up in the blood plasma shortly after birth. The antibody levels peak at about eight to ten years of age, and the antibodies remain present in declining amounts throughout the rest of life. A person normally produces antibodies against those antigens that are not on his red blood cells but does not produce antibodies against those that are present on his red blood cells. Thus a person with antigen A has anti-B antibodies; a person with B antigens has anti-A antibodies; a person with neither antigen A or B (blood type O) has both anti-A and anti-B antibodies; and a person with both antigens A and B has neither anti-A nor anti-B antibodies.

The four blood groups are known as types A, B, AB and O. Blood type O is the most common, with 45% of the population in the United States, type A is found in 39% of the population, type B is found in 12% and type AB is most rare with a percentage of 4.

Table 1

ABO System

Blood Type	Antigens on Erythrocytes	Antibodies in Plasma	Can Give Blood to:	Can Receive Blood from:
A	A	Anti-B	A, AB	O, A
B	B	Anti-A	B, AB	O, B
AB	A and B	Neither anti-A nor anti-B	AB	O, A, B, AB
O	Neither A nor B	Both anti-A and anti-B	O, A, B, AB	O

Objectives:

1. To determine the ABO blood type of four unknown blood samples.

2. To determine the Rh factor of four unknown simulated blood samples.

Materials:

* blood typing slides
* toothpicks
* anti-A, anti-B, anti-Rh simulated typing serum
* 4 unknown simulated blood samples
  - -Mr. Smith
  - -Ms. Jones
  - -Mr. Green
  - -Ms. Brown

Procedure:

1. Each lab table will determine the blood type of one of the four unknown blood samples.

2. Place 3-4 drops of the assigned unknown blood in each of the A, B, and Rh wells of the blood typing slide.

3. Add 3-4 drops of the simulated anti-A serum in well A on the slide.

4. Add 3-4 drops of the simulated anti-B serum in well B on the slide.

5. Add 3-4 drops of the simulated anti-Rh serum in well Rh on the slide.
6. Use separate toothpicks to stir each sample serum and blood. Record your observations and results in the table below.

* This lab is adapted from the WARD'S Simulated ABO and Rh Blood Typing Kit.

Agglutination Reactions
Data Table

	Anti-A Serum	Anti-B Serum	Anti-Rh Serum	Blood Type	What you Observe
Mr. Smith					
Ms. Jones					
Mr. Green					
Ms. Brown					

Analysis of Results:

1. What ABO agglutinogens are present on the red blood cells Mr. Green's blood?

2. What ABO agglutinins are present in the plasma of Mr. Green's blood?

3. If Ms. Jones needed a transfusion, what ABO type(s) of blood could she safely receive?

4. If Ms. Brown were serving as a donor, what ABO blood type(s) could receive her blood safely?

5. Why is it necessary to match the donor's and the recipient's blood before a transfusion is given?

6. Could a man with an AB blood type be the father of an O child?

7. Could a Type B child have a mother with Type A and a father with Type A?

8. What are the possible combinations of an offspring when the blood types of the parents are A and B?

APPENDIX L

Science Sleuth
"Twins or Not?"

Student/Group Name: ______________________________

Case: ______________________________

Mission Statement: ____

How to solve the mystery: Watch the *scene set* and the *mission* for the sleuthers. Develop one or more hypotheses to solve the problem using your knowledge from the genetics unit. Then choose *resources* to view for clues to support your theories. At each step, discuss the information learned and build or discard your theories. At each step, also take notes listing the resources and information learned. When you have a solution to the mystery, complete your lab reports with a summary and recommendations for further study.

Resources	Notes/Observations

Resources	Notes/Observations

Summary Findings:

Recommendations for Further Study:

APPENDIX M

Name ____________________
Hour ______
Science Test - Unit 8

Genetics Unit Test

True or False:

_____1. Genetics is the scientific study of heredity.

_____2. A recessive trait can cover up a dominant trait.

_____3. In heredity, blending is the same as dominance.

_____4. Mendel experimented with Drosophila, (fruit flies).

_____5. A gene is a part of the DNA molecule.

_____6. The union of male sperm cell with a female egg cell restores the chromosome number of species.

_____7. The Law of Dominance explains the inheritance of all traits.

_____8. Hemophilia occurs in more women than men.

Multiple Choice:

__________1. (Meiosis, Mitosis, Asexual Reproduction) produces body cells which has 23 chromosomes.

__________2. Seeds from pure tall pea plants produce (short, tall and short, tall, medium) pea plants.

__________3. The number of chromosomes in an egg cell is (half two times, the same as, three times) the number of chromosomes in a body cell.

__________4. In a cross between two hybrid traits about (¼, ½, ⅓, ¾) of the offspring will be expected to show the dominant trait.

__________5. In a cross between a pure dominant trait and a pure recessive trait (25, 50, 75, 100) percent of the offspring will show the dominant trait.

__________6. Genes are located in (chromosomes, cytoplasm, RNA).

__________7. DNA is present in (cytoplasm, RNA, genes).

___________8. Identical twins have (the same, different, either the same or different) sex.

___________9. (Purebred, Hybrid, Crossbred) animals breed true.

__________10. To be sure that he will get the kinds of genes he wants, a plant breeder controls (pollination, growth).

Completion:

______________________1. Every living cell comes from another ________.

______________________2. Inherited traits are controlled by pairs of ______.

______________________3. ________ organizes information about the parents' and offspring's genes and predicts the ratio in which offspring will inherit genes.

______________________4. A sudden change in an inherited trait is called a _________.

______________________5. _________ is an example of a recessive trait.

______________________6. _________ is an example of a dominant trait.

______________________7. _________ is the Austrian monk that announced his observations on plant inheritance.

______________________8. If there are 26 chromosomes in a species, there will be _________ chromosomes in the sperm and __________ chromosomes in the egg.

Punnett Squares:

Complete the Punnett squares and give the phenotype, genotype and ratio of the offspring.

1. What type of children would a woman having (AO) blood type and a man having (BO) blood type have?

phenotype - ____________________

genotype - ____________________
ratio - _________________

2. Cross a tall round pea plant (TtRr) with a short round pea plant (ttRr). Tall is dominant over short. Round is dominant over wrinkled.

phenotype - _________________
genotype - __________________
ratio - _______________

Essay:

I. Explain how traits are passed on from one generation to the next.

2. Why are organisms within a species different from one another?

3. Where at, in the living body, does the passing on of traits take place? Be specific.

4. Does environment play a role in the development of living things? Explain.

5. What happens if there is something wrong with the traits? Give an example.

6. How can new traits be formed from manipulating or changing genes?

APPENDIX N

Genetics Test - Essay Rubrics

Question 1
Explain how traits are passed on from one generation to the next.

0. Off target
1. The passing of traits from parents to young.
2. When the parent cells (egg and sperm) unite and pass on their genes to the new offspring.
3. Traits are passed on to the next generation by the sperm cells, containing 23 chromosomes, fertilizing the egg cell, which also contain 23 chromosomes, to produce a new offspring with 46 chromosomes. The new young will have inherited traits from both of the genes that the parents passed on.

Question 2
Why are organisms within a species different from one another?

0. Off target
1. Organisms are different because they have different characteristics or traits.
2. Organisms are different because they have different genetic make-up and parents.
3. Organisms within a species differ from one another because of combinations and recombinations of genetic material within the gene pool. Environmental factors may also influence gene expressions.

Question 3
Where at, in the living body, does the passing on of traits take place? Be specific.

0. Off target
1. The passing on of traits takes place in the cells.
2. Traits are passed on in the genetic material of the nucleus in cells.
3. Traits are passed on in the nucleus of the cells on the chromosomes composed of DNA and proteins that are divided into sections called genes.

Question 4

Does environment play a role in the development of living things? Give an example.

0. Off target
1. Environment changes living things.
2. The environment changes living things like, weight, hair color, etc.
3. Traits of living things can be influenced by environmental factors such as stress, overall health, nutritional choices, regular exercise, cosmetic choices, etc.

Question 5

What happens if there is something wrong with the traits? Give an example.

0. Off target
1. If something goes wrong with the traits then the offspring wont be right.
2. The young could have birth defects or die if something is wrong with the traits.
3. Birth defects and miscarriages result from mutations, chromosome abnormalities, developmental errors, and the inheritance of certain abnormal or lethal genotypes.

Question 6

How can new traits be formed from manipulating or changing genes?

0. Off target
1. Can change the genetic material in cells.
2. Scientist manipulate the sequence of the DNA strand in order to get a desired trait.
3. Geneticist can manipulate DNA, in the cell's nucleus, in order to alter the organism's traits, thus performing genetic engineering.

APPENDIX O

Name _______________
Hour ______

Heredity
Self-Assessment and Unit Evaluation

I. Number the following teaching methods from 1-6 in order that you thought they helped you learn the most about the unit?

____individual work
____small group work
____laboratory experiments
____note taking
____class discussions
____videos

2. Put a "+" on the activity you liked most and a "-" on the activity you liked least in this unit.

____ 8th grd. Class survey
____Family Tree Activity
____Wisconsin Fast Plants
____Mitosis/Meiosis
____Chromosomes
____Blood Typing
____Punnett Squares
____Genetic Disorders
____Science Sleuth

3. How was the unit different from others taught this year?

4. What was the hardest concept for you to understand in the unit?

5. Grade yourself on the following life skill areas, (A-E):

____My homework was completed and handed in on time.
____I follow directions written and orally.
____I am organized.
____My science journal was complete.
____I studied for all quizes and tests.
____I read through all assignments thoroughly.
____I take good notes.
____I participate in class discussions.

6. Write an academic or life skill goal that you would like to work on during the next unit in order to improve your grade.

7. Write a statement, giving your opinion about one thing you liked about the unit and one thing you would change.