THESIS

6193218

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thesis entitled

TEACHING GENETICS IN AN INTRODUCTORY BIOLOGY COURSE

presented by

KRISTINA A. PORTER

has been accepted towards fulfillment
of the requirements for the

MS degree in INTERDEPARTMENTAL BIOLOGICAL SCIENCE

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TEACHING GENETICS IN AN INTRODUCTORY BIOLOGY COURSE

By

Kristina A. Porter

A THESIS

Submitted to
Michigan State University
In partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Division of Science and Mathematics Education

2004

ABSTRACT

TEACHING GENETICS IN AN INTRODUCTORY BIOLOGY COURSE

By

Kristina A. Porter

The purpose of this study was to test the effectiveness of a genetics unit taught to high school freshmen in an introductory biology course. The unit incorporated the Michigan Essential Goals and Objectives for Science Education (MEGOSE) benchmarks for genetics as well as some of the basic biotechnology that students may encounter on a daily basis. A variety of teaching methodologies were utilized to reach students of many different learning styles while trying to teach the content in a timely manner. Students engaged in a mixture of teacher and student centered activities, had one large project based assessment, and participated in discussions over bioethical concerns raised by applications of this new technology. The effectiveness of the unit was measured by comparing the results of a pretest and post-test over the material, as well as a student survey addressing the newly created activities. Statistical analysis comparing the pretest and post-test data indicated a 99.99% level of confidence that the genetics unit presented during the study did facilitate student knowledge of genetics.

DEDICATION

I dedicate this work to my family and friends, especially my father who was unable to see it completed. With your faith and support anything is possible. Thank you.

ACKNOWLEDGEMENTS

Thank you to Dr. Merle Heidemann for her guidance and support through the DSME program. I also wish to thank all of the DSME instructors and Frontiers in Science presenters for their efforts to improving science education through increasing teacher content knowledge.

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INTRODUCTION

Purpose and Rationale

The purpose of this study was test the effectiveness of a redesigned genetics unit taught to high school freshman in an introductory biology course. Genetics is traditionally a popular unit in high school biology, stemming from student interest in how and what types of traits can be inherited. It is important to learn genetics not only for the sake of interest in inheritance, but because the technology surrounding genetics impacts food, medical treatment, and legislation. In most introductory biology courses the genetics unit is comprised of Mendelian genetics with very little time spent on DNA fingerprinting, genetic engineering, or cloning, despite the frequent coverage of these issues in the media. Another concern was time constraints because this introductory course covers all of the life science Michigan Essential Goals and Objectives for Science Education (MEGOSE) benchmarks to prepare students for the Michigan Educational Assessment Program (MEAP) test. Genetics may be one of the most talked about areas of biology, but there are only three MEGOSE objectives regarding heredity.

Basic information on the historical development of genetics can be found in any introductory genetics text, such as Genetics: From Genes to Genomes by Hartwell, Goldberg, Silver, Veres, and Reynolds (2004). Humans have been aware of the fact that characteristics can be passed from one generation to

another for centuries. This idea was used to maintain "royal blood" within ruling families, improve crops, and domesticate animals. However the study of the mechanics of this phenomenon, genetics, is fairly recent.

In 1866 Gregor Mendel published a paper describing the inheritance pattern of pea plant traits. The scientific community largely ignored this paper until three different scientists rediscovered and confirmed his findings in 1900. A British scientist, William Bateson, championed the study of heredity, and coined the phrase "genetics" in 1905. During the early 20th century genetic study focused on finding the mechanism for trait inheritance. The idea that chromosomes carried hereditary information was first proposed by Sutton and Bovary, and later confirmed by the *Drosophila* eye color experiments of T.H. Morgan in 1910. Work done by Griffith in the late 1920's, Avery in the 1940's, and Hershey and Chase in 1952 with transforming bacteria and bacteriophages identified DNA as the molecule responsible for heredity. Research done in the 1950's increased knowledge of the DNA molecule. In 1953 Watson and Crick (with the help of x-ray crystallography images from Franklin and Wilkins and nitrogenous base pair information from Chargaff) unveil the structure of DNA to be a double helix comprised of two chains of nucleotides joined by specific nitrogenous base pairs. Gene expression, how DNA causes traits to occur was pieced together in 1966 by Nirenberg, Matthaei, Leder, and Khorana.

From this initial understanding of DNA and gene expression there have been many advances in our understanding of genetics and corresponding

biotechnology in the last 30 years, and especially within the last decade. Once gene expression was uncovered the focus shifted to molecular genetics and the manipulation of DNA. In the early 1970's Cohen and Boyer inserted foreign DNA into a DNA strand creating recombinant DNA. In 1977 Fred Sanger created a method to sequence DNA fragments, paving the way for the genomics projects of the 1990's. Kary Mullis developed a method for rapidly producing copies of DNA fragments, even from segments of poor quality, for use in a wide range of applications such as forensics and genetic engineering, called Polymerase Chain Reaction (PCR) in 1986. The 1990's and early twenty-first century saw a huge jump forward in the development and use of biotechnology. DNA fingerprinting is used to solve crimes and paternity cases, mammals were successfully cloned, humans have been treated by gene therapy, and the genome of entire organisms, including humans, have been decoded.

Since the 1990's genetics and biotechnology have received a lot of media attention. The public is faced almost daily, from both the entertainment industry and news media, with topics like DNA fingerprinting, gene therapy, cloning, genetically modified foods, stem cell research, pharming (the use of GMO's to produce pharmaceuticals), and the Human Genome Project, and yet these topics are often not discussed in an introductory level biology course.

Teaching genetics and biotechnology is important to give students enough background information to make informed decisions about how they will use and

interact with the products of biotechnology in their lives. All students, those on a science career pathway and those that are not, will have to make decisions about the use of biotechnology. It impacts the food they eat, medical treatment, pets, and our justice system. Our job as educators is to provide them with the background knowledge so that they can make informed decisions regarding the role biotechnology plays in their lives (Johansen and Harris, 2000). A lack of understanding of biotechnology leads students to overestimate its use and its possible future applications. (Dawson and Schibeci, 2003). It is important for students to have a basic understanding of the more complex processes in genetics to aid their ability to take advantage of the benefits it can bring, and not be at the mercy of those who have a vested interest in it's use or disuse. (Trumbo, 2003).

One reason for the omission of these topics is the result of standardized testing. School finance and student scholarship money are tied into the Michigan Educational Assessment Program (MEAP) Test. With the high stakes attached to standardized testing, teachers tend to focus only on the test objectives (Barksdale-Ladd and Thomas, 2000). However the MEGOSE objectives related to genetics, on which the MEAP test is based upon, do not include such topics as DNA structure, gene expression, the Human Genome Project, and DNA fingerprinting (MDE, 2000). MEGOSE objectives stress the results of genetics, but not the processes. For example, MEGOSE objective III.3.3 states that students should know the products of genetic engineering (MDE, 2000), but there

is no mention of how those products were created. This seems at odds with current proposed best practices in science teaching that stress a process oriented approach to learning science (NRC, 1996). Indeed, courses geared for standardized test preparation often forgo the more time consuming best practice teaching methodologies in an effort to cover all the test objectives (Wildeen, O'Shea, Pye and Ivany, 1997).

At Vicksburg High School (VHS), the site for this study, students must take three semester long science courses to graduate. The courses required are an introductory level Biology course, Physical Science course, and one other elective science course. The Biology and Physical Science courses have been aligned to cover all of the high school level MEGOSE benchmarks. The genetics unit in the introductory biology course traditionally was strong on Mendelian genetics, with little to no mention of genetic engineering or biotechnology. There are a variety of electives for the students to take, but only the only one with any genetics content is AP Biology. AP Biology enrollment numbers are very small, between 10-15 students a year. Approximately 95% of graduating students at VHS receive information regarding genetics only from this introductory biology course. Therefore, efforts to effectively educate the majority of students on basic biotechnology must occur in the introductory biology course.

The most difficult challenge for a teacher is not identifying the objectives to be taught, but developing strategies for effectively teaching those objectives.

Students in the average introductory science course are a heterogeneous mixture of interests, skill levels, learning styles and intelligences. By consensus, there are three main learning styles; auditory learners who learn best through listening, visual learners who learn best through seeing/reading, and tactile/kinesthetic learners who learn best through doing activities. Gardner (1983) adds to these basic learning types seven kinds of multiple intelligences: linguistic intelligence, logical-mathematical intelligence, spatial intelligence, kinesthetic intelligence, musical intelligence, interpersonal intelligence, intrapersonal intelligence, and naturalist intelligence. Obviously, students learn better if the teaching methodology matches their learning style. One of the difficulties for teachers is trying to pick the correct methodology to teach the content while reaching as many students, with varied learning styles and intelligences, as possible. It is considered to be good teaching practice to utilize a variety of teaching methods (Newton and Rogers, 1996). Each teaching technique is designed to increase a certain subset of students' understanding, but it may not benefit all students learning equally. It is up to the educator to evaluate and utilize available instructional methods in ways that create a maximal learning environment for all students in the classroom.

Inquiry based learning is considered to be the current best practice for teaching science (NRC, 1996), but it is difficult to define. Inquiry learning is a process based learning, where students learn through testing their own questions and curiosities. The amount of inquiry in an activity may range from students asking a

question and developing the procedure to students picking one variable to test during a lab. Inquiry activities can increase student achievement, but they also widen gaps in understanding between groups of students (Von Secker and Lissitz, 1999). Inquiry activities are a useful teaching tool, but not always the most efficient method of teaching more information (Rusbelt, 2000), which is a consideration for teachers trying to teach a large number of objectives in preparation for a standardized test.

Hands on activities and the use of manipulatives to teach science have been pushed aside in favor of the more process-based inquiry activities, but they can still positively impact student interest and performance. Both inquiry and hands on activities allow students to observe phenomena and draw conclusions from their observations. The difference is that inquiry activities have student-generated procedures/variables as opposed to those formed entirely by the teacher which the student then just performs. Frequent use of hands-on activities has a positive impact on student test scores (Stohr-Hunt, 1996) as well as promotes positive attitudes toward science (Freedman 1997).

One researcher reviewed over 300 journal articles and created a list of eleven benefits student gain through cooperative learning (Lord, 2001). The benefits according to Lord (2001) include enhanced science thinking, along with enhanced practical and social skills. Drawbacks to cooperative learning include students becoming less willing/ unable to work independently and putting

students who are willing to work at a disadvantage by having to carry a non-working partner through the activity (Ashraf, 2004).

Inquiry and cooperative learning teaching methodologies are examples of student-centered learning, wherein the students "become active knowledge workers rather than passive knowledge recipients" (Harmon S.W. & Hirumi A., 1996).. There has been a shift away from teacher-centered instruction in the last two decades. Many studies, including one done by McManus, Dunn and Denig (2003) indicate that student attitude and achievement increase when teacher-centered methodologies are not employed. This does not mean that traditional lecture has no role in the classroom, and one study showed students taught using teacher centered instruction performed better on written tests than their counterparts who were taught using student-centered methods (Livecci, Stemmans, Merrick and Ingersoll, 2001).

There are many Internet resources available to teach science. The Internet can provide enriching interactive learning opportunities for students (Greene, 1998). Computer graphic-enhanced lessons can improve student understanding of science concepts (Butler and Wiebe, 2003). Concerns with utilizing this technology include finding worthwhile resources, obtaining access to the Internet with computers that have the ability to run graphic intensive programs, and blocking students from accessing inappropriate websites. The use of Internet technology can be utilized with inquiry and cooperative learning activities.

Assessment strategies are also being re-examined by educational researchers. Standardized testing is often criticized for its limited ability to adequately assess student knowledge. Performance assessment or project-based assessment requires students to demonstrate their knowledge by producing a project or product as opposed to a traditional test. This method of assessment allows students with varying learning styles and intelligences to explain material in a way more fitting with their learning style (Brualdi, 1998). Typical multiple-choice tests do not allow for differences in student understanding to be expressed, and tend to emphasize facts rather than processes (Ediger, 2003). Project-based assessments are also more time consuming for students to produce and can cut into instructional time.

The purpose of this study was to test the effectiveness of a genetics unit, that incorporates activities for many types of learners, taught to high school freshmen in an introductory biology class. The genetics unit was designed to incorporate the Michigan Essential Goals and Objectives for Science Education (MEGOSE) benchmarks for genetics as well as some of the basic biotechnology that students may encounter on a daily basis. Since so few students elect to take more advanced biology classes, the more advanced coursework was moved into the introductory biology course to give all students a basic understanding of the technology surrounding genetics to allow them to become informed decision makers. In order to reach as many students as possible, a variety of teaching methods and assessments were utilized in this unit, including guided inquiry,

hands-on activities, cooperative learning techniques, use of technology, and one project based assessment. The unit also had to be compressed to teach the content in a timely manner. Students engaged in a mixture of teacher- and student-centered activities, had one large project-based assessment, and discussions over bioethical concerns raised by applications of this new technology. The effectiveness of the unit was measured by comparing the results of a pretest and post-test over the material, as well as a student survey addressing the newly created activities.

Study Group

The study was conducted at Vicksburg High School (VHS) located in Vicksburg, MI. It is a mostly rural district with an enrollment of 2,800 students, 880 of which attend the high school. The majority of the students are Caucasian, with less than three percent minorities. Sixteen percent of the students are categorized as economically disadvantaged. The graduation rate is 97%, and the majority of the students are college-bound.

Vicksburg High School prides itself on the scholastic achievement of its students. Vicksburg's MEAP passing rate in 2002 was 63%. Seventy nine percent of first time takers passed the MEAP Science section in 2003. This compares favorably with the average State of Michigan passing rate of 60%. Vicksburg High School received a letter grade of "B" on their 2003 Michigan School Report Card, which grades schools on student achievement, school performance, and amount of adequate yearly progress (AYP) or improvement in these areas.

VHS classes are nine weeks in length, with the majority of courses consisting of two separate nine-week segments. The Biology course consists of 9 weeks of Biology A plus 9 weeks of Biology B. Biology A course content includes the scientific method, macromolecules, cells, and human body systems. Biology B course content includes genetics, evolution, taxonomy, and ecology. The classes are 80 minutes long. The majority of students take 4 academic classes, plus lunch and 50 minute Academic Enhancement (AE) period. Students have the

opportunity to complete homework assignments, seek assistance from their current teachers, and utilize library and computer lab resources during AE.

Several years ago VHS started encouraging students to enroll in science courses no sooner than the spring of their freshman year. This recommendation was made due to the low scores in science courses, thought to be the result of students overloaded by too many core curricular courses while trying to adjust to the pace and academic rigor of the High School. Therefore, in their first semester, the vast majority of students enrolled in biology during the spring semester are freshmen that have not had a previous high school science course. Their last biology instruction occurred during the sixth grade.

The study was held during the second nine-week segment of two biology courses taught by the author during the Spring 2004 semester. The combined enrollment of the two biology classes involved in the study was 48 students. Twenty-nine of those students voluntarily returned signed consent forms (Appendix A) allowing the use of their data in this project. The study group consisted of twelve males and seventeen females. All were Caucasian. No member of the study group qualified for special education services or other accommodations. All students were freshmen with the exception of one female who was a sophomore. No student participating in the study was repeating the course. It was the first high school science course for all but three of the students, who had previously taken Physical Science.

CHAPTER 1. IMPLEMENTATION

The biology course is made of two individual nine-week long classes that meet daily for 80-minute block periods. The genetics unit was taught at the beginning of the second nine- week period. Teaching the unit later in the year allowed students to gain knowledge of macromolecules, cells, and the reproductive system before discussing genetics.

Entering this unit, students had been exposed to the ideas that DNA is a type of nucleic acid found in the nucleus of a cell that contains hereditary information, DNA replicates during the S portion of the cell cycle, and gametes contain half as much DNA as the parent cell. The unit starts with a more detailed look at the structure of DNA, then moves on to gene expression, basic Mendelian principles, more complex forms of inheritance, and finally genetic engineering.

The unit was taught during 24 days. A daily listing of the activities performed during the unit can be seen in Figure 1. The daily class schedule was altered to accommodate MEAP testing during the middle of the unit, but this did not affect the length of the class periods, or the schedule of activities performed during the unit.

Figure 1. Unit Outline

Topic	Day	Activity
DNA Structure and Gene Expression	Day 1	Pretest* Lecture DNA structure*
	Day 2	DNA Extraction Lab*
	Day 3	Finish Lecture Notes DNA structure ***DNA Model Activity**** DNA Synthesis HW*
	Day 4	DNA vs RNA* Transcription Activity* Homework: read Translation
	Day 5	***Protein Synthesis Lab****
	Day 6	Finish Protein Synthesis Lab
Basic Mendelian Genetics	Day 7	Lecture Basic Mendelian Inheritance* Pigoletto WS*
	Day 8	Lecture Punnett Squares* Worksheets
	Day 9	Punnett Squares day 2
	Day 10	Genetic Inheritance Patterns in Corn Lab* Dihybrid crosses
	Day 11	Dragon Lab
	Day 12	Pedigrees Modeling and WS
More Complex Inheritance Patterns	Day 13	Lecture Different types of Inheritance* Uber- Critter Project*
	Day 14	Mutations Activity*
	Day 15	Lecture How Humans Can Mess...* ~~Breeding Activity~~
	Day 16	Video Cracking the Code of Life part 1
	Day 17	Video Cracking the Code of Life part 2 Case Study Activity
	Day 18	HGD and Karyotyping Activity*
Genetic Engineering	Day 19	***Processes of Genetic Engineering****
	Day 20	GMO Computer Activity*
	Day 21	Fingerprinting Lab*
	Day 22	Cloning*
Testing	Day 23	Review
	Day 24	Post Test*
		* Denotes original material found in Appendixes ***Bold italicized type denotes three part activity***

A variety of teaching methodologies were incorporated into the unit (Figure 2). Lecture notes, a traditional teacher-centered method, incorporate cooperative learning techniques such as "Think- Pair- Share", where students are asked to think about a question posed by the teacher, work with a partner to try to figure out the answer, and then be prepared to share their answer with the rest of the class. This increases student involvement during the presentation of lecture notes, instead of letting them be lulled into doing nothing more than copying words from an overhead screen. Students were encouraged to ask questions regarding misconceptions or interests they had while learning the unit, increasing their interest level. The Transcription Activity is a cooperative learning activity. Other activities were a combination of group work and cooperative learning. The Genetic Inheritance in Corn, DNA Extraction, and DNA Fingerprinting were all inquiry-based labs. Those three labs, plus the Mutation Lab, DNA Modeling, and Processes of Genetic Engineering are hands-on activities using different types of manipulatives. The HGD and Karyotyping, Cloning, and GMO activities were done on computers using information from the Internet. Students viewed animated tutorials, and researched material on the Internet.

Figure 2. Teaching Methods Utilized During the Unit of Study

Teaching Method	**Activity**
Cooperative Learning	Transcription Activity
Hands-on Activities	Corn Lab DNA Modeling DNA Fingerprinting Lab Mutations Protein Synthesis Lab
Inquiry Activities	DNA Extraction Lab

Internet-Technology based Activities	Cloning GMO's HGD and Karyotyping
Project based Assessment	Uber Critters

The centerpiece of the unit is a newly developed three-part activity regarding a fictional canine DNA sequence. Students were given the base pairs of one side of a DNA sequence. From that they built a model of the DNA base pair sequence on paper. Then they translated it and drew the resulting organism. Finally students used their paper models to model restriction enzymes action, recombinant DNA formation, and DNA fingerprinting. The idea was to have the unit revolve around the DNA strand, giving a sense of continuity to the unit.

The timing of the unit presented several challenges. The first challenge was overcoming student apathy upon their return from spring vacation. We also learned about the death of a long time staff member who was important in many students' lives. This created a depressed atmosphere in the school and made it difficult to get the students excited about starting the new unit. Secondly, the second marking period traditionally has a higher rate of missing/incomplete work as many students become more involved in extracurricular activities and the phenomenon known as "spring fever". MEAP testing is held during this marking period, which disrupts the daily schedule for two weeks during the unit.

On day one, the students took the pretest (Appendix A). The pretest is a method for gathering information on the amount of prior student knowledge over the

topics in this unit. All of the pretest questions were short answer questions. This question format allowed students to express what they knew regarding the topics as opposed to being forced to use a multiple choice or true/false response that may not represent their knowledge. Some of the questions on the pretest did not have any relevance to a genetics unit, and were placed in the instrument as controls. Students were reassured several times that the pretest was not graded, and that it was all right to have "I don't know", as an answer, but that they should attempt to answer all of the questions. Once all the students had finished the pretest we started the *DNA lecture notes* (Appendix B).

On day two, students performed the *DNA Extraction Lab* (Appendix C). This lab allowed students to see and touch actual DNA, making it more real to them that DNA is a molecule found in all living things as opposed to the cartoon image of the double helix, or the stained blob of a chromosome they see under a microscope. After all the groups completed the activity, each group reported their results to the rest of the class so the class could gather data to figure out from which organism were they able to extract the most DNA.

Day three started with a short class discussion on the *DNA Extraction Lab*, followed by the tail end of the DNA lecture notes, and the start of the *DNA Modeling* project (Appendix C). Students drew a paper DNA segment out of a beaker, and were instructed to keep track of it over the course of the unit. There

was a lot of student complaining about the length of the DNA strand, but it took less time than they anticipated completing the model once they got started.

Day four started with a discussion comparing the nucleic acids DNA and RNA (Appendix B), which was followed by the *Transcription Activity* (Appendix C). Students worked in cooperative groups with cut out paper DNA and RNA nucleotides and enzymes to model the process of transcription. Once the group felt confident all members could explain the process they had to present it to me, with the understanding that the teacher could change the speakers at will and ask questions regarding the process, and the group would be sent back until all members could demonstrate understanding. They were assigned to read the section in their textbook on protein synthesis to prepare for the lab on day five.

Day five started with a discussion on the process of translation based on the previous night's reading assignment as part of the pre-lab activity for the *Protein Synthesis Lab* (Appendix C). Students translated the DNA sequence they were given on day three, figured out which protein each gene coded for, and the effect of the protein on the organism's phenotype. Students then drew the organism showing the traits encoded by the DNA segment. This activity took a little longer than anticipated, and was finished in class the following day.

On day seven, students were asked if they could really tell what an organism looked like by examining one segment of one chromosome. The resulting

discussion led into the lecture on *Basic Mendelian Inheritance* (Appendix B), and was reinforced using the worksheet *Pigoletto* (Appendix C).

Day eight started with a lecture modeling how to solve Punnett Squares, followed by some cooperative learning groups working with slates solving problems. The groups were created randomly by pulling "name sticks" out of a cup. Students were given a Punnett square problem to solve at the beginning of day number nine, and it was discerned through class discussion and their response to a practice problem at the beginning of the class period that they still did not have a solid grasp of the material (mainly the terminology "heterozygous, genotype" etc) so another day was spent reviewing these concepts.

Day ten started with the *Genetic Inheritance Patterns in Corn Lab* (Appendix C). After students gathered data on the corn, and shared the results with the class a discussion started on why such a pattern might be expected. This led to lecture notes on how to solve a dihybrid cross.

On day eleven one biology class performed the Dragon Lab, while the other class did not meet because of changes in the daily schedule to accommodate the MEAP testing schedule.

Day twelve was spent learning how to interpret pedigrees. After demonstrating how to use the symbols of a pedigree, several types of inheritance patterns were

modeled. Students showed their understanding by completing a worksheet with a sample pedigree, which asked students if each of five different types of inheritance patterns was possible, and to explain why or why not.

On the thirteenth day a short lecture called *Different types of Inheritance* (Appendix B) was given. The *Uber-Critters* project (Appendix C) was assigned after the lecture. Students were asked to take the information presented on basic Mendelian genetics, pedigrees, complex patterns of inheritance and Punnett Squares to create a profile of a new organism. Project style assessments allow students to express their knowledge in a variety of methods utilizing their individual learning styles and intelligences to give a more authentic representation of their understanding of a topic.

Day fourteen was the *Mutations* activity (Appendix C), it was preceded by a discussion of the different things that could cause mutations. The lab had students manipulate words in a sentence, modeling both chromosomal and point mutations. After the lab, the class discussed whether mutations were good or bad, and referenced the role of DNA polymerase in DNA synthesis.

The *Breeding Activity* scheduled for day fifteen was deleted due to a clerical error in signing out the computer lab. Instead of the activity, we had an impromptu lecture over the material (Appendix B).

Days sixteen and seventeen were spent showing the Nova video titled "Cracking the Code of Life". This video is two hours long and discusses the Human Genome Project and some of the surrounding issues. The video and corresponding case study worksheet (available at http://www.pbs.org/wgbh/nova/teachers/activities/2809_genome_03.html) led to interesting class discussions regarding the use of genetic engineering and who should be able to own or copyright genomic information. Students were assigned into four groups in which they discussed one case study at a time, and then presented their group's opinion to the rest of the class. One scenario in particular, regarding gene enhancement for intelligence, was hotly debated.

Day eighteen the students did the *HGD and Karyotyping Activity* (Appendix C). This is a computer-based activity, having students utilize the Internet for information regarding human genetic diseases such as sickle cell anemia, Huntingtons Disease and Down Syndrome. One of the websites that they are directed to visit had many small video clips they could play to help them review mutations.

On day nineteen students brought out their DNA models to do the *Processes of Genetic Engineering* (Appendix C). Students started with a sheet that explained restriction enzymes. Students then acted as the restriction enzyme EcoR1 and broke their models apart at the appropriate base strands. In small groups students were given a DNA sequence printed on pink paper that represented a

gene for pink pigmentation, and inserted the gene making recombinant DNA. A student in each group was instructed to line up their DNA fragments on the floor, largest to smallest. Students compared the differences between patterns and were asked during a class discussion to explain why the patterns were different. Day twenty was spent in the computer lab performing the GMO or Genetically Modified Organism activity. Students visited several sites learning about some of the current examples of genetic engineering. After finishing the activity, a class discussion on the use of genetic engineering took place. Students were assigned to write paragraphs explaining their views on the uses of this technology.

On day twenty-one students performed the *DNA Fingerprinting Lab* (Appendix C). This laboratory exercise was originally intended to be done using fish protein and electrophoresis chambers. Due to the expense of running the lab in this manner and the lack of departmental budget, it was changed to a lab that used chromatography paper and food coloring to model DNA electrophoresis. Students were given access to a reference chromatography strip of the crime scene "DNA" and then had to identify the criminal by match the crime scene DNA pattern with the possible subjects.

Day twenty-two sent us back to the computer lab for an animated tutorial on cloning (Appendix B). The animation took the students stepwise through the process of cloning mice.

On day twenty-three students reviewed for the end of the unit test that served as the post-test evaluation for this project. They studied in small groups, asked questions, and played a review game. The *Post- test* (Appendix A) was given to students on day twenty-four, to assess the knowledge they gained during the course of the unit. Like the pre-test, all of the analyzed questions were in the format of short answer questions It also contained questions not relevant to a genetics unit serving as controls. The pretest and post- test were graded using the same rubric shown in Figure 5. Students were asked to fill out the *survey* (Appendix A) after the test, and told they could return it the following day. Activities were graded on a point system and rated by the students. Students rated the new activities as some combination of effective or not effective at helping them understand the concept and if the activity was enjoyable or not.

CHAPTER 2. RESULTS AND DISCUSSION

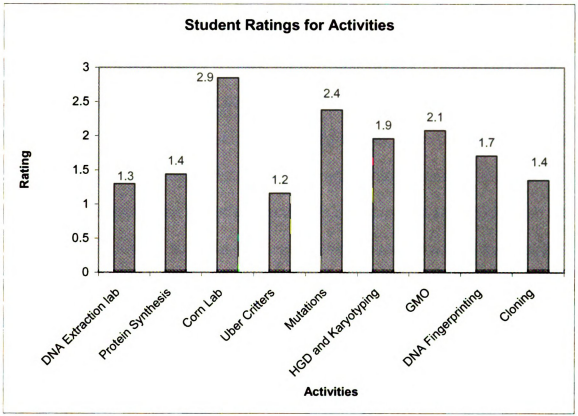
The effectiveness of the unit was measured both subjectively and objectively. Objective data was obtained from student grades on the activities, and a comparison of pretest and post-test item responses. The pretest and post-test item comparisons were then analyzed by a t-test to see if the results were statistically significant.

Subjective data came from student responses to a survey asking them to rate and comment upon activities (Appendix A). Students filled out a survey (Appendix A) ranking each activity as to how well the student felt the activity helped them understand the concept, and if they enjoyed the activity or not. The ranking scale (Figure 3) was 1-4. Students assigned activities they felt were helpful and enjoyable a 1. A ranking of two meant the activity was helpful, but not enjoyable. Activities that were helpful, but not fun were assigned a 3. Lastly activities that were neither fun nor helpful were ranked 4. A graph of the student opinion of the activities is shown in Figure 4.

Figure 3. Student Activity Rating Scale

Scale Ranking	Criteria
1	Helped me understand the material, was enjoyable.
2	Helped me understand the material, was not enjoyable.
3	Did not help me understand the material, was enjoyable.
4	Did not help me understand the material, was not enjoyable.

Figure 4. Student Ratings for Activities



The first activity is the *DNA Extraction Lab* (Appendix C). The lab reinforced the scientific method, and had the class working cooperatively to solve the problem of which organism had the most DNA. The lab also had elements of an inquiry investigation, as students were able to choose which plant material they tested. This activity generated a lot of student excitement. One class was interrupted by a fire alarm just as they were to start the lab, leading to some very distracted students, and a shortened class period. The students were supposed to extract the DNA from the test tube and dry it on a piece of filter paper. This did not work well at all for the first class; the students had difficulties trying to get the DNA to spool, and not much accuracy using beral pipets to remove the DNA. The

procedure was changed before the next class period where students developed their own procedure for measuring the amount of DNA in each test tube. Students compared the amount of DNA in each test tube by measuring the thickness of the DNA layer or creating a scale measuring the cloudiness of the DNA layer. Students rated this activity very highly, and was the activity the majority of students cited as being their favorite activity of the unit. The average ranking was a 1.3. No student rated it as "not enjoyable", but a few felt it did not help them understand the material. Comments regarding the DNA Extraction Lab included "It was fun because we got to see DNA", "I liked smashing the fruit, it was fun!", "It didn't help a lot but was cool", and "This was my favorite lab!". The average score on the lab was an 82.2%.

The second activity, the protein synthesis lab titled "*Draw that Dog*!" (Appendix C) was also given a favorable rating by the students. Students were apprehensive at the beginning of the lab, but seemed to enjoy it once they got started. The average ranking for this lab was a 1.4. No student ranked it as a 4, and more students ranked it as a 1 than as a 2. Comments regarding the activity included, " it was hard, but fun to see your dog afterwards", "it was OK", "reading the DNA and creating the dogs was cool", and "confusing". The average score on this lab was an 82.9%.

The third activity, the corn lab, *Genetic Inheritance Patterns in Corn* (Appendix B), asked students to come up with a pattern of inheritance for two corn kernel

traits- color and smoothness. Students worked in cooperative groups on this activity. This activity was not as popular as the previous two. The average rating was a 2.9, with only three students ranking it as both helpful and enjoyable and almost one third of the students ranking it as a four. The majority of students struggled with this activity. The numbers the class produced for the phenotypic ratios were not close to the expected 9:3:3:1, making it difficult for them to recognize the pattern. Part of the problem for the skewed ratio was students had to look at the ears of corn through a plastic bag (to prevent students from removing more seeds from the ear, and retaining the loose seeds that belonged to the ear) making it difficult to determine if the seed was smooth or wrinkled. The average score on the assignment was a 58.3%. Students were asked to finish the discussion questions of the lab as homework, and many students did not complete the lab. Comments included "too much math", "I didn't see the point and it isn't fun to count kernels", "boring", and "it was OK".

The fourth activity was the *Uber Critters* project (Appendix C), a project based assessment of basic "Mendelian" genetics. The project required students to put their knowledge of inheritance types, pedigrees and Punnet squares to work designing a new organism. This activity was also ranked highly, coming in a close second for a favorite activity. Students rated this activity a 1.2, both helpful and enjoyable. Student comments regarding this activity were "was really fun and helped me understand everything we did on this project", "I had a great time making up my Uber Critter. Definitely do it again next year", and "fun!" The

average student score on this project was a 95.4%. One difficulty with the project was getting students to create a unique organism that varied from the provided example.

The fifth activity was the *Mutations Lab* (Appendix C). Students modeled chromosomal and point mutations. The students rated this lab unfavorably, an average score of 2.4. The majority of students rated it as not enjoyable and split equally between helpful and not helpful. The average score on this lab was a 72.5%. Comments on the Mutations Lab include, " I thought it was boring", "I was confused and not fun", and "it was cool learning the mutations, but kind of boring". Student remarks during the lab gave evidence to their lack of motivation regarding the activity, as they did not want to spend time reading the directions and wanted me to "just tell them" how to do the activity.

The *Human Genetic Disease and Karyotyping activity* (Appendix C) was sixth. This was a computer-based activity where students performed a karyotype by means of an interactive computer graphic and then researched six different human genetic diseases. The average rating of this activity was a 1.9, with the all but a few students rating it as a 1 or 2. Comments included "interesting, but not fun", "good, but super long", and "rather fun and interesting". The average grade on the assignment was an 83.3%.

The seventh activity was the *GMO or Genetically Modified Organisms* activity (Appendix C), also a computer-based activity. The average student rating was a 2.1, and the majority of students ranked it as helpful, but not enjoyable. The computers used for this lab were old and had slow processing speeds. Students became frustrated trying to access some of the sites and started worrying about completing the assignment instead of learning the material. Students did enjoy the discussion that followed the project, and many expressed amazement over some of the GMO's. Most students were particularly interested in the development of grass that doesn't need to be mowed, and goats that produce silk protein in their milk. Comments regarding this activity were "really cool to look at stuff, but took too long", "kinda boring", and "best lab EVER! Learned a lot". The average grade on the assignment was an 86.2%.

The DNA fingerprinting lab titled "*Old MacDonald had a Crime E-I, E-I, Uh Oh!*" (Appendix C) was very popular with the students. Prior to this activity they modeled the process of DNA fingerprinting using their paper DNA models. Students were very excited to perform the lab, and it received an average rating of 1.7, with the majority of students giving it a 1 rating. Comments included " it was fun, but it didn't teach a ton, but it put what was being taught together", " I didn't get it", "awesome", and "this was awesome- I love this kind of stuff, it was my highlight of the class." The average grade on the assignment was an 83.4%.

The final activity, *Cloning* (Appendix C), was also a computer-based activity. Students used the Internet to access an interactive site that walked them stepwise through the cloning process and play a few learning games about cloning. Students really enjoyed the interactive mouse site, especially the squeaking sounds issued by the mice. This activity was rated at 1.4, with only four students not ranking it as both helpful and enjoyable. Comments regarding this activity included "fun!", "the mouse thing was cool", and "fun and helpful". The average grade on this assignment was a 97.7%.

Student responses to the pretest and post-test were graded using the rubric shown in Figure 5. Students demonstrating complete understanding of the concept were given a score of 4. If the response demonstrated understanding of the topic, but the question was not completely answered, they were scored a 3. Answers that only demonstrated some understanding of the concept were given a 2. Student responses demonstrating limited understanding of the topic were rated a 1. Zeros were given to answers that showed no understanding of the concept or when the question was not answered. For example, responses to the problem " Two solid white dogs produce a litter of solid black puppies. Explain how this could happen", were scored in the following manner:

- **0** – No answer, left blank. There was no evident understanding, so this was given 0 points.
- **1**- "The genes skipped a generation". This student response shows knowledge that gene code for traits, and may not be expressed in

every generation. However, it does not use proper terminology, nor does it explain why genes may have skipped a generation.

- **2**- "Because back in the parents lines could be a black dog". This student response shows understanding that the parents may have passed on a trait held by one of their ancestors, but does not use proper terminology.
- **3**- "Because the mother could have carried a recessive black allele". This response uses proper terminology and demonstrates understanding of the concept, but fails to include that both parents must carry a recessive allele for the recessive trait to be expressed in the offspring.
- **4**- "If white was the dominant trait and black was the recessive trait this is possible. The parents would be heterozygous for this trait. They would have a 75% chance of having white dogs, but black is still possible. (Response also included a Punnett Square showing how the student derived the percentages.) " This student uses proper terminology and displays complete understanding of the concept.

Figure 5 . Rubric for Grading Pre and Post-test Questions.

Score	Criteria
0	Answer shows no understanding of concepts, or question is unanswered.
1	Answer shows very limited understanding of the concepts and improper use of terminology.

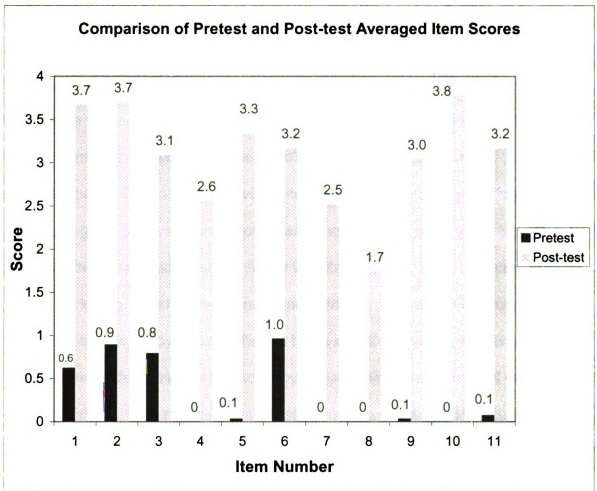
2	Answer shows some understanding of the scientific concept and does not use the proper terminology.
3	Answer shows substantial understanding of the scientific concepts but does not use all the correct terminology.
4	Answer shows complete understanding of the scientific concepts and uses the correct terminology.

Questions on the pre and post-test evaluations were similar but in different sequential order. A few of the questions were reworded because the pretest question had been used as an example during the unit. For these reasons the questions have been listed as test items in Figure 6. A table showing the relationship between pretest question, post-test question and item number can be found in Appendix D. Student responses to eleven different items were evaluated. A graph of the student scores on each of the pretest and post-test items is show in Figure 7.

Figure 6. Pre/Post Test Items

Item Number	Question/Concept
1	Structure of a DNA molecule.
2	Identifying simple mode of inheritance by recognizing the pattern of recessive genes and carriers.
3	Explain gene expression.
4	Identify mode of inheritance from a pedigree.
5	Explain the process of Gene Therapy
6	Explain process of cloning
7	Explain the process of DNA fingerprinting
8	Explain a GMO.
9	How to change the traits of an organism using artificial selection and/ or genetic engineering.
10	Solving a monohybrid Punnett Square problem.
11	Differentiate between the terms DNA, trait and allele.

Figure 7. Comparison of Pretest and Post-test Averaged Item Scores



The pretest results (Figure 7) indicate that the students had very little prior understanding of genetics. The average score for each pretest question response was less than 1, demonstrating a lack of student understanding over all of these concepts. The majority of the questions were answered, "I don't know", or left blank. DNA was discussed during two previous units, though it's structure, the focus of item one, was not covered. Scoring answers to item one included, "a twisty ladder", "spiral", or a drawing of the double helix. Item number two asked

students to explain why two white dogs were able to produce black puppies. Responses to item two showing some level of understanding included "solid black is the recessive trait", "some genes can stay dormant and skip a generation", and "the white dogs could have had a parent who was solid black". Item three asked students to explain how DNA generated specific traits (was responsible for heredity). Examples of student responses include "I don't know", "DNA determines what traits people have", and "is makes up your chromosomes". One student answered item number 5, explain gene therapy, as "make bad gene go away", and another as "where all the genes go for psychiatric help". Students showed some familiarity with item number 6, the question regarding cloning. Students were exposed to the concept of cloning during an earlier unit on the cell cycle and different types of cell reproduction. Many students responded, "make an exact copy of something", but could not explain how it was done. Item number 9 asked students to explain how they could create purple colored oranges. An example of a high scoring answer was "change it's DNA", low scoring answers included "paint it" and "use a marker to color it". Finally, item 11 directed students to explain the difference between the terms allele, gene, trait, and DNA, terms that are frequently used when discussing genetics. One student correctly answered the question, the rest replied "I don't know" or left it blank. Items 4, 7, 8, and 10 had no correct student responses.

Figure 7 also shows the post-test student scores on the eleven test items. The average post-test score on test item 1 was a 3.7 out of 4. An example of a high

scoring student response was "Double helix created from two strands of nucleotides which are made of a phosphate group, nitrogenous base and a sugar". A low scoring student response was, " DNA holds the genes and traits from your parents". Almost every student was able to identify the recessive inheritance pattern in test item number two. The average score on test item two was a 3.7, and only one student scored less than a 3 on this question. Test item three regarding gene expression had an average student score of 3.1. An example of a high scoring student response was " DNA is like a code for proteins, and proteins which are made of amino acids control almost everything in your body which gives you your traits. DNA→ RNA→ Proteins." An example of a low scoring student response is "because DNA is the molecule of heredity". The average post-test score for test item number four, identifying an inheritance pattern from a pedigree, was 2.6. This score was lower than expected. A few students noted they skimmed over the question in their rush to complete the test and did not look at the parental generation, only the F1, and missed the recessive pattern. Explaining gene therapy was post-test test item number 5, and the average score was 3.3, showing the majority of students have a fairly good grasp of gene therapy. A high scoring response was " use a restriction enzyme to chop DNA at certain spots and insert a better gene that will make the organism more "normal" and the sticky ends will seal back up". Only one student scored beneath a two rating on this question. Test item number six, explaining the process of cloning, had a post-test average score of 3.2, indicating most students have a substantial understanding of the process. Test item number

seven, explaining the process of DNA fingerprinting was lower, with an average score of 2.6. Some students remarked upon looking for different colored bands of DNA- a misconception from the lab activity where food-coloring chromatography took the place of gel electrophoresis. Four students confused DNA fingerprinting with recombinant DNA. This misconception probably occurred during the "Processes of Genetic Engineering Activity" (Appendix B) where students used a paper DNA strip to model the processes of creating recombinant DNA and DNA fingerprinting. Test item number eight, explain a GMO, had the lowest average score, 1.7. After the test many students asked what a GMO was, and when told it was a genetically modified organism they indicated they knew what a genetically modified organism was, but had not made the connection with the GMO abbreviation, which was not used frequently in the class. Test item number nine asked students to explain two different methods for creating watermelons that need little water to grow, and so could be grown in the desert. The average score on this item was 3.0, with only four students scoring less than a 3. An example of a high scoring student response is " hybridization- cross a watermelon with a cactus or genetic engineering- clip the cactus gene that helps it to retain water and insert into the right spot of a watermelon's DNA so operons turn it on/off at the right time". An example of a low scoring response to this question was "you could grow watermelon in the desert by genetic engineering because you could find a way so it doesn't use as much water to grow". All students demonstrated substantial understanding of how to solve a monohybrid Punnett square cross, test item number ten. The average score on this problem

was 3.8 out of 4, and no student scored less than 3. Finally, test item number eleven, asking students to differentiate between the terms gene, DNA, trait and allele has an average post-test score of 3.2, and only 4 of the 29 students scored less than a 3 on the question. The average percentage grade on the entire post-test (all questions, not just the test items listed in Figure 6) was 85.6%.

Comparisons between pretest and post-test scores in Figure 7 indicate a significant increase in student understanding. A one tailed t-test for correlated samples was calculated (utilizing the website http://faculty.vassar.edu/lowry/t_corr_stats.html) on the student scores of each test item to show the increase is the result of students gaining knowledge from the activities taught during the unit and not coincidence. The results of the t-tests are presented in Table 1. Level of confidence indicates the level of certainty that the increase in student understanding was the result of knowledge gained during the unit. There is a greater than 99.99% level of confidence for each of the eleven test items that student knowledge was increased as a result of the materials taught during this unit.

Table 1. t-Test Results for Pretest and Post-test Score Comparison

Test Item Number	df value	t value	Standard Deviation	Level of Confidence
1	28	12.65	1.243	> 99.99%
2	28	11.94	1.2663	> 99.99%
3	28	12.89	0.9608	> 99.99%
4	28	12.03	1.1443	> 99.99%
5	28	21.21	0.8373	> 99.99%
6	28	9.11	1.3018	> 99.99%
7	28	10.08	1.3462	> 99.99%
8	28	5.31	1.7646	> 99.99%

9	28	15.62	1.0351	> 99.99%
10	28	49.83	0.4082	> 99.99%
11	28	16.67	1.0005	> 99.99%
				n= 29 for all test items.

Students demonstrated a high level of interest during this unit that as evidenced by the number of questions regarding genetics asked during class. Most student questions were based on genetic concepts introduced by the media through news and entertainment. Though the questions were relevant to the unit, and served to clear up misconceptions and increase student interest (Chin, 2004), they also began to take up a considerable amount of instruction time, and leaving other activities pressed for time. A question box was placed at the front of the classroom and students were encouraged to place questions in the box to be answered at the end of the class period, or the beginning of the next hour.

The student survey also asked students to provide any general comments they had regarding the unit. Many students did not provide any comments. Comments included "most labs were fun and interesting", " I liked this unit and learned a lot", " It was mostly fun but I didn't understand as much as I thought I did", and "don't change anything except maybe the Corn Lab". The comments were positive and supportive of the unit, but since students had to put their names on the survey form (so students in the study could be differentiated from the ones not participating) they may have written only positive comments.

CHAPTER 3. CONCLUSION

The purpose of this study was to test the effectiveness of a redesigned genetics unit taught to high school freshman in an introductory biology course. The unit was redesigned to cover all of the MEGOSE objectives for heredity as well as introduce students to some of the basic concepts of genetic engineering and biotechnology. The unit incorporated many different teaching methodologies to reach students of many different learning styles and intelligences. The unit was also designed to be concise as genetics is just one of the many units covered during this introductory biology course. The unit was evaluated on both subjective and objective data gathered from students participating in the study group. Subjective data was gathered from a student survey, and the objective data from graded assignments, as well as pretest and post-test questions. Student knowledge of eleven test items was gathered during a pretest given before the unit, and post-test assessment at the end of the unit. Statistical analysis comparing the increase of knowledge students demonstrated on the post-test was found to have a 99.99% level of confidence that the genetics unit presented during the study did increase student knowledge of genetics. The genetics unit titled "Teaching Genetics in an Introductory Biology Course" was successful at increasing student understanding of genetics.

While the unit of study increased student understanding of genetics, it also increased the researchers knowledge of teaching. The pretest showed that

students are not retaining the basic concepts of genetics from their sixth grade biology course work. The unit also revealed, through low student scores, areas of weakness in student knowledge and assessment questions on the pretest and post-test. Student survey responses and activities grades gave insight to the use of each individual activity as well as the effectiveness to using a variety of teaching methods during a unit.

The pretest results showed student understanding of the concepts presented during this unit was almost non-existent. Students were taught a unit in genetics during the 6th grade that covered such ideas as dominant and recessive traits, Punnett squares, genes and chromosomes. They seem not to retain the information. The district 6-12 science department will investigate this information as we continue our work on realigning the science curriculum.

Students showed improvement in their understanding of all eleven test items (Figure 7). However, test items 4, 7, 8 showed lower levels of student understanding than the rest of the of test items. Test item 4 was a question asking students to identify the pattern of inheritance by looking at a genetic pedigree. Student misinterpretation during the test seemed to be the main reason for the low score on this test item, as when the test was reviewed during class time many students expressed dismay at having missed this problem and said they had focused on the F1 generation and not the parental generation. To correct this problem I would format the test a bit differently giving more space

around the pedigree, making the top of it stand out more from the text of the test, as well as increase the number of pedigree practice problems. Test item 7 was a question asking students to explain the process of DNA fingerprinting. Student responses to this question on the post-test demonstrated they had misconceptions regarding DNA fingerprinting from the *DNA Fingerprint* lab activity as well as the work with the DNA model showing the work of restriction enzymes and what could be done with the remaining fragments. The definition of a GMO, and how they are formed, was the problem for test item 8. Many students did not know GMO was an acronym for Genetically Modified Organism, and did not answer the question. This can be fixed by making sure to include the words "genetically modified organism" next to the letters GMO on the test, as well as utilizing the term more frequently through the genetic engineering portion of the unit.

The new activities assessed during the unit were successful (as determined by student performance and student survey feedback) with the exception of the *Corn Lab* and *Mutations Lab*. The students deemed the *Corn Lab* too difficult and boring. This resulted in their inability and unwillingness to complete the assignment. Counting kernels may never be considered exciting by high school freshmen, but the activity does have value in teaching students to recognize patterns of inheritance. Future modifications to this lab may include shellacking the corn ears to increase the visibility of the traits, allowing for easier and more accurate kernel counts by the students. The *Mutations Lab* was also not as

successful as anticipated. A website with video animated mutations (http://gslc.genetics.utah. edu/units/disorders/karyotype/karyotypeinfo.cfm) was discovered during the *HGD and Karyotyping Activity* and students responded more favorably to that than the hands on manipulative lab. Future lessons over mutations will include a combination of the paper manipulative and this website.

The students rated the DNA Fingerprinting activity favorably, but it created a misconception that one of the criteria for comparing DNA "fingerprints" is the color of the bands. In the future this activity will be supplemented with follow up activity containing pictures of actual DNA "fingerprints" to prevent this misconception. Additional care must also be taken when performing the Process of Genetic Engineering activity to ensure students don't confuse the process of creating recombinant DNA with DNA fingerprinting.

The DNA Extraction Lab was also very popular with the students, but is also in need of modifications to the data collection procedure. Extracting the DNA from the test tube in a manner so that it could be weighed proved to be extremely difficult for the students. The procedural failure added another element of inquiry for the students, which turned it into a better lab from a working and pedagogical viewpoint. Students rated this lab as both educational and enjoyable, and as their favorite activity of the entire unit. It is unknown if the students regarded the lab so favorably because of the inquiry nature, or because the activity of smashing plant material and using chemicals to extract DNA. While most students rated

this activity as having helped them better understand the subject material, the lab did not actually teach them anything about the structure of DNA; if anything, it taught them about the scientific method.

The use of a variety of teaching methods during this unit of study was successful as measured by student enjoyment of the different activities, and their resulting grades on the assignment. The inquiry *DNA Extraction* Lab was very popular with the students, though as stated earlier, it is unknown if it was the methodology or the procedure of the activity itself students found engaging. The hands on activities had both positive and negative responses from students. The *DNA Fingerprinting Lab* and *Protein Synthesis Lab* were rated strongly by students, and student achievement grades were also very good. Hands-on activities that were not favorably rated were the *Corn Lab* and *Mutation Lab.* These were the most unpopular of all the activities in the unit, and the average student grade was the lowest on these two activities. The Internet based activities had a mostly positive response from students. Students preferred the activities containing interactive graphics found in the *Cloning* activity as opposed to the plain text reading of the *GMO* activity. The *Uber Critters* assignment, a project-based assessment was also rated favorably by the students and had very high student achievement. Cooperative learning techniques were used during the teaching of the unit, but were not on the student survey. Their use in lecture led to many valuable class discussions that increased student involvement in the learning process. The positive student response to activities which utilized different

teaching methodologies shows that there is no one "best" method for teaching students, and supports the use different teaching methods in a unit. In order to increase the most effective elements of the unit (as defined by student survey results and achievement grades), future modifications to this unit might include more inquiry-based labs, more interactive computer tutorials, and a project based assessment for the biotechnology portion of the unit.

APPENDICES

APPENDIX A

Parent/Student Consent Form
Re: **Collection of Data for Master's Thesis**

Dear Parents/Guardians/Students,

For the past 3 years I have been working on a Masters of Science degree at Michigan State University through the Division of Science and Math Education. An important requirement for obtaining this degree is to write and submit a thesis based on the effectiveness of a unit taught during a class. This past summer I redesigned the genetics unit taught during this course in with the goal of increasing student understanding of the State of Michigan science benchmarks of genetics. In order to evaluate the effectiveness of this unit, I will be collecting data on pre and post tests, surveys on the students' reflections and opinions, responses to short answer questions from laboratory experiments, homework, and other assessments. With your voluntary permission, I would like to use this data in my Master's Thesis. **At no time will the student's names be used in, or connected to, any part of the thesis paper.** Your privacy will be protected to the maximum extent allowable by law.

There is no penalty for denying permission to use this data. Your decision will **not** affect your student's grade in any way. The assignments for this section of the course will remain the same for all students whether their data is used in the thesis or not. Declining simply means data from your student's class work will not be used in the thesis. You may request your student's work not be included in the data analysis at any time throughout the course.

The title of the study is "Teaching Genetics in an Introductory Biology Course". It will begin in mid-April and last approximately four weeks.

If you have any questions about this study, please contact me at (269) 321-1116, or email me at porterkr@msu.edu. If you have questions or concerns regarding your rights as a study participant, or are dissatisfied at any time with any aspect of this study, you may contact – anonymously, if you wish –Peter Vasilenko, Ph.D., Chair of the University Committee on Research Involving Human Subjects (UCRIHS) by phone: (517) 355-2180, fax: (517) 432-4503, e-mail: ucrihs@msu.edu, or regular mail: 202 Olds Hall, East Lansing, MI 48824

Sincerely,

Tina Porter
Science Teacher * Vicksburg High School

Please complete the form and return it to me no later than April 15, 2004.
.....

I voluntarily agree to have

_____ participate in this study.
(print student name)

_____ _____
Parent/Guardian Signature Date

I voluntarily agree to participate in this study.

_____ _____
Student Signature Date

Genetics
Pretest **Name:**

1. Explain why DNA is considered to be the molecule of heredity.

2. Describe the structure of a DNA molecule.

3. Why do some metals emit colored light when heated?

4. Two solid white dogs produce a litter of solid black puppies. Explain how this could happen.

5. You decide to create purple colored oranges. Describe 2 different ways you could accomplish this goal.

6. Does the DNA in one of your nose cells contain the code for your hair color? If yes, why isn't your nose the same color as your hair?

7. Briefly describe (what they are, how they are created, what they are used for, etc) each of the following:

    - Gene therapy

    - Cloning

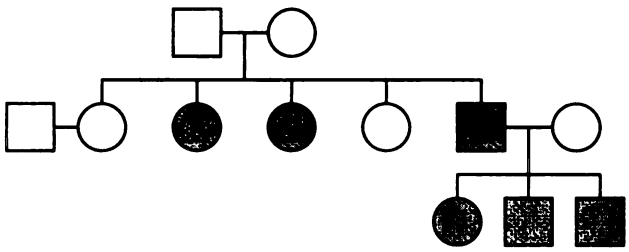
    - Recombinant DNA

- DNA fingerprinting
- GMO's

8. Describe 4 ways sexually reproducing organisms can increase the genetic variability of their species.

9. Explain why the sky is blue.

Use the pedigree below to answer questions 11-14



10. What is the mode of inheritance for this trait?

11. What is the most likely genotype for the P generation female?

12. How many children are in the F1 generation?

13. What is the probability that the next child produced by couple C will be express the trait?

14. Compare and contrast the following terms: trait, gene, allele, DNA, and chromosomes.

Fur Color	Hairy Toes	Antennae	Tails	Spots
In order of dominance F^g- Green F^w- white F^b- blue	H- hairy toes h- no hair on toes	A- no antennae a- have antennae	T- Tails t- no tails	S- no spots s- spots

15. Is the allele for having spots dominant or recessive?

16. A heterozygous hairy-toed msuga is mated with a homozygous hairy toes msuga. Make a punnett square and write down the genotypes and phenotypes of the offspring.

17. How many grams of calcium phosphate are found in one mole of calcium phosphate?

Biology
Genetics Test

1. Describe the structure of a DNA molecule.

2. Why do some metals emit colored light when heated?

3. Two solid white dogs produce a litter of solid black puppies. Explain how this could happen.

4. Describe 2 ways new traits may arise through changes in genetic material.

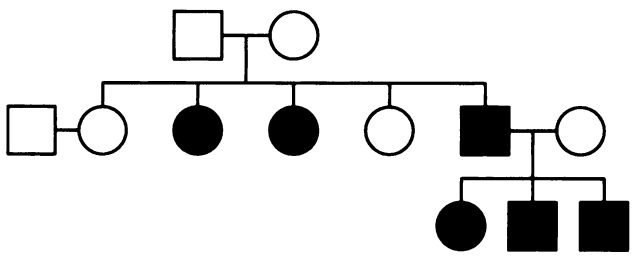
5. DNA is responsible for generating specific traits. Explain how DNA does this.

6. Describe 2 ways sexually reproducing organisms can increase the genetic variability of their species.

7. Explain why the sky is blue.

8. Each of these terms is related, but different. Explain how they are different.
   * gene vs trait * gene vs DNA * gene vs allele

Use the pedigree below to answer questions 9-10.



9. What is the most likely mode of inheritance for this trait?

10. What is the probability that the next child produced by couple C will be express the trait?

11. Write 3 uses for genetic engineering.

12. You have recently moved to the Sahara desert and miss growing watermelons in your garden. (And no, you don't have a greenhouse, or a water supply other than the tiny bit that falls during the year.) Describe two different ways you could create a watermelon that can grow in the desert.

13. Briefly describe the process of
    a. gene therapy/recombinant DNA

    b. Cloning

    c. DNA fingerprinting

    d. GMO

Multiple Choice

_____ 1. What an organism "looks like" is known as it's
a. genotype b. karyotype c. heterozygous d. phenotype

_____ 2. The 3 base pair sequence of mRNA is known as a
a. codon b. anticodon c. nucleotide d. amino acid

_____ 3. A display of all the chromosomes in a cell nucleus is called
a. amniocentesis b. Chorionic villus sample
c. gene mapping d. Karyotype

_____ 4. Hemophilia is
a. autosomal dominant b. sex linked c. more common in women

_____5. Down Syndrome is the result of what type of mutation of chromosome #21?
a. deletion b. inversion c. non-disjunction d. addition point mutation

_____6. If a family has 4 sons, what is the probability that their next child will be a boy?
a. ½ b. ¼ c. 1/5 d. 4/5

_____7. Anyone who is a carrier for a trait is
a. homozygous and affected b. heterozygous and not affected

_____8. When certain types of black roosters are crossed with white hens, speckled chickens result. These chickens have a mixture of all black and all white feathers, and are an example of
a. dominance b. codomiance
c. incomplete dominance d. polygenetic inheritance

_____9. A normal human female has which of the following sex chromosomes?
a. XY b. XX c. XXY d. XYY

_____10. If a characteristic might be sex-linked (on the X chromosome) if it
a. occurs most commonly in males b. an never occur in females
c. only occurs in females d. is always fatal

_____11. This type of RNA brings an amino acid to the ribosome.
a. mRNA b. tRNA c. aRNA d. rRNA

_____12. Which of the following base pairs is NOT found in DNA?
a. adenine b. thymine c. guanine d. uracil

_____13. Which of the following is NOT true about RNA?
a. RNA is made of a single strand of nucleotides
b. RNA can only be found in the nucleus of the cell
c. RNA is contains the sugar ribose
d. RNA contains adenine

_____14. When certain types of white msugas are mated with red msugas, msuga's with pink fur result. What type of inheritance pattern is occurring here?
a. recessive b. codominant
c, incomplete dominant d. polygenic

MSUGA TRAITS

Fur Color	Hairy Toes	Antennae	Tails	Spots
In order of dominance F^g- green f^w - white f^b- blue	H- hairy toes h- no hair on toes	A- no antennae a- antennae	T- tails t- no tails	S- no spots s- spots

1. Is the allele for having spots dominant or recessive?

2. What are the possible **genotypes** of a msuga who has antennae?

3. A heterozygous hairy toed msuga is mated with a homozygous hairy toed msuga. Make a punnett square, and write down the genotypes and phenotypes of the offspring.

4. Two spotted msugas are expecting a litter of little Spartans. What is the possibility that the babies will not have spots?

5. A homozygous tailed, heterozygous non-spotted msuga is mated with a heterozygous tailed, heterozygous non-spotted msuga. List all possible phenotypes of the offspring.

Student Activity Log **Name**

Please rate the following activities using this scale:

1. **Helped** me understand the material, and was **enjoyable**.
2. **Helped** me understand the material, was **not enjoyable**.
3. Did **not help** me understand the material, was **enjoyable**.
4. Did **not help** me understand the material, was **not enjoyable**.

DNA Extraction Lab 1 2 3 4

Comments:

Protein Synthesis Lab 1 2 3 4

Comments:

Corn Lab 1 2 3 4

Comments:

**** Dragon Genome Lab** 1 2 3 4

Comments:

"Uber- Critters" 1 2 3 4

Comments:

Mutations 1 2 3 4

Comments:

Cloning 1 2 3 4

Comments:

Electrophoresis/Chromatography Lab 1 2 3 4

Comments:

GMO's 1 2 3 4

Comments:

Karyotyping and HGD 1 2 3 4

Comments:

Which was your favorite activity?

Which was your least favorite activity?

General Comments:

APPENDIX B

Lecture Notes DNA

DNA – **d**eoxyribo**n**ucleic **a**cid – the molecule that makes up chromosomes. You may already know a bit about DNA, but let's start with the history of it's discovery.

1884-1888-

1903-

1928-

1944-

1952-

1950's-

DNA Structure

DNA is huge molecule (think of a chain) found in the _____.
DNA molecules are made of a smaller subunit called a _____.

Each _____ is made out of 3 main components:

1.

2.

3.

So, what does it LOOK like?

DNA is often referred to as a ladder...with the sugar-phosphates being the sides, and the nitrogenous bases the rungs.

Only, it is a twisted ladder. It's shape is called a "double helix". (sketch)

A DNA molecule is made of 2 strands- they are called complimentary. Why?

The nitrogenous bases come in 2 types:

Purines **Pyrimidines**

What pairs do they make?

Lets make some DNA!!!!

Lecture Notes DNA
(teacher version)

DNA – deoxyribonucleic acid – the molecule that makes up chromosomes. You may already know a bit about DNA, but let's start with the history of it's discovery.

1884-1889- Scientists report the detailed process of mitosis and meiosis, including all the changes in the cell nucleus. It was proposed the material in the nucleus may have something to do with inheritance.

1904- Theodore Bovary and Walter Sutton formally submit the idea that chromosomes contain genes. (Genes are regions on the chromosomes that code for a particular trait). Most scientists remained skeptical.

1929- Fredrick Griffith does an experiment where he mixed a live harmless bacterium with dead bacteria that causes disease. When tested on mice, this mixture killed the mice. (When the live harmless and dead disease causing bacterial was injected into mice separately, the mice lived.) Griffith calls this "transformation", but at the time, nobody knew what caused the previously harmless bacteria to become killers.

1944- Oswald Avery does a series of experiments to figure out which molecule is responsible for transformation. His experiments showed the responsible molecule was DNA.

1953- Alfred Hershey and Martha Chase perform an experiment that prove virus genes are made out of DNA.

1950's- James Watson and Frances Crick determine (with the help of pictures by Rosalind Franklin and Maurice Wilkins, and observations by Erwin Chargaff) the structure of DNA.

DNA Structure

DNA is huge molecule (think of a chain)
Each link of the DNA chain is called a nucleotide.

Each nucleotide is made out of 3 main components:

1. (a 5 carbon sugar called deoxyribose)

2. (phosphate group)

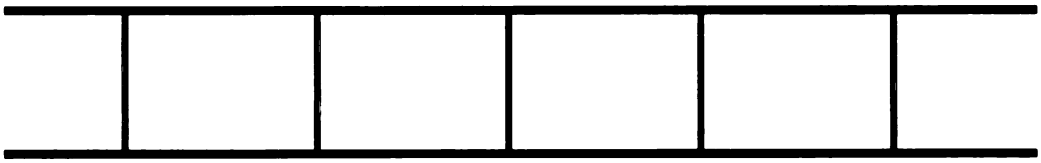
3. (nitrogenous base)

So, what does it LOOK like? (have students draw this in)

```
P       P       P       P       P       P
    S       S       S       S       S
    N       N       N       N       N

    N       N       N       N       N
    S       S       S       S       S
P       P       P       P       P       P
```

DNA is often referred to as a ladder...with the sugar-phosphates being the sides, and the nitrogenous bases the rungs.



Only, it is a twisted ladder. It's shape is called a "double helix". (sketch)
(discuss Wilkins and Franklin's contributions)

A DNA molecule is made of 2 strands- they are called complimentary. Why?

The nitrogenous bases come in 2 types (based on the number of carbons they have) (mention Chargaff's contribution here)

Purines	**Pyrimidines**
Adenine (A)	Thymine (T)
Guanine (G)	Cytosine (C)

(rewrite the N's showing base pairing).

Lets make some DNA!!!!

Lecture Notes
DNA vs RNA
(student)

Where is DNA found?

Ok, so if DNA spends **all** of it's time in the _____. How does the message of what to make get spread to the rest of the cell?

Easy!

It uses a "go-between" molecule - _____.

RNA? What's that?

RNA- ribonucleic acid. Like DNA, it is made out of nucleotides. There area few differences though...

	DNA	**RNA**
Sugar		
Nitrogenous Bases		
Strands		
Location		

RNA has a couple different functions in your cells.

mRNA

rRNA

tRNA

Now that you know how they are different, let's look at how they work together.

First DNA unzips, exposing it's base pairs.

mRNA nucleotides line up, matching the DNA pattern.

DNA zips back up, and the mRNA travels out of the nucleus and heads to the nearest ribosome.

This whole process is called "_____".

Lecture Notes
DNA vs RNA
(teacher version)

Where is DNA found? *The nucleus*

Ok, so if DNA spends all of it's time in the __*nucleus*_____. How does the message of what to make get spread to the rest of the cell?

Easy!

It uses a "go-between" molecule - ____*RNA*_____.

RNA? What's that?

RNA- ribonucleic acid. Like DNA, it is made out of nucleotides. There area few differences though...

	DNA	**RNA**
Sugar	*Deoxyribose*	*Ribose*
Nitrogenous Bases	*Adenine, Thymine, Cytosine, Guanine*	*Adenine, Uracil, Cytosine, Guanine*
Strands	*Two strands*	*One strand*
Location	*Always found in the nucleus*	*Found in nucleus **AND** cytoplasm*

RNA has a couple different functions in your cells.

mRNA- carries a copy of DNA's pattern to ribosome to make a protein

rRNA- is what ribosomes are made of!

tRNA- bring amino acids to the ribosome to make proteins according to the DNA pattern the mRNA brought in.

Now that you know how they are different, let's look at how they work together.

First DNA unzips, exposing it's base pairs.

mRNA nucleotides line up, matching the DNA pattern.

DNA zips back up, and the mRNA travels out of the nucleus and heads to the nearest ribosome.

This whole process is called "transcription".

LN Intro to Genetics
(student version)

Yesterday we only translated the information from a chunk of DNA found on one chromosome and used that to determine what the dog looked like. However, as you learned during cell reproduction, animals have 2 copies of each of their chromosomes- one copy from mom, and one copy from dad. This means that mom contributes DNA that codes for what color the dog is, and so does dad. In reality, the dogs traits depend on the information from both chromosomes.
(Get out the tables from the protein synthesis lab.)

Example:Dog A.

The DNA on the copy of the chromosome Dog A inherited from Mom codes for the following amino acids: Serine- leucine - lysine-threonine-tyrosine	The DNA on the copy of the chromosome Dog A inherited from Dad codes for the following amino acids: Serine-alanine – lysine –leucine
According this gene- Dog A should be what color?	According to this gene- Dog A should be what color?

So what color is Dog A?
The answer?

Let's look at Dog B.
Dog B has the same father, but Mom passes on protein A4561. What color is dog B?

Answer:

Finally lets look at Dog C.

Dog C has the same father, but yet a different mother. Dog C inherits the DNA coding for protein A0212 from his mom. What color is Dog C?

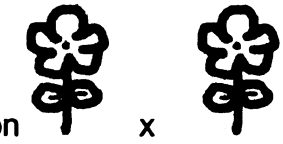
Answer:

What is going on here?

Mendelian Genetics!

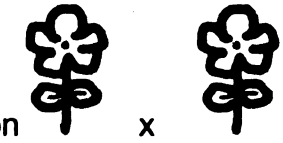
Mendel-

Experiments were done using pea plants.

P generation  x

F1 

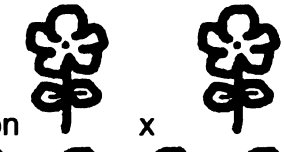
Results?

P generation  x

F1 

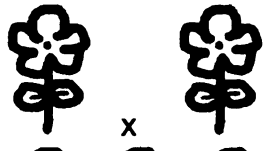
Results?

So he tried breeding a purple flowering plant to a white flowering plant.

P generation  x

F1 

Results?

F1 generation  x

F2 

Results?

The results of his work led him to the Chromosome Theory of Inheritance:

1. For each inherited trait, an individual has two copies of the gene that codes for that trait, one from each parent.

2. There are alternative versions of genes. (alleles)

3. When two different alleles occur together one of them may be completely expressed, while the other is not. (dominant and recessive alleles)

4. When gametes are formed, the alleles for each gene in an individual separate independently of one another. Thus, gametes carry only one allele for each inherited trait. When gametes unite during fertilization, each gamete contributes one allele. (meiosis)

Let's learn some terminology!

Phenotype- what the organism "looks" like. Example, purple flowers or white flowers.
Trait- inherited characteristic, such a flower color
Gene- segment of DNA that codes for a trait. Pea plants have a gene that codes for flower color.
Allele- version of the trait/gene. Each allele is given a version of the letter assigned to a trait. Example- the gene for flower color has two alleles- one for purple flowers, and one for white flowers.
Dominant- an allele that is expressed in the phenotype no matter what other allele you have. Dominant alleles are written as capital letters. In the case of pea flower color, purple is the dominant allele (P).
Recessive- An allele that is only expressed if a more dominant allele is NOT present. Recessive alleles are written as lower case letters. The recessive allele coding for white flower color is (p).
Genotype- what alleles you have for a particular trait. Remember you have 2 alleles, one from mom, and one from dad. A genotype is written as 2 letters, each letter represents an allele. .
Homozygous- A genotype that contains the same alleles. PP or pp.
Heterozygous- A genotype that contains different alleles Pp.

Back to the dog examples at the beginning of the notes!

1. What is the trait we are looking at?
2. What is the phenotype of dog A?
3. Which allele do you think is dominant?
4. What is the genotype of dog A?
5. Is black dominant or recessive?
6. Is dog C's genotype heterozygous or homozygous?

LN Intro to Genetics
(teacher version)

Yesterday we only translated the information from a chunk of DNA found on one chromosome and used that to determine what the dog looked like. However, as you learned during cell reproduction, animals have 2 copies of each of their chromosomes- one copy from mom, and one copy from dad. This means that mom contributes DNA that codes for what color the dog is, and so does dad. In reality, the dogs traits depend on the information from both chromosomes. (Get out the tables from the protein synthesis lab.)

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According this gene- Dog A should be what color? *(sable)*	According to this gene- Dog A should be what color? *(black)*

So what color is Dog A?
The answer? *Sable. Sable is dominant to black. (In German Shepherds. It is dominant in other breeds.)*

Let's look at Dog B.
Dog B has the same father, but Mom passes on protein A4561. What color is dog B?

Answer: *Black and tan. Black and tan is dominant to black. (Again, this is true for German Shepherds, but not all dog breeds).*

Finally lets look at Dog C.

Dog C has the same father, but yet a different mother. Dog C inherits the DNA coding for protein A0212 from his mom. What color is Dog C?

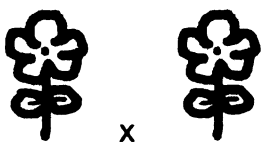
Answer: *black*

What is going on here?

Mendelian Genetics!

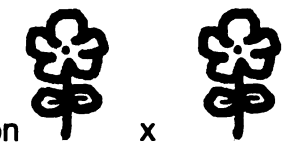
Mendel- Austrian monk living in 1880's. Studied science and math. Repeated the experiments of a British farmer, and used math to predict patterns of heredity- leading to the creation genetics- the study of heredity.

Experiments were done using pea plants.

P generation  x

F1 

Results?

P generation  x

F1 

Results?

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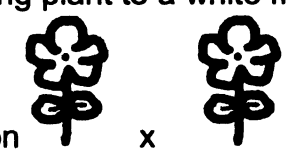
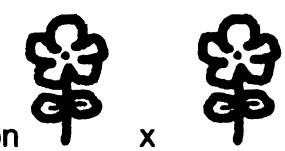
P generation  x

F1 

Results?

F1 generation  x

F2 

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6. Is dog C's genotype heterozygous or homozygous?

Other Types of Inheritance
(student version)

As it turns out, Mendel's concept of all traits being the result of dominant and/or recessive alleles was just the tip of the iceberg! There are other types of inheritance patterns, as you shall learn.

*

A horse with red hair is bred to a horse with white hair. The foal has both red and white hairs in it's coat. (This color is called "roan".)

Why?

*

A purebred white flower is crossed with a purebred red flower. All resulting seeds produce pink colored plants. What happened?

*

- blue hydrangeas
- Siamese cats/artic rabbits/artic foxes
- Height
- Hair color

*

Eye color- brown, blue green
Hair color- brown, blonde, red, black
Humans can have a blood type of A, B, AB, or O. .

*

The DNA that codes for these traits is found on the sex chromosomes – the one that determine if you are male (XY) or female (XX).

_____

- Hemophilia
- Duchennes Muscular Dystrophy
- Male Pattern Baldness
- Colorblindness

_____

- Hairy Ears

*

Traits that are the result of the expression of several genes… like coat color!

*

Two overo paint horses are bred together, and a white foal is produced, and shortly dies. Over many repeated trials, it is determined only the white foals die.

Other Types of Inheritance

(teacher version) – it is helpful to find pictures in the text or online (and placed on the teachers computer) to show students during the lecture.

As it turns out, Mendel's concept of all traits being the result of dominant and/or recessive alleles was just the tip of the iceberg! There are other types of inheritance patterns, as you shall learn.

* *Codominance*

A horse with red hair is bred to a horse with white hair. The foal has both red and white hairs in it's coat. (This color is called "roan".)

Why?

Both alleles expressed individually, so there are individual red and individual white hairs present. Scientists are still trying to figure out how and why cells pick which chromosome (allele) to use.

* *Incomplete Dominance*

A purebred white flower is crossed with a purebred red flower. All resulting seeds produce pink colored plants. What happened?

Neither allele is dominant over the other, and neither is fully expressed. Instead a mixture of the two is expressed. This is different from codominance because neither allele is ever fully expressed.

* *Environmental Factors*

- blue hydrangeas - *soil acidity makes them turn blue, not a gene*
- Siamese cats/artic rabbits/artic foxes- *temperature controls production of hormone that turns the pigment on*
- Height- *nutrition plays a role*
- Hair color- *sunlight, hair dyes*

* *Multiple Alleles*

Eye color- brown, blue green
Hair color- brown, blonde, red, black
Humans can have a blood type of A, B, AB, or O.

It is not just a dominant and a recessive allele for each gene. There can be several different alleles (variations) for a gene.

* *Sex-linked*

The DNA that codes for these traits is found on the sex chromosomes – the one that determine if you are male (XY) or female (XX).

_____*X-Linked*____

- Hemophilia
- Duchennes Muscular Dystrophy
- Male Pattern Baldness
- Colorblindness

_____Y-linked_____

- Hairy Ears

* *Polygenetic Traits*

Traits that are the result of the expression of several genes… like coat color!

Dog coat color is the result of several different genes. One controls if the dog can make black pigment, one controls how much black will be on their body, one controls if there will be spotting, one controls the shade of brown, etc.

* *Lethal Genes*

Two overo paint horses are bred together, and a white foal is produced, and shortly dies. Over many repeated trials, it is determined only the white foals die.

LN – How Humans can Mess With an Organism's Traits
(student)

Humans have been messing with the genetics of plants and animals for thousands of years. Let's look at how it is done.

Example: You love the color pink. You decide to create the worlds first all pink furry pet, the pink guinea pig. (Hereafter known as PGP). The question is, how are you going to do it?

Selective Breeding- aka, Artificial selection
Selecting only the individuals that have desired traits to serve as parents for the next generation.

Ex. *You find "pinkish" wild guinea pigs and breed them together. Then take only the pinkest of the offspring, and allow them to become parents.*

Advantages	**Disadvantages**

Inbreeding- breeding related individuals who have desired traits ensuring the traits appear in the offspring. (To "lock in" recessive phenotype).

Ex. *The offspring in the example above would be bred together, or to a close relative to try and double up the number of "pink" genes in the guinea pigs.*

Advantages	**Disadvantages**

Hybridization- crossing members of different species (usually closely related species, or breeds/varieties), in order to produce offspring with the "best of both worlds".

Ex. *You try to breed a guinea pigs to a flamingo.*

Advantages	**Disadvantages**

Many times a hybrid is created, then the hybrids go through either selective or inbreeding to maximize traits.

Mutations- mutations can be either spontaneous or caused by the application of a mutagen. Common mutagens- uv, rad, chemicals etc.

Ex: *Somewhere near Three Rivers there is a guinea pig who has a point mutation causing a change in the pigment protein it produces, and has pink fur.*

Advantages	**Disadvantages**

New varieties often emerge from a mutation that causes a desirable trait, and then being selectively bred for.

Genetic Engineering- clip the gene for the desired trait out of an organism, and then place it into the DNA of the organism you want to have that trait.

Example: *Find the gene making pink pigment in a geranium and clip it out. Find the pigment gene in the guinea pig, pull it out, and replace it with the pink gene from the geranium.*

Advantages	**Disadvantages**

LN How Humans can Mess With an Organism's Traits
(teacher version)

Selective Breeding- aka, Artificial selection
Selecting a few individuals that have desired traits to serve as parents for the next generation.

Advantages	Disadvantages
Produce new characteristics	Loss of some genetic variability
Increase frequency of desired trait	Susceptibility to disease (due to above)

Inbreeding- breeding related individuals who have desired traits ensuring the traits appear in the offspring.

Advantages	Disadvantages
Maintains a certain set of desired traits	Individuals are related, ethics questions
Quickly "fixes" a trait in the population	Increased chance of recessive genetic disorders
	Loss of genetic variability
	Susceptibility to disease

Hybridization- crossing members of different species (usually closely related species), in order to produce offspring with the "best of both worlds".

Advantages	Disadvantages
Produces a hardier variety	Offspring are often sterile (unable to reproduce) more often a problem with animals than plants.
Increases genetic variability	Does not always maximize the desirable trait.
Decreases chance of recessive genetic disorders	

Many times a hybrid is created, then the hybrids go through either selective or inbreeding to maximize traits.

Mutations- mutations can be either spontaneous or caused by the application of a mutagen. Common mutagens- uv, rad, chemicals etc.

Advantages	Disadvantages
Increases genetic variability	Can cause serious genetic disease

	Very slow process, and very sporadic

New varieties often emerge from a mutation that causes a desirable trait, and then being selectively bred for.

Cloning- you finally have one pink guinea pig! How can you make more of them exactly like this one? If you use selective breeding, you may end up with non-pink offspring. By taking a cell of your PGP and putting it's nucleus into the egg cell of a different guinea pig you can make a bunch of exact copies of your PGP.

Advantages	**Disadvantages**
Can make exact copy of an organism.	Expensive, and low survival rate. (Many attempts, few living organism). Ethics questions.

Genetic Engineering- clip the gene for the desired trait out of an organism, and then place it into the DNA of the organism you want to have that trait.

Example: *Find the gene making pink pigment in a geranium and clip it out. Find the pigment gene in the guinea pig, pull it out, and replace it with the pink gene from the geranium.*

Advantages	**Disadvantages**
You can create an organism with all the traits you desire, and none of the traits you don't.	Difficult to find gene you want to insert to get desired trait.
	Low success rate, and expensive
	Ethics questions.

APPENDIX C

DNA Model

Create DNA molecule using the sequence provided. Must have sugar, phosphate group, nitrogenous bases, and the complimentary strand. (Remember DNA is a **double** helix). **You will be using this particular DNA strand in 2 other labs during this unit, so DON'T LOSE IT.** (I will **deduct 5 points** from your grade each time I have to give you a new DNA sequence)

On calculator paper (roll paper)
Make star on the upper Left corner of the strip. Write the sequence I gave you along the left hand side, create the complimentary sequence on the right hand side. Even though I only gave you the nitrogenous bases, you must include the 5 carbon sugar deoxyribose (pentagon with a D drawn inside) and phosphate (circle w/P inside it). You may write the letter representing the base pair- be sure to draw a line representing the hydrogen bond holding the base pairs together.
C-G
Place your name, hour, date and the number of your DNA sequence on the back of your DNA model strip.

Example:

You do not have to draw the shapes for the nitrogenous bases. You also do not have to draw all of the bonds between the bases, one line between the pair is fine. (A and T are held together by a double bond, G and C are held together by a triple bond).

You may use colored pencils if you wish, but they are not required.

Be accurate! Be neat! Be finished by the end of the hour! ☺

_____ DNA sequence #!

DNA model is complete!

_____
Teacher's Signature

Your homework:
Read pages 196-198

1. How is "new" DNA made? (You may make a drawing if you explain what is happening. Do not copy the book word for word.)

2. When in the cell cycle is DNA made?

3. How does DNA make sure the copy is "perfect"?

4. How often do errors occur in DNA synthesis?

5. What are these errors called?

6. Lets say you are trying to produce many copies of DNA in a hurry. How can you increase the speed of replication?

DNA Model (teacher instructions)

The DNA sequences the students use to build the model are a bit longer (roughly 125 bp) than traditional models. However, they will be used during a protein synthesis activity, as well as a model during genetic engineering. If this activity is not going to be used in conjunction with the other two, you may want to shorten the DNA sequence.

The homework reading is from the text Biology: Principles and Explorations published by Holt Rinehart and Winston, 2001, ISBN 0-03-0538834-3.

Teacher's Instructions:

Print out the list of DNA sequences.
Cut out sequences and have students draw one at random.
Hand out DNA Model Worksheet

The DNA strips can be loosely coiled to demonstrate the double helix shape, and can be hung from the ceiling.

Student Materials

DNA sequence
Strip of paper, such as from a calculator.
Colored pencils.
You may want to supply a plastic baggie for storage of the DNA model and the original sequence.

DNA Sequences

(Teacher note, the quotation marks surround genes – helpful for reference during the protein synthesis activity.)

1.
TACAGGCGTTTCGACACT'CCC'TACACCGTATTATATGAATTCATC'GAATTC'
TACCTAGAATTCCCTATC'AGA'TACCTCGGGGCGCATGTGCACATC'GAATTC
'TACACCACCGTAACT'CGC

2.
TACAGGGAATTCTGAATAATT'CCC'TACACCGTATTATATGAATTCATC'GAAT
TC'TACCTAGAATTCCCTATC'AGA'TACCTCGGGGCGCATGTGCACATC'GAA
TTC'TACACCACCGTAACT'CGC

3.
TACAGGCGTTTCTGAGACACT'CCC'TACACCGTATTATATGAATTCATC'GAA
TTC'TACCTAGAATTCCCTATC'AGA'TACCTCGGGGCGCATGTGCACATC'GA
ATTC'TACACCACCGTAACT'CGC

4.
TACAGGCGTTTCTGAGAATTCATC'CCC'TACACCGTATTATATGAATTCATC'T
TC'TACCTAGAATTCCCTATC'AGA'TACCTCGGGGCGCATGTGCACATC'GAA
TTC'TACACCACCGTAACT'CGC

5.
TACAGGCGTTTCGACACT'CCC'TACACCGTAAATATACCCGACATT'GAATTC'
TACCTAGAATTCCCTATC'AGA'TACCTCGGGGCGCATGTGCACATC'GAATTC
'TACACCACCGTAACT'CGC

6.
TACAGGGAATTCTGAATAATT'CCC'TACACCGTAAATATACCCGACATT'GAA
TTC'TACCTAGAATTCCCTATC'AGA'TACCTCGGGGCGCATGTGCACATC'GA
ATTC'TACACCACCGTAACT'CGC

7.
TACAGGCGTTTCTGAGACACT'CCC'TACACCGTAAATATACCCGACATT'GAA
TTC'TACCTAGAATTCCCTATC'AGA'TACCTCGGGGCGCATGTGCACATC'GA
ATTC'TACACCACCGTAACT'CGC

8.
TACAGGCGTTTCTGAGAATTCATC'CCC'TACACCGTAAATATACCCGACATT'

TTC'TACCTAGAATTCCCTATC'AGA'TACCTCGGGGCGCATGTGCACATC'GA
ATTC'TACACCACCGTAACT'CGC

9.
TACAGGCGTTTCGACACT'CCC'TACACCGTATTATATGAATTCATC'GAATTC'
TACCTATTATATCCTATT'AGA'TACCTCGGGGCGCATGTGCACATC'GAATTC'
TACACCACCGTAACT'CGC

10.
TACAGGGAATTCTGAATAATT'CCC'TACACCGTATTATATGAATTCATC'GAAT
TC'TACCTATTATATCCTATT'AGA'TACCTCGGGGCGCATGTGCACATC'GAAT
TC'TACACCACCGTAACT'CGC

11.
TACAGGCGTTTCTGAGACACT'CCC'TACACCGTATTATATGAATTCATC'GAA
TTC'TACCTATTATATCCTATT'AGA'TACCTCGGGGCGCATGTGCACATC'GAA
TTC'TACACCACCGTAACT'CGC

12.
TACAGGCGTTTCTGAGAATTCATC'CCC'TACACCGTATTATATGAATTCATC'G
AATTC'
TACCTATTATATCCTATT'AGA'TACCTCGGGGCGCATGTGCACATC'GAATTC'
TACACCACCGTAACT'CGC

13.
TACAGGCGTTTCGACACT'CCC'TACACCGTAAATATACCCGACATT'GAATTC'
TACCTATTATATCCTATT'AGA'TACCTCGGGGCGCATGTGCACATC'GAATTC'
TACACCACCGTAACT'CGC

14.
TACAGGGAATTCTGAATAATT'CCC'TACACCGTAAATATACCCGACATT'GAA
TTCTACCTATTATATCCTATT'AGA'TACCTCGGGGCGCATGTGCACATC'GAA
TTC'TACACCACCGTAACT'CGC

15.
TACAGGCGTTTCTGAGACACT'CCC'TACACCGTAAATATACCCGACATT'GAA
TTC'TACCTATTATATCCTATT'AGA'TACCTCGGGGCGCATGTGCACATC'GAA
TTC'TACACCACCGTAACT'CGC

16.
TACAGGCGTTTCTGAGAATTCATC'CCC'TACACCGTAAATATACCCGACATT'

GAATTC'TACCTATTATATCCTATT'AGA'TACCTCGGGGCGCATGTGCACATC'
GAATTC'TACACCACCGTAACT'CGC

17.
TACAGGCGTTTCGACACT'CCC'TACACCGTATTATATGAATTCATC'GAATTC'
TACCTAGAATTCCCTATC'AGA'TACCTCGGGGCGCATGTGCACATC'GAATTC
'TACACCACCGTAACT'CGC

18.
TACAGGGAATTCTGAATAATT'CCC'TACACCGTATTATATGAATTCATC'GAAT
TC'TACCTAGAATTCCCTATC'AGA'TACGAATTCGCGCATGTGCTCACT'GAAT
TC'TACACCACCGTAACT'CGC

19.
TACAGGCGTTTCTGAGACACT'CCC'TACACCGTATTATATGAATTCATC'GAA
TTC'TACCTAGAATTCCCTATC'AGA'TACGAATTCGCGCATGTGCTCACT'GAA
TTC'TACACCACCGTAACT'CGC

20.
TACAGGCGTTTCTGAGAATTCATC'CCC'TACACCGTATTATATGAATTCATC'T
TC'TACCTAGAATTCCCTATC'AGA'TACGAATTCGCGCATGTGCTCACT'GAAT
TC'TACACCACCGTAACT'CGC

21.
TACAGGCGTTTCGACACT'CCC'TACACCGTAAATATACCCGACATT'GAATTC'
TACCTAGAATTCCCTATC'AGA'TACGAATTCGCGCATGTGCTCACT'GAATTC'
TACACCACCGTAACT'CGC

22.
TACAGGGAATTCTGAATAATT'CCC'TACACCGTAAATATACCCGACATT'GAA
TTC'TACCTAGAATTCCCTATC'AGA'TACGAATTCGCGCATGTGCTCACT'GAA
TTC'TACACCACCGTAACT'CGC

23.
TACAGGCGTTTCTGAGACACT'CCC'TACACCGTAAATATACCCGACATT'GAA
TTC'TACCTAGAATTCCCTATC'AGA'TACGAATTCGCGCATGTGCTCACT'GAA
TTC'TACACCACCGTAACT'CGC

24.
TACAGGCGTTTCTGAGAATTCATC'CCC'TACACCGTAAATATACCCGACATT'
TTC'TACCTAGAATTCCCTATC'AGA'TACGAATTCGCGCATGTGCTCACT'GAA
TTC'TACACCACCGTAACT'CGC

25.
TACAGGCGTTTCGACACT'CCC'TACACCGTATTATATGAATTCATC'GAATTC'
TACCTATTATATCCTATT'AGA'
TACGAATTCGCGCATGTGCTCACT'GAATTC'TACACCACCGTAACT'CGC

26.
TACAGGGAATTCTGAATAATT'CCC'TACACCGTATTATATGAATTCATC'GAAT
TC'TACCTATTATATCCTATT'AGA'TACGAATTCGCGCATGTGCTCACT'GAATT
C'TACACCACCGTAACT'CGC

27.
TACAGGCGTTTCTGAGACACT'CCC'TACACCGTATTATATGAATTCATC'GAA
TTC'TACCTATTATATCCTATT'AGA'TACGAATTCGCGCATGTGCTCACT'GAAT
TC'TACACCACCGTAACT'CGC

28.
TACAGGCGTTTCTGAGAATTCATC'CCC'TACACCGTATTATATGAATTCATC'G
AATTC'
TACCTATTATATCCTATT'AGA'TACGAATTCGCGCATGTGCTCACT'GAATTC'T
ACACCACCGTAACT'CGC

29.
TACAGGCGTTTCGACACT'CCC'TACACCGTAAATATACCCGACATT'GAATTC'
TACCTATTATATCCTATT'AGA'
TACGAATTCGCGCATGTGCTCACT'GAATTC'TACACCACCGTAACT'CGC

30.
TACAGGGAATTCTGAATAATT'CCC'TACACCGTAAATATACCCGACATT'GAA
TTCTACCTATTATATCCTATT'AGA'TACGAATTCGCGCATGTGCTCACT'GAAT
TC'TACACCACCGTAACT'CGC

31.
TACAGGCGTTTCTGAGACACT'CCC'TACACCGTAAATATACCCGACATT'GAA
TTC'TACCTATTATATCCTATT'AGA'TACGAATTCGCGCATGTGCTCACT'GAAT
TC'TACACCACCGTAACT'CGC

32.
TACAGGCGTTTCTGAGAATTCATC'CCC'TACACCGTAAATATACCCGACATT'
GAATTC'TACCTATTATATCCTATT'AGA'TACGAATTCGCGCATGTGCTCACT'
GAATTC'TACACCACCGTAACT'CGC

33.
CGC'TACAGGCGTTTCGACACT'CCC'TACACCGTATTATATGAATTCATC'GAA
TTC'TACCTAGAATTCCCTATC'AGA'TACCTCGGGGCGCATGTGCACATC'GA
ATTC'TACATATATGATACT

34.
CGC'TACAGGGAATTCTGAATAATT'CCC'TACACCGTATTATATGAATTCATC'
GAATTC'TACCTAGAATTCCCTATC'AGA'TACCTCGGGGCGCATGTGCACATC
'GAATTC'TACATATATGATACT'

35.
TACAGGCGTTTCTGAGACACT'CCC'TACACCGTATTATATGAATTCATC'GAA
TTC'TACCTAGAATTCCCTATC'AGA'TACCTCGGGGCGCATGTGCACATC'GA
ATTC'TACATATATGATACT'CGC

36.
TACAGGCGTTTCTGAGAATTCATC'CCC'TACACCGTATTATATGAATTCATC'T
TC'TACCTAGAATTCCCTATC'AGA'TACCTCGGGGCGCATGTGCACATC'GAA
TTC'TACATATATGATACT'CGC

37.
TACAGGCGTTTCGACACT'CCC'TACACCGTAAATATACCCGACATT'GAATTC'
TACCTAGAATTCCCTATC'AGA'TACCTCGGGGCGCATGTGCACATC'GAATTC
'TACATATATGATACT'CGC

38.
TACAGGGAATTCTGAATAATT'CCC'TACACCGTAAATATACCCGACATT'GAA
TTC'TACCTAGAATTCCCTATC'AGA'TACCTCGGGGCGCATGTGCACATC'GA
ATTC'TACATATATGATACT'CGC

39.
TACAGGCGTTTCTGAGACACT'CCC'TACACCGTAAATATACCCGACATT'GAA
TTC'TACCTAGAATTCCCTATC'AGA'TACCTCGGGGCGCATGTGCACATC'GA
ATTC'TACATATATGATACT'CGC

40.
TACAGGCGTTTCTGAGAATTCATC'CCC'TACACCGTAAATATACCCGACATT'
TTC'TACCTAGAATTCCCTATC'AGA'TACCTCGGGGCGCATGTGCACATC'GA
ATTC'TACATATATGATACT'CGC

41.
TACAGGCGTTTCGACACT'CCC'TACACCGTATTATATGAATTCATC'GAATTC'
TACCTATTATATCCTATT'AGA'TACCTCGGGGCGCATGTGCACATC'GAATTC'
TACATATATGATACT'CGC

42.
TACAGGGAATTCTGAATAATT'CCC'TACACCGTATTATATGAATTCATC'GAAT
TC'TACCTATTATATCCTATT'AGA'TACCTCGGGGCGCATGTGCACATC'GAAT
TC'TACATATATGATACT'CGC

43.
TACAGGCGTTTCTGAGACACT'CCC'TACACCGTATTATATGAATTCATC'GAA
TTC'TACCTATTATATCCTATT'AGA'TACCTCGGGGCGCATGTGCACATC'GAA
TTC'TACATATATGATACT'CGC

44.
TACAGGCGTTTCTGAGAATTCATC'CCC'TACACCGTATTATATGAATTCATC'G
AATTC'
TACCTATTATATCCTATT'AGA'TACCTCGGGGCGCATGTGCACATC'GAATTC'
TACATATATGATACT'CGC

45.
TACAGGCGTTTCGACACT'CCC'TACACCGTAAATATACCCGACATT'GAATTC'
TACCTATTATATCCTATT'AGA'TACCTCGGGGCGCATGTGCACATC'GAATTC'
TACATATATGATACT'CGC

46.
TACAGGGAATTCTGAATAATT'CCC'TACACCGTAAATATACCCGACATT'GAA
TTCTACCTATTATATCCTATT'AGA'TACCTCGGGGCGCATGTGCACATC'GAA
TTC'TACATATATGATACT'CGC

47.
TACAGGCGTTTCTGAGACACT'CCC'TACACCGTAAATATACCCGACATT'GAA
TTC'TACCTATTATATCCTATT'AGA'TACCTCGGGGCGCATGTGCACATC'GAA
TTC'TACATATATGATACT'CGC

48.
TACAGGCGTTTCTGAGAATTCATC'CCC'TACACCGTAAATATACCCGACATT'
GAATTC'TACCTATTATATCCTATT'AGA'TACCTCGGGGCGCATGTGCACATC'
GAATTC'TACATATATGATACT'CGC

49.
TACAGGCGTTTCGACACT'CCC'TACACCGTATTATATGAATTCATC'GAATTC'
TACCTAGAATTCCCTATC'AGA'TACCTCGGGGCGCATGTGCACATC'GAATTC
'TACATATATGATACT'CGC

50.
TACAGGGAATTCTGAATAATT'CCC'TACACCGTATTATATGAATTCATC'GAAT
TC'TACCTAGAATTCCCTATC'AGA'TACGAATTCGCGCATGTGCTCACT'GAAT
TC'TACATATATGATACT'CGC

51.
TACAGGCGTTTCTGAGACACT'CCC'TACACCGTATTATATGAATTCATC'GAA
TTC'TACCTAGAATTCCCTATC'AGA'TACGAATTCGCGCATGTGCTCACT'GAA
TTC'TACATATATGATACT'CGC

52.
TACAGGCGTTTCTGAGAATTCATC'CCC'TACACCGTATTATATGAATTCATC'T
TC'TACCTAGAATTCCCTATC'AGA'TACGAATTCGCGCATGTGCTCACT'GAAT
TC'TACATATATGATACT'CGC

53.
TACAGGCGTTTCGACACT'CCC'TACACCGTAAATATACCCGACATT'GAATTC'
TACCTAGAATTCCCTATC'AGA'TACGAATTCGCGCATGTGCTCACT'GAATTC'
TACATATATGATACT'CGC

54.
TACAGGGAATTCTGAATAATT'CCC'TACACCGTAAATATACCCGACATT'GAA
TTC'TACCTAGAATTCCCTATC'AGA'TACGAATTCGCGCATGTGCTCACT'GAA
TTC'TACATATATGATACT'CGC

55.
TACAGGCGTTTCTGAGACACT'CCC'TACACCGTAAATATACCCGACATT'GAA
TTC'TACCTAGAATTCCCTATC'AGA'TACGAATTCGCGCATGTGCTCACT'GAA
TTC'TACATATATGATACT'CGC

56.
TACAGGCGTTTCTGAGAATTCATC'CCC'TACACCGTAAATATACCCGACATT'
TTC'TACCTAGAATTCCCTATC'AGA'TACGAATTCGCGCATGTGCTCACT'GAA
TTC'TACATATATGATACT'CGC

57.
TACAGGCGTTTCGACACT'CCC'TACACCGTATTATATGAATTCATC'GAATTC'
TACCTATTATATCCTATT'AGA' TACGAATTCGCGCATGTGCTCACT'GAATTC'
TACATATATGATACT'CGC

58.
TACAGGGAATTCTGAATAATT'CCC'TACACCGTATTATATGAATTCATC'GAAT
TC'TACCTATTATATCCTATT'AGA'TACGAATTCGCGCATGTGCTCACT'GAATT
C' TACATATATGATACT'CGC

59.
TACAGGCGTTTCTGAGACACT'CCC'TACACCGTATTATATGAATTCATC'GAA
TTC'TACCTATTATATCCTATT'AGA'TACGAATTCGCGCATGTGCTCACT'GAAT
TC' TACATATATGATACT'CGC

60.
TACAGGCGTTTCTGAGAATTCATC'CCC'TACACCGTATTATATGAATTCATC'G
AATTC'
TACCTATTATATCCTATT'AGA'TACGAATTCGCGCATGTGCTCACT'GAATTC'T
ACATATATGATACT'CGC

61.
TACAGGCGTTTCGACACT'CCC'TACACCGTAAATATACCCGACATT'GAATTC'
TACCTATTATATCCTATT'AGA' TACGAATTCGCGCATGTGCTCACT'GAATTC'
TACATATATGATACT'CGC

62.
TACAGGGAATTCTGAATAATT'CCC'TACACCGTAAATATACCCGACATT'GAA
TTCTACCTATTATATCCTATT'AGA'TACGAATTCGCGCATGTGCTCACT'GAAT
TC' TACATATATGATACT'CGC

63.
TACAGGCGTTTCTGAGACACT'CCC'TACACCGTAAATATACCCGACATT'GAA
TTC'TACCTATTATATCCTATT'AGA'TACGAATTCGCGCATGTGCTCACT'GAAT
TC'TACATATATGATACT'CGC

64.
TACAGGCGTTTCTGAGAATTCATC'CCC'TACACCGTAAATATACCCGACATT'
GAATTC'TACCTATTATATCCTATT'AGA'TACGAATTCGCGCATGTGCTCACT'
GAATTC'TACATATATGATACT'CGC

DNA Extraction

You should remember from our units on macromolecules and cell reproduction a little bit about DNA, such as:

- Where is DNA found?
- What is the basic unit of DNA?
- Do all cells have DNA?

In this lab, you will extract DNA from 3 different plant substances. It is your job to test each type of plant, and determine from which one you can extract the most DNA.

You will draw three cards with the name of the plant material from which you will extract DNA.

Prelab

Plants to be tested:

Hypothesis:

What is the independent variable?

What is the dependant variable?

Materials

Buffer solution
Mortar and pestle
Warm distilled water
3 large test tubes
Funnel
Cheesecloth
3 wooden sticks
3 samples
3 rubber stoppers
Ice cold isopropanol
25 ml Dawn dishwashing detergent

Buffer Solution:
(this has been made for you)
600 ml distilled water
25g baking soda
7.5g table salt

Procedure for extracting the DNA.

1. Obtain a 10g sample of the plant you are testing.
2. Place the plant sample into the pestle with 20 ml of warm distilled water. (NOT TAP WATER)
3. Crush the plant sample and water until there are no visible pieces left. Let that sit while you do step 4 and 5.
4. Pour 15 ml of the buffer solution into the test tube
5. Place a funnel lined with a triple layer of cheesecloth onto the test tube.
6. Pour the plant sample into the funnel/filter and allow the filtrate to approximately double the volume in the test tube. Remove the filter and remaining sample and throw it out.
7. Cap the test tube and invert for 2 minutes. **Do not shake the test tube!**
8. Tilt the test tube and gently pour 10ml of ice-cold isopropanol on top of the DNA solution. **DO NOT MIX THESE LAYERS**.
9. Let the solutions sit for a few minutes. You should start to see a cloudy layer develop at the water/ isopropanol boundary. This is DNA!
10. Determine which plant sample contained the most DNA. While you are waiting, weigh your pieces of filter paper. (**Read How to Compare the Amounts of DNA Extracted**).
11. Insert a narrow wood rod, glass rod, or paper clip hook through the alcohol layer- just below the boundary of the alcohol and buffer. Gently twist the wood stick and spool the DNA around the stick.
12. Place the DNA on a piece of filter paper. Spread it out so it will dry faster. (You could also use a pipet to suck the DNA out, and then spread it on the filter paper. But be careful to only pick up DNA, and not the plant sample.)
13. Repeat steps 1-11 for the remaining samples
14. Clean up your lab station. All solid materials must be placed in the waste basket- **not the sink**! All liquids may be washed down the drain with water. Clean all the glassware, and put it back where you found it.

How to compare the amount of DNA extracted:

1. Get 3 pieces of filter paper (one for each DNA sample). Label them with the name of your sample, your name, and class hour.
2. Weigh pieces of filter paper. Record your results.
3. Use a hook to place the DNA you extract on these pre-weighed filter paper pieces. Spread the DNA out as much as possible, it will dry more slowly if it is clumped.
4. Let the DNA sit overnight until it is dry.
5. Weigh the filter paper again with the dried DNA on it. Record your results.
6. Calculate the DNA weight (weight of filter paper with dry DNA on it minus the weight of filter paper).

Data Table

	Sample 1	Sample 2	Sample 3
Type of Plant Sampled			
Mass of Filter paper + DNA			
Mass of Filter Paper			
Mass of DNA			

Graph

Conclusion Questions

1. Was your hypothesis correct? Explain your answer.

2. Why did you get different amounts of DNA from the different plants?

3. What were some potential sources of error, and how could you fix them if you were to do the experiment again?

Biology
DNA Transcription

1. Cut out the RNA polymerase enzyme as well as all the nucleotides. You do NOT have to cut them exactly on the lines.
2. Use the DNA nucleotides to make a DNA molecule. Then use the RNA polymerase and RNA nucleotides to model the process of transcription.
3. You will work in groups of 3. I will walk to each lab group and have you explain it to me. All of your group members must know the ENTIRE process, as I will ask questions of each member.
4. After I have checked off your demonstration, answer the question below.

_____
Teacher's Initials

---

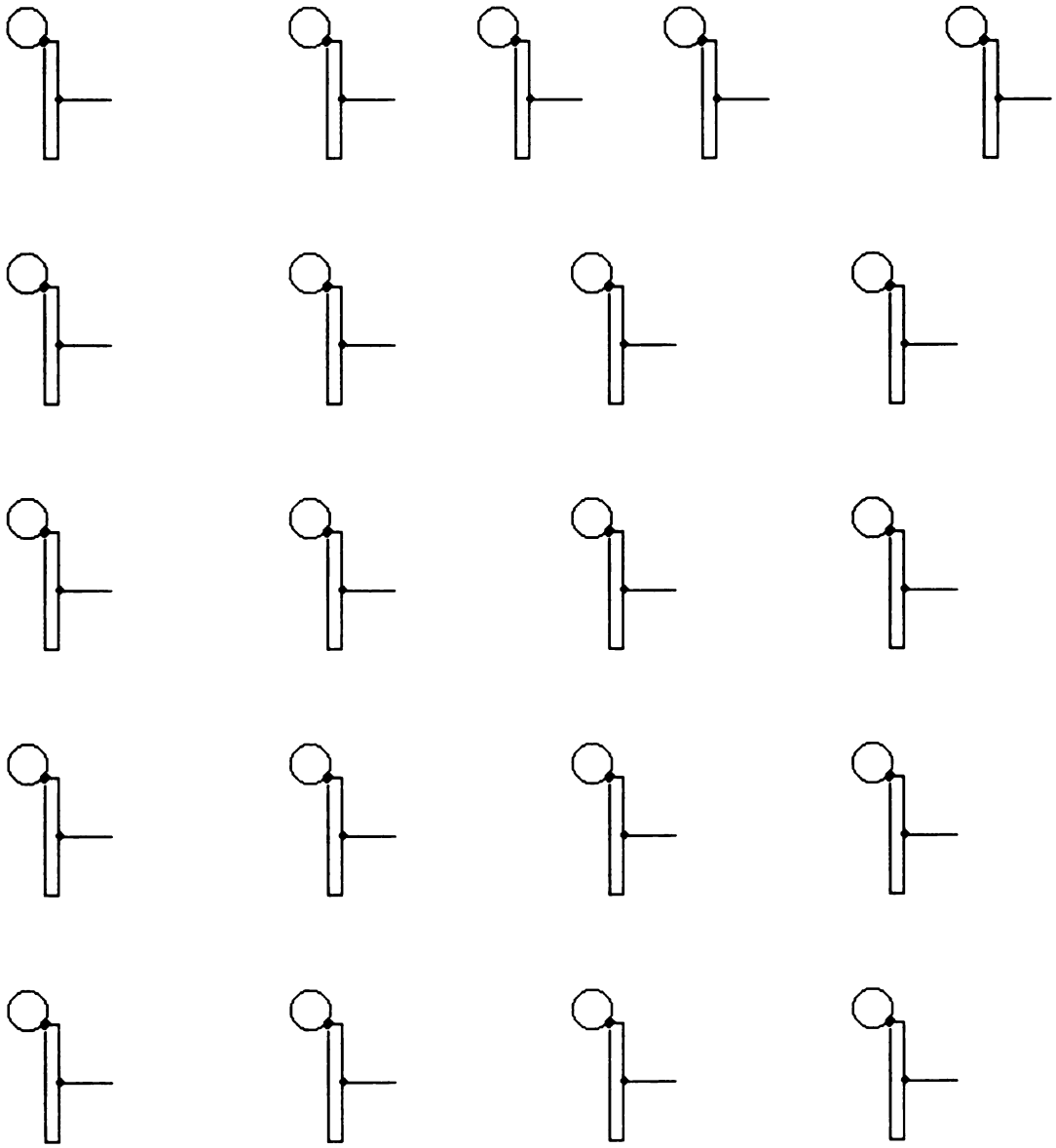
1. Describe at least three ways DNA replication is different from transcription. Be specific and detailed in your answer.

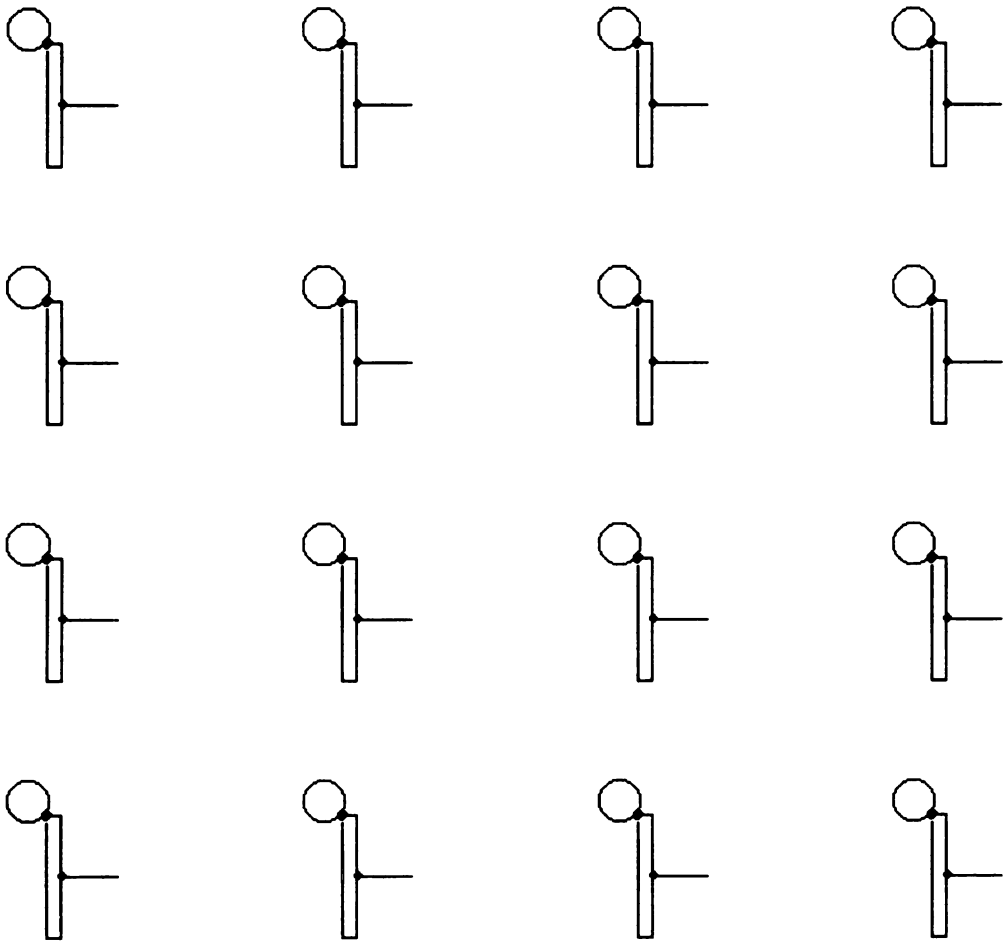
2. Explain "gene expression".

3. (Read pages 209-211).

4. What amino acid is coded for by the DNA sequence ATG?

Teachers- you will need to draw in the appropriate base pair letter next to the ball and stick DNA and RNA nucleuotide representative. The cloud acts as RNA polymerase.





Protein Synthesis

Pre lab questions

1. What specific type of macromolecule does the patterns of DNA code for? What is the "building block" of this type of macromolecule?

2. Briefly describe how the base pair sequence in a segment of DNA is turned into a protein.

3. What is a codon? Which molecule is a codon found on?

4. What is an anti codon? Which molecule is an anti-codon found on?

Take out your DNA sequence. (If you are looking at your model place it so the star is in the upper left hand corner.) This particular DNA sequence belongs to a dog, and codes for it's coat color, the shape of it's ears and the shape of it's tail. It is up to you to decode the dogs DNA sequence and then draw a picture of the dog your sequence codes for.

How will you do this?

Step 1: (Turn DNA into mRNA)

Step 2: (Find codons)

Step 3. (Find the amino acids the codons code for – use Figure 10-4 on page 209 of your book.)

Step 4. (Write the sequence of amino acids in the proteins...warning...the proteins are found between the start and stop codons! The rest is "junk" or "nonsense" DNA.) On your DNA model, lightly shade in the area where you find your gene, and write it what the gene codes for.

Example: **CCGA<u>ATGGGCCCCGC</u>GGG**

Step 5. (Use Table 1 to identify the protein using the amino acid sequence)

Step 6. (Use Table 2 to learn what function the protein has and how it affects what your dog looks like).

Step 7. Draw the dog!

Table 1. Protein Identification

Protein Identification Number	Amino Acid Sequence
A00121	Serine- leucine - lysine-threonine- tyrosine
A225	Serine – alanine- leucine-threonine- lysine
A4561	Serine- alanine- lysine- threonine- leucine
A0212	Serine-alanine – lysine -leucine
A4905	Serine- alanine- lysine- tyrosine- leucine- lysine
A8825	Serine – lysine- lysine –leucine
A3092	Serine- alanine- lysine- threonine- leucine- lysine
DF8675	Tryptophan – histidine – asparagine – tyrosine- leucine- lysine
LHX201	Tryptophan – histidine – asparagine – isoleucine- leucine- lysine
LHX004	Tryptophan – histidine – leucine – tyrosine- glycine- leucine
EU431	Aspartic acid – leucine – lysine -glycine
HE411	Aspartic acid – asparagine – isoleucine - glycine
ET812	Glutamic acid – proline – proline- valine- histidine- valine
ET019	Leucine- lysine- proline- valine- histidine- glutamic acid
PE309	Aspartic acid – asparagine – isoleucine - alanine
TS007	Tryptophan- tryptophan- histidine
TS0100	Tryptophan- tryptophan- leucine
TS2100	Tyrosine- isoleucine- leucine

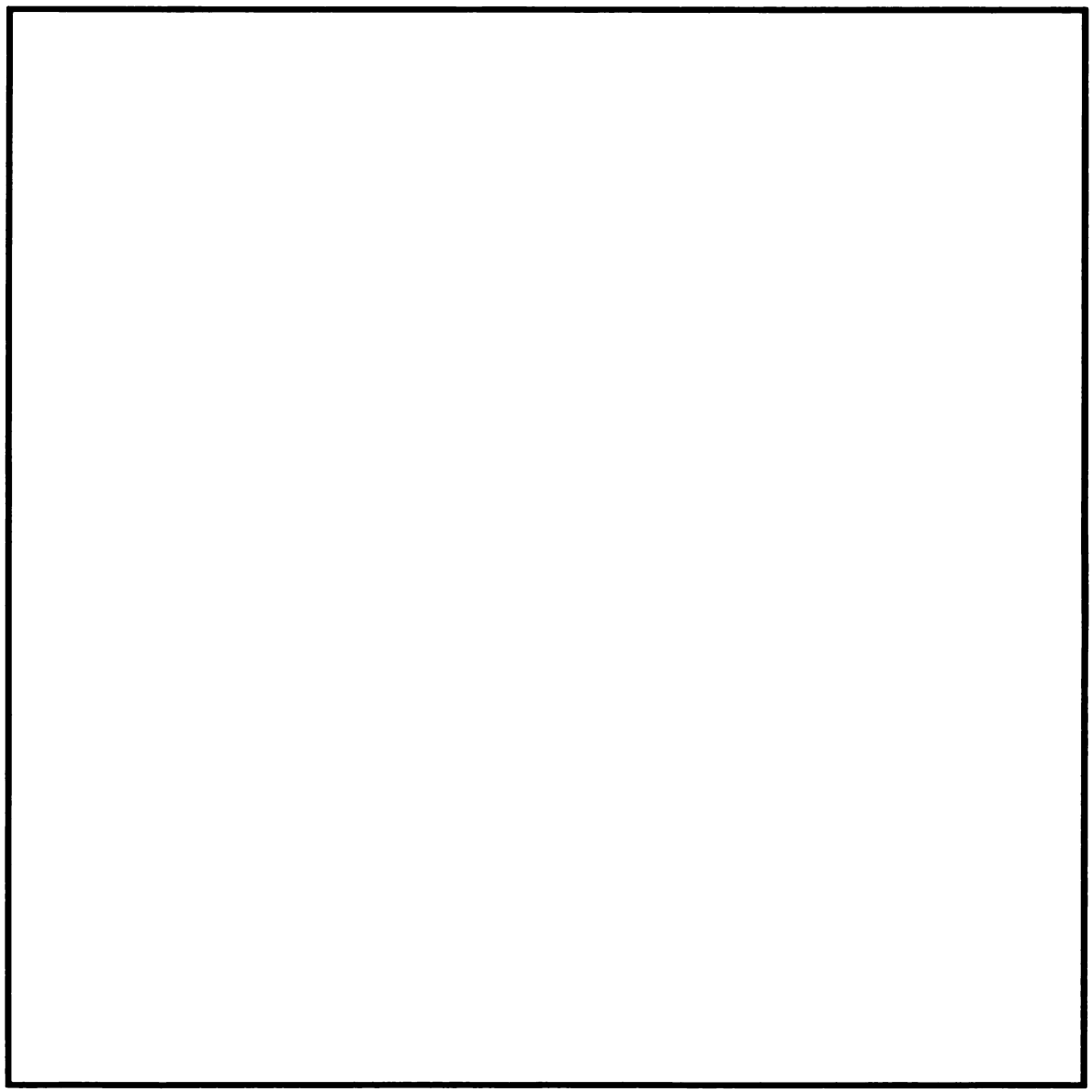
Table 2. Protein Actions

A00121	The presence of protein A00121 causes each hair on a dog's body to have 2 colors – like someone with a bad dye job. This hair pattern is called sable	
A0212	Protein A0212 causes the pigment that produces black colored hairs to be found all over the body. The dog has a solid black coat.	
A4561	This protein causes the pigment that produces black hair to be found in a "saddle" on the middle of the back, sides and tail. The legs, face, and rest of dog tan colored. This pattern is called "black and tan"	
A3092	This protein causes the pigment that produces black hair to be spread all over the body, except for the legs. This pattern is called "dual".	
LHX201	Protein LHX201 makes the dog unable to produce black pigment. Instead all the black areas on a dog are brown in color.	
LHX004	LHX004 allows for the normal production of the black pigment.	
EU431.	This protein is used to make connective tissue in the ears very strong. Dogs with this protein have ears that stand up on their heads.	
HE411	This protein is used to make connective tissue that is soft. Dogs with this protein have ears that hang on the side of their heads.	
ET812	This protein causes the cells at the ends of the ear to divide in a way that makes the end of the ear have a smooth round edge.	
ET019	Protein ET019 causes the cells at the ends of the ear to divide in a	

	way that make the end of the ear have a pointed tip.	
TS007	Protein TS007 directs certain muscle cells to have attachments causing the tail to be curly.	
TS2100	Protein TS2100 directs certain muscle cells to have attachments causing the tail to be straight.	
A8825	When present protein 8825 makes a red pigment that blocks out black and tan colors. Dogs with protein 8825 are solid red in color, like an Irish Setter.	
A225	Protein A225 causes black pigment to be distributed randomly all over the body- giving dogs a spotted look- like a Dalmatian.	
TS0100	This protein inhibits the formation of a tail. Dogs with TS0100 are born without tails.	
DF8675	This protein dilutes black pigment to a grayish color. All the regions that are supposed to be black on this dog would instead be a pale gray color.	
A4905	Protein A4905 inhibits the production of all pigments. Dogs with this protein in their cells are solid white.	
PE309	This protein is used to make connective tissue that is medium soft. Dogs with this protein have ears that neither hang flat nor are completely upright. This trait is called "pricked ears" and is found in Shelties and Collies.	

Draw Your Dog!

I am the dog with DNA sequence # _____ My name is _____



1. What proteins #'s did your DNA sequence have?

2. What do these proteins do?

3. How is the DNA of a sable dog and a black dog different?

4. How are proteins different from each other? (Hint – look at Table 1 and steps 2-3)

5. Explain why the base pair pattern of DNA is important.

6. Does all DNA code for a protein?

Thinking Ahead- Lets say you have a dog with a straight tail, but you really wanted it to have a curly tail. How could you make the dog have a curly tail?

Protein Synthesis Lab

Teacher Instructions.

Materials- DNA sequence, paper, pencil

* The DNA sequences and proteins are fictitious.* Key

DNA Sequence #	Color	**L**iver/**N**ot liver	**U**p ears/ **H**anging ears	**R**ounded Ear/ **P**ointy Ear	**C**urly/**S**traight Tails
1 (33)	Black	L	U	R	C (S)
2 (34)	Sable	L	U	R	C (S)
3 (35)	Blk & Tan	L	U	R	C (S)
4 (36)	Dual	L	U	R	C (S)
5 (37)	Black	N	U	R	C (S)
6 (38)	Sable	N	U	R	C (S)
7 (39)	Blk & Tan	N	U	R	C (S)
8 (40)	Dual	N	U	R	C (S)
9 (41)	Black	L	H	R	C (S)
10 (42)	Sable	L	H	R	C (S)
11 (43)	Blk & Tan	L	H	R	C (S)
12 (44)	Dual	L	H	R	C (S)
13 (45)	Black	N	H	R	C (S)
14 (46)	Sable	N	H	R	C (S)
15 (47)	Blk & Tan	N	H	R	C (S)
16 (48)	Dual	N	H	R	C (S)
17 (49)	Black	L	U	P	C (S)
18 (49)	Sable	L	U	P	C (S)
19 (50)	Blk & Tan	L	U	P	C (S)
20 (51)	Dual	L	U	P	C (S)
21 (52)	Black	N	U	P	C (S)
22 (53)	Sable	N	U	P	C (S)
23 (55)	Blk & Tan	N	U	P	C (S)
24 (56)	Dual	N	U	P	C (S)
25 (57)	Black	L	H	P	C (S)
26 (58)	Sable	L	H	P	C (S)
27 (59)	Blk & Tan	L	H	P	C (S)
28 (60)	Dual	L	H	P	C (S)
29 (61)	Black	N	H	P	C (S)
30 (62)	Sable	N	H	P	C (S)
31 (63)	Blk & Tan	N	H	P	C (S)
32 (64)	Dual	N	H	P	C (S)

Pigoletto: How much is that guinea pig in the window...(reet reet) ?

You decide to get a guinea pig- and contact a breeder. Knowing you are a genetics wiz, the breeder sends you not a picture of Pigoletto, your future guinea pig, but instead a picture of his cute furry face he sends you a picture of his chromosomes. The breeder tells you if you can answer the following questions correctly, he'll let you have Pigoletto for free! Otherwise, he is going to the nearest lab to be a lipstick tester. Carefully read the information below, and save Pigoletto!

Guinea pigs have 64 chromosomes (pairs 1-31 are autosomes, the 32nd pair are the sex chromosomes). Thinking back to meiosis, you remember that one of each chromosome pair came from mom's egg cell, and the other from dad's sperm cell.

Here we are looking at Pigoletto's 23rd pair of chromosomes. Use the table below to help answer the questions. Good Luck!

Pigoletto's Chromosome pair number 23

Chromosome 23 from "Mom"

Chromosome 23 from "Dad"

Trait	Dominant Gene	Recessive Gene
Eye Color	Brown (B)	Red (b)
Hair Color	Black (L)	Brown (l)
Hair length	Short Hair (H)	Long hair (h)
Hair type	Straight (G)	Wavy (g)
White Spots	No white spots (N)	White spots (n)

1. Does Pigoletto have a black coat? Explain.

2. Does mom have a black coat? Explain.

3. Does dad have a black coat? Explain.

4. What is Pigoletto's hair type?

5. Will Pigoletto's hair length be the same as either of his parents? Explain.

6. Does Pigoletto have straight or wavy hair?

7. Does Mom have wavy hair? Does Dad have wavy hair?

8. Define the term homozygous.

9. For which traits is Pigoletto homozygous?

10. Define the term heterozygous.

11. For which traits is Pigoletto heterozygous?

12. Explain why you cannot completely describe the Pigoletto's parents, even though you can accurately describe Pigoletto?

13. Based on these chromosomes, what is Pigoletto's phenotype?

14. Based on these chromosomes, what is Pigoletto's genotype?

What if I told you Pigoletto's sister, Pygmalia, is homozygous for the following traits: brown eyes, black hair, straight hair, and white spots. Can you tell me more about what Pigoletto and Pygmalia's parents look like?

Genetic Inheritance in Corn

Purpose: To determine the phenotypic ratio expressed in a dihybrid cross.

As you all know crossing a homozygous dominant individual with a homozygous recessive individual will create heterozygous offspring, all who have the dominant phenotype. However, no organism's appearance is only the result of one gene. Your job is to count the seeds (baby plants) and figure out the phenotypic ratio of the offspring produced by crossing two heterozygous purple heterozygous smooth corn plants.

Pre-Lab

What are the four phenotypic possibilities?

Procedure

1. DO NOT remove the corn from the bag!
2. Use a piece of tape to mark a row to start your count.
3. Count the number of each type of seed in one row. Record results in the data table.
4. Repeat step three until you have counted 10 rows.
5. Total the number of seeds in each row.
6. Record the totals of 2 other groups. Add your totals with the two from other groups for a grand total of each type of seed.

Row #	1	2	3	4	5	6	7	8	9	10	Total
Smooth Yellow											
Wrinkled Yellow											
Smooth Purple											
Wrinkled Purple											

Group #	Ours	Other group 1	Other group 2	**Grand Total**
Smooth Yellow				
Wrinkled Yellow				
Smooth Purple				
Wrinkled Purple				

Analysis

1. Find the type of seed that had the smallest grand total number. Write that number here.
2. Divide all the other grand total numbers by this number.
3. Round these numbers (one of them should be 1) to the nearest whole number.
4. Write these numbers as a ratio. (Remember the 3 purple : 1 white flowers?)

Conclusion

1. Which color is dominant? How can you tell?

2. Are wrinkled or smooth seeds dominant? How can you tell?

3. If you use a "w" to represent the trait of kernel shape (wrinkled or smooth) and the letter "r" to represent kernel color, list all the genotypes that would produce the phenotypes found in these kernels.

4. Why did you have to round the numbers for the ratio? Why wasn't it an exact whole number?

Uber- Critters

Now that you have learned all about pedigrees, Punnet squares and types of inheritance, it is time to put your knowledge to work! You have been hired by the large corporation "Uber-Critters" and have been given the task of developing a new species that every person will want to own as a pet. (Keep in mind- some people keep bunnies as pets, and some people keep alligators- so feel free to use your imagination!)

The creature must have at least 7 genetic traits from the following list:

2 Single gene traits

1 Polygenic trait

1 Codominant Trait

1 Incomplete dominant Trait

1 Sex linked Trait

1 Lethal

1. Create a mini-poster for each of the traits on the list, showing genotypes and phenotypes for each. Include a sketch of one of your creatures, and include its complete genotype. (Hint- this means it should have at least 7 different allele pairs!) Also give a brief description of the critter. (See sample).

2. Pick one of your traits and create a sample pedigree for your creature that includes at least 4 generations. Be sure to include a title, and identify the trait you are studying.

3. Create 5 practice problems using any of your traits. One of them should be a dihybrid cross using your two single allele traits. Yes, you do have to solve them.

4. Extra Credit opportunities on this assignment: doing more than 7 traits, creating more than 5 practice problems, and doing more than a 4 generation sample pedigree.

5. The President of "Uber-Critters" has asked that you submit your project in the following format:

- Your Mini-poster should be on a single sheet of typing paper.
- Place your pedigree on a single sheet of typing paper.
- The practice problems and solutions can go on lined paper, as long as they are neatly written. You may choose to type it if you wish.

Have fun! Uber-Critters is counting on YOU!

Uber- Critters- Species Project (Sample)

Msuga- The msuga is a friendly woodland creature. They weigh approximately 10 lbs, and come in a variety of colors. They make excellent pets for people who are not U of M fans, as they are prone to giggling during U of M basketball games. Warning - some become vicious when provoked during football and hockey season!

Single Allele Trait #1 - Tails
Tail No tail

Single Allele Trait #2 – Coat length
Long hair Short hair

Codominant Trait- Color
Green

Green/White

White

Incomplete Dominant- Coat Texture
Curly coat

Wavy Coat

Smooth Coat

Polygenic Trait #1 Antennae

Long Short

Ball Ended Heart Ended

Coiled Straight

Sex-linked Trait Eye shape

Round XR

Slant Xr

Lethal

Green coat Blue

Sample Genotype

Sample Phenotype

Mutations

Problem: How can mutations change an organism?

Objectives:
To define the types of mutations

Materials:
Scissors lab sheet sheet of "bases"

Mutations are changes in DNA, either at the chromosomal level or at the base pair level. In this activity you will model both chromosomal and "point" mutations.

Procedure:
Part A: Organize your chromosome.

1. Cut out the words (genes) on the Chromosome Cut-Out Sheet.
2. Using your gene cut-outs arrange the genes in the following order:

THE BIOLOGY STUDENT NIBBLED ON MOUSE FEET

Chromosomal Mutations-
For these examples each word in the sentence will represent a gene, and the entire sentence represents a chromosome.

Part B: Simulating an addition (or duplication) mutation.
Addition mutations occur when an extra copy of a gene is added during DNA replication.

1. Using your base cut-outs, arrange the bases as in part A.
2. Create the addition mutation by adding an additional MOUSE right behind the first one.

    a. Rewrite the new sentence.

    b. Does the sentence have a new meaning? Explain. (Example, how many mouse feet did the student eat?)

    c. Explain the effect this type of change would have in a chromosome, and the mutated cell.

Part C: Simulating a deletion mutation.
Addition mutations occur when a gene is deleted from a chromosome during DNA replication.

1. Using your base cut-outs, arrange the bases as in part A.
2. Create the addition mutation by removing MOUSE from the sentence.

    a. Rewrite the new sentence.

    b. Does the sentence have a new meaning? Explain.

    c. Explain the effect this type of change would have in a chromosome, and the mutated cell.

Part D: Simulating an inversion mutation.
Inversion mutations occur when genes change position on a chromosome.

1. Using your base cut-outs, arrange the bases as in part A.
2. Create the inversion mutation by placing the genes THE BIOLOGY STUDENT where the MOUSE FEET is, and vice versa.

    a. Rewrite the new sentence.

    b. Does the sentence have a new meaning? Explain.

    c. Explain the effect this type of change would have in a chromosome, and the mutated cell.

Part E: Simulating a translocation mutation.

Translocation mutations occur when genes from one chromosome are either swapped with, or added to a non-homologous chromosome.

1. Using your base cut-outs, arrange the bases as in part A.
2. Create the translocation mutation by replacing MOUSE FEET genes with YUMMY SNACKS. (From a different chromosome "While their teacher ate yummy snacks")

    a. Rewrite the new sentence.

    b. Does the sentence have a new meaning? Explain.

c. Explain the effect this type of change would have in a chromosome, and the mutated cell.

POINT MUTATIONS

Point mutations are changes in the sequence of the DNA base pairs.

Part A: Organizing the sequence

1. Cut out the letters on the "base cut out sheet"
2. Using your base cut-outs arrange the bases in the following order

THE CAT SAW THE DOG

Part B: Simulating a substitution point mutation

1. Using your base cut-outs, arrange the bases as in part A.
2. Replace the letter D with the letter M.
   a. Rewrite the new sentence.

   b. Does the sentence have a new meaning? Explain.

   c. Explain the effect this type of change would have in a DNA molecule and the resulting protein.

Part C: Simulating a frame shift mutation

1. Using your base cut-outs, arrange the bases as in part A.
2. Add the letter M after the letter C and regroup the letters in groups of 3's.

   a. Rewrite the new sentence.

   b. Does the sentence have a new meaning? Explain.

   c. Explain the effect this type of change would have in a DNA molecule and the resulting protein.

Part D: Simulating a deletion point mutation

1. Using your base cut-outs, arrange the bases as in Part A.
2. Remove the letter C and regroup the letters into groups of three.
   a. Rewrite the new sentence.

   b. Does the sentence have a new meaning? Explain.

c. Explain the effect this type of change would have in a DNA molecule and the resulting protein.

Analysis

1. What is a mutation?

2. How can DNA mutate? Describe how this occurs.

3. Why is a change in DNA permanent for the cell?

4. How can a point mutation cause severe changes in the organism?

5. Using this chromosome as a base, draw a new version of it showing each of the following types of chromosomal mutation. Make sure you label your diagram.
   - Addition
   - Deletion
   - Inversion
   - Translocation

5. Why should we be concerned about mutations?

Thought Questions (or things you might need to look up in your book!)

1. What are some things that cause mutations?

2. Are all mutations harmful? Give an example.

3. In part E of the Chromosomal Mutations, what do you think the other "chromosome sentence" said?

Chromosomal Mutations
Gene Cut-Out Sheet

THE	BIOLOGY	STUDENT	NIBBLED	ON
MOUSE	FEET	YUMMY	SNACKS	WHILE
TEACHER	THEIR	ATE	MOUSE	

Point Mutations
Base Cut-Out Sheet

T	H	E	C	A
T	S	A	W	T
H	E	D	O	G
W	M	D	C	A

Adapted from Michael Sampson's "Mutations- Get the Point?"

Karyotyping and Human Genetic Disease

Objective: Students will learn about the inheritance of a variety of human genetic diseases and how geneticists identify these disorders (i.e. karyotype)

Go to the URL below and answer the questions.

http://www.biology.arizona.edu/human_bio/activities/karyotyping/karyotyping.html

1. How do scientists create a karyotype?

2. What features of a chromosome do scientists look at to match the homologous chromosomes?

3. OYO- Name the two procedures used to get the cells to do a karyotype on an unborn child. (Hint- check out your book!)

Now go to

http://gslc.genetics.utah.edu/units/disorders/karyotype/karyotype.cfm

Read the text carefully, and then click on the large button "Organize the chromosomes into a karyotype". Now that you have seen a karyotype being created it is time to do one on your own. Look at the yellow box on the right side of the page and click on "Matching up chromosomes in a karyotype".

Complete the karyotype, and close the window. Scroll to the bottom of the page and click on "Using karyotypes to predict genetic disorders".

Read the information on this page and answer the following questions. You do not need to play the videos, unless you need to "refresh" your memory.

1. How many of each kind of chromosome are found in a normal human karyotype?

2. What kinds of changes (not normal) can you see in a karyotype?

3. What is the name of the mutation that causes a cell to inherit either too many or two few chromosomes? (It is not on the website.)

4. Name the other types of mutations that may cause genetic disorders. (Hint:- yesterday's lab!)

5. What can't you see in a karyotype?

Now lets learn about some diseases!
Use the two websites listed below to help you.

http://www.ncbi.nlm.nih.gov/books/bv.fcgi?call=bv.View..ShowTOC&rid=gnd.TOC&depth=10

http://www.kumc.edu/gec/support/groups.html

Include the following information for each of the diseases listed below:

- Which chromosome is the gene causing this disease located on?
- Type of mutation – if applicable.
- Number of people affected.
- Symptoms and Onset of symptoms
- Treatment/Life Expectancy.

Do not use any terms you do not understand, and do not plagiarize the websites!

Sickle Cell Anemia	**Hemophilia**
Downs Syndrome	**Cystic Fibrosis**
Huntington's Disease	**Phenylketoneuria**

Which disease would you like to know more about?
Pick any two diseases from the disease lists on the either of the two websites. Do not pick the same diseases as the people you are sitting next to. You must provide the same information for these two diseases as you did above. You may do an extra disease for extra credit.

http://www.ncbi.nlm.nih.gov/disease/chr1-4.html
Nifty cool diagrams for your bedroom wall!

Processes of Genetic Engineering

It's everywhere , it's everywhere! From the nightly TV dramas CSI and Law and Order, to the nightly news, and the ever popular TV talk shows, everyone is talking about DNA.

The question is, how? We know what DNA looks like, and what it does. But how do they use it to prove who a killer is, who is the father of a baby, and make a clone? Or make tomatoes that have fish DNA in them???

There are roughly 3 billion nucleotides in your DNA. In order to work with DNA, scientists must cut DNA strands into more manageable sized pieces. To do this, scientists use restriction enzymes, which cut the strand in particular spots marked by a palindrome (same backward and forward) sequence. We are using EcoR1, a restriction enzyme from E.coli that cuts at the GAATTC sequence.

Step 1- DNA strand

Step 2- Restriction Enzyme identifies region to cut at. We are using a restriction enzyme called EcoR1, (Eco because it comes from E. coli bacteria) This enzyme seeks out the pattern GAATTC.

Step 3- Notice that the right side strand has an upside down GAATTC sequence right across from the left side strand. This is known as a palindrome.

Step 5. The enzyme now makes a vertical cut between the nitrogenous base pairs of the G**AATTC** .

Step 4. The restriction enzyme makes a cut between the G and A in the GAATTC pattern on the right and left side of the DNA strand.

Step 6. The DNA strand is now cut in ½. You can see they have non-bonded AATT's sequences at the end of each strand. These are called "Sticky Ends".

Ok, now take your DNA model, a pair of scissors, and be EcoR1 !

Great Miss Porter…I have DNA snippets. What am I supposed to do with them now?

Well….you could

1. Insert a new gene between your snipped segments.

2. Identify a killer!

3. Piece the snippets back together (using special segments called markers as a reference guide) in order to make a map of the DNA and figure out where/what all the genes are! (A'la the Human Genome Project)

GMO's

How do you create genetically modified organisms? Go to the site

http://www.bbc.co.uk/science/genes/gm_genie/gm_science/index.shtml

In your own words, describe how to create a genetically modified organism.

Now, lets learn a little about genetically modified organisms. Go to the following website:

http://members.tripod.com/c_rader0/gemod.htm

Scroll down to "Some early fruits of transgenic agriculture". You will see a list of links underneath. You must click on **6** of them, and for each record:

- What was the original organism
- What gene is being altered (what it's function is, and it's source)
- What's the benefit?
- Is there any risk?

Now click on "Legitimate concerns about transgenic agriculture".
What are the concerns listed on this site? Give a very brief explanation of each concern.

Now it is your turn!
Write two paragraphs stating your opinion on using this technology. If you are against it, might there be a circumstance that you support it? If you are for it, are there instances you are against it? Use some of the examples from this activity, the Cracking the Code of Live movie to support your answer. A simple yes or no will not get you full credit.

If you have some time left over.... Check out this site!

http://www.bbc.co.uk/science/genes/gene_safari/index.shtml

Old McDonald had a Crime E-I, E-I, Uh-OH!

Old McDonald woke up late one morning and was shocked to see that someone had taken his tractor out for a joyride, and then crashed it into the side of a barn. The tractor was totaled, and the barn is going to need several thousand dollars worth of repair. The police checked the tractor for prints, but couldn't find any. They did find a tiny tissue sample and are investigating several suspects.

#1 Mr. Turkey- Still angered by the "Thanksgiving Slaughter" that took the life of his brother, Mr. Turkey has been looking for a way to take his revenge on Old McDonald.

#2 Anna Cow-nikova- Tired of being just one of the herd, Anna has been dreaming of life as Tennis Star. When she told her dreams to Old McDonald he laughed at her. Could this have been her revenge?

#3 Chicken McGee- has been acting as Old McDonald's alarm clock for the last 6 years, faithfully waking him up at 5 am. He has laryngitis. Did he crash the tractor in an attempt to wake up Old McDonald?

#4 Pig Diesel- Is a big fan of the movie The Fast and The Furious. He has made no secret of his desire to get his hooves on a motorized vehicle to take it for a "spin".

#5 Soylent Bean- Was seen arguing with Old McDonald about the lack of irrigation in his field. Could he have been responsible for trashing Old McDonald's tractor?

As part of the local CSI department, the case has been turned over to you. Your next task is to obtain a tissue sample from each of the suspects and perform a gel electrophoresis (fingerprint) test. Who crashed Old McDonalds tractor?

PreLab-

Explain how gel electrophoresis can be used to create a genetic "fingerprint". You may draw a picture if you wish.

We will be doing a simulation of an electrophoresis lab using a mixture of different food colorings as DNA, chromatography paper as the gel, and water as the buffer/electricity. Each sample has been cut apart by the restriction enzyme, and each segment of "DNA" will have it's own color. Just like DNA, the smallest molecules travel the furthest.

Materials:

Toothpick
10cm by 15cm strip of chromatography paper
1 beaker
pencil
ruler

Procedure

1. Cut a paper strip 10 cm wide and 15 cm long. Fold paper so that it will stand in container. Sketch the set up you see on your teacher's desk here.

2. Draw a **pencil** line about 2 cm above the lower edge of the filter paper. Draw five small marks on this line. Mark five locations on the line, evenly spaced, and number these locations below the line.
3. Using a new toothpick for each solution, transfer the suspects DNA samples to the marked locations. Let the solutions dry on the paper. (3 minutes)
4. While the "DNA" dries, pour about 1 cm of water into the container.
5. Position the folded filter paper in the water container so that the treated end is in contact with the water – the samples should be about 1 cm above the surface of the water. DO NOT let the water touch the sample. It is best to check and see how much water you will need to pour into the beaker before you actually do it.
6. After 15 minutes, examine the paper. If the colors are no longer traveling up the paper, take the paper out of the beaker, and pour out the water. Then place the paper back into the beaker and allow it to dry.
7. Compare your results with a trusted neighbor, and then compare it to the suspects sample located on my desk. Pay attention to the color, size and location of each band.
8. Answer the questions on Data Sheet.

Data Sheet-

Sketch the results. Use colored pencils!

Crime Scene	#1	#2	#3	#4	#5

Questions

Which suspect do you think was responsible for crashing Old McDonalds tractor? Explain why you think this is true.

Would you expect closely related suspects to have a DNA "fingerprint" that is more or less alike? Explain your answer.

You cut all five suspects DNA samples with Eco R1. Three of the samples have the exact same fingerprint. Does this mean all their DNA pattern is exactly the same? Explain your answer. As a CSI officer, what would be your next step to try and prove who left their DNA at the crime scene?

What is the function of a restriction enzyme?

Which "DNA segment/Color" was the largest? The smallest? How can you tell?

Teacher Resources for DNA Fingerprinting Lab

Each of the "DNA" samples was a mixture of food coloring. I combined 2-3 colors in a separate vial. The red, blue, and green food coloring all came from the same manufacturer, the purple was from a different source.

Example-

Subject 1- blue and purple food coloring
Subject 2- red and purple food coloring
Subject 3- yellow and purple food coloring
Subject 4- green and purple food coloring
Subject 5- red, blue and green food coloring

The crime scene sample was taken from one of the subject vials. I set up the equipment on the teachers desk and ran the crime scene sample there. That prevented students from trying to identify the culprit by looking at the initial color of the DNA "dot" placed on the chromatography paper.

Cloning

Go to the following site: http://gslc.genetics.utah.edu/ (If the computer won't allow you to access the site, type gslc genetics into the search engine, and click on the first link.)

Scroll down the page. Look in the box on the left side of the screen for Cloning in Focus, and click on the link. Answer the following questions.

1. What is cloning?

2. What is the difference between artificial embryo twinning and somatic cell nuclear transfer?

Now click on the back button and go to "Why Clone?".

1. Briefly describe the four main reasons "to clone".

Now click on the back button and go to " What are the Risks of Cloning?"

1. Briefly describe the four main risks of cloning.

Click on the back button and go to "Click and Clone" – and clone a mouse!

Briefly describe how to create a clone.

Now that you are an expert at cloning mice, play the game, Is it Cloning? Or Not?

There are seven questions in this game.

Place your score here. _____ Correct _____ Incorrect.

Answer any two of the following questions on a separate piece of paper and attach it to this lab :

- Who has the right to have children, no matter how they are created? Who doesn't? Why?
- Is human cloning "playing with nature?" If so, how does that compare with other reproductive technologies such as *in vitro* fertilization or hormone treatments?
- Does cloning to create stem cells, also called therapeutic cloning, justify destroying a human embryo? Why, or why not?
- If a clone originates from an existing person, who is the parent?
- What are some of the social challenges a cloned child might face?
- Do the benefits of human cloning outweigh the costs of human dignity?
- Should cloning research be regulated? How, and by whom?

Now that you have finished, use this site to help you review some genetic basics!

Click on Home, then Basics and Beyond. There is an interactive protein synthesis game that is helpful. Check out any other page on this site that looks interesting to you. Extra credit if you write a short summary of the information on the page you visited, and if you thought it was helpful. Once you are finished with the site, log off, and work on your test review sheet.

APPENDIX D

Figure 9. Pretest and Post-test Item Correlations

Question Number	Question Concept	Correlating Pre-Test Item Number	Correlating Post-Test Item Number	MEGOSE Benchmark Number
1	Structure of a DNA molecule.	2	1	
2	Identifying simple mode of inheritance by recognizing the pattern of recessive genes and carriers.	4	3	III.3.1
3	Explain gene expression.	1	5	
4	Identify mode of inheritance from a pedigree.	10	9	III.3.1
5	Explain the process of Gene Therapy	7a	13a	III.3.3
6	Explain process of cloning	7b	13b	
7	Explain the process of DNA fingerprinting	7c	13c	
8	Explain a GMO.	7d	13d	III.3.3
9	How to change the traits of an organism using artificial selection and/ or genetic engineering.	5	12	III.3.3
10	Solving a simple monohybrid Punnett Square problem.	16	MSUGA traits #3	
12	Differentiate between the terms DNA, trait and allele.	14	8	

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