NC STATE UNIVERSITY

EXPLORING GENETICS

Across the Middle School Science and Math Curriculum©

NSF

MUSEUM of LIFE + SCIENCE
DURHAM NC

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North Carolina State University is a land-grant university and a constituent institution of The University of North Carolina

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Dear Middle Grades Educator,

This kit "Genetics Across the Middle School Science and Math Curriculum" has been designed with you in mind. Our team of university scientists, middle grades classroom teachers, middle school students, and museum educators developed and tested the activities in a school setting. The activities are easily implemented and follow the North Carolina Standard Course of Study in both a science and math requirement within the Standard Course of Study for the middle school grades. The career information, reflection activities, and the inquiry based nature of the activities provide a well rounded introduction to genetic science and its relation to mathematics at the middle grades level.

The kit was developed as an outreach project for National Science Foundation project in plant genomics (DBI-0421651). I am very grateful to the Foundation for continuing support. In addition, I'd like to thank the NCSU co-Principal Investigators working with me on this project for their involvement and dedication: Dr. Linda Hanley-Bowdoin, Dr. George Allen, and Dr. Bryon Sosinski. I'd also like to thank the postdoctoral associates and graduate students who contributed their time and expertise: Dr. Sharon Settlage, Dr. Tae-Jin Lee, Dr. Randall Shultz, Miguel Flores, and Mariana Franco-Ruiz. For more information on this project visit www.plantreplication.org.

Most of the credit for the activities contained within this project goes to Hawley Middle School (Granville County, NC) teachers Dr. Jeff Batten and Rob Caine for their development, testing, and scrutiny from a teacher's point of view of each activity. Jeff and Rob spent countless hours of creative energy in pursuit of the best possible explanation of genetic science to a middle grade student. All of us at NCSU enjoyed getting to know these two talented and dedicated teachers.

A word of thanks is also in order for Shawntel Landavazo and Nancy Dragotta-Muhl at the Museum of Life and Science in Durham, NC. Their insight into classroom teacher challenges, science kit construction, and activity alignment to the North Carolina Standard Course of Study was instrumental to refining the kit.

Finally, a very important word of thanks goes to Carol Cutler-White for developing the concept, creating the collaboration, and managing the project.

I trust you will find this kit to be highly valuable as you teach science and math at your school.

Sincerely,

Dr. William F Thompson
University Research Professor
North Carolina State University
Campus Box 7550
Raleigh, NC 27605

Acknowledgements and Biography

ACKNOWLEDGEMENTS

Special thanks to:
Dr. Julie Hicks for helpful scientific and editorial suggestions.

Todd Guentensberger from Duke University CIBL (Center for Inquiry-Based Learning) for helpful suggestions on developing an Inquiry Based science kit for middle schools.

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BIOGRAPHY

Dr. Jeffrey Batten received M.S. and Ph.D. degrees in Plant Pathology and Microbiology from Texas A&M University, where he studied how plant viruses replicate. During graduate school, he became interested in science education and developed several hands-on workshops for students. After finishing his Ph.D., Dr. Batten continued researching the biochemistry of plant viruses during his postdoctoral research at NC State University. During this time he also designed and facilitated workshops for Sally Ride Science Festivals. These workshops provided middle school girls with unique opportunities to learn about how beneficial microbes influence our everyday lives. In 2004, Dr. Batten accepted a position at G.C. Hawley Middle School in Granville County, where he is currently teaching middle school science.

Robert Caine received his degree in education from The Port Elizabeth College of Education. He furthered his degree with a year in Cape Town College of Education, South Africa, where he majored in math, science, physical education and geography. Robert taught 6 years in South Africa and in North Carolina for 7 years. He recently completed his National Boards in mathematics. Currently teaching at G.C. Hawley Middle School in Granville County, Robert also serves as the Math Chairperson, a mentor and trainer during staff development.

Overview

Using the Exploring Genetics Across the Middle Grades Science and Math Curriculum Manual

This manual was designed to leverage the interdisciplinary and inquiry based learning potential of genetics within science and math. In studying genetics within the context of both science and math, students will be able to increase their understanding and the application of genetic science within their world. While we focus on the "what" of learning, this manual also focuses on the "why" of genetic science. Students will be required to conduct experiments within the science activities and analyze the data within the math activities. Their learning will parallel the research being conducted at NC State which funded the development of this manual. Genetic scientists generate raw data through their research. They must work in collaboration with statisticians and computer scientists to process and analyze the data in order to draw conclusions. If students can grasp the overlap of the two disciplines, they will understand the current state of scientific research.

There are two distinct sections to the manual; science and math. To increase the effectiveness of the material, the two subjects would be implemented at the same time. However, realizing the diverse nature of public school schedules, teaching loads, and the many obstacles teachers face each day, the manual is designed with two options for implementation. The nine activity science portion is a stand alone set of activities. It can be implemented within the science curriculum and meet the objectives of many strands of the North Carolina Standard Course of Study. The math activities analyze data generated through the science activities, and are therefore dependent upon the activity taking place within the science curriculum. We encourage the interaction of the science and math departments as you undertake the activities within this kit and manual.

Alignment to the North Carolina Standard Course of Study

Both the science and the math activities are aligned to the North Carolina Standard Course of Study. The alignment is noted on the content specific chart included within this manual. Additionally, the Standard Course of Study objectives are listed within each activity. Science activities are aligned to the 7th grade Standard Course of Study. The math activity alignment encompasses 6th to 8th grade increasing the flexibility of the classroom application.

Using the Genetics Science in a Suitcase Kit from the Museum of Life and Science

This manual is designed to be used with supplies provided through the Museum of Life and Science titled Genetics Science in a Suitcase. All of the supplies listed in the Materials List are included in the kit. If you received a copy of this manual without renting the kit from the Museum, it is possible to conduct the activities with basic supplies found at local department stores. If you would like to rent the kit, please contact: Nancy Dragotta-Muhl, Phone: 919.220.5429 (x362), Email: nancy.dragotta-muhl@ncmls.org.

Career information and high school course sequencing

Included within the kit from the NC Museum of Life and Science is a Career Pathways book published by the North Carolina Biotechnology Center and the NC Department of Public Instruction. We encourage you to incorporate this career information, because it assists them with planning their course sequence for the high school curriculum. The Career Pathways book is available online at: http://www.ncpublicschools.org/cte/publications/career_pathways/biotechnology_career_publication.pdf. Parents may also be interested in this information as it relates to planning the high school course curriculum.

Textbook Resources

This kit is designed to be used as a stand-alone unit or in conjunction with the three main seventh grade science textbooks currently used in the Triangle school districts: Prentice Hall, McDougal Littell, and Holt.

McDougal Littell Science Integrated Course 2, Teacherâ€™s Edition
Grade 7 Science North Carolina Edition,
McDougall Littell, Evanston, IL
Copyright 2005
ISBN: 0-618-46999-0
unspecified number of pages

Prentice Hall Science Explorer North Carolina Grade 7, Teacherâ€™s Edition
Pearson Prentice Hall, Upper Saddle River, NJ
Copyright 2005
ISBN: 0-13-125791-9
817 pages

Holt Science & Technology, North Carolina Grade 7, Studentâ€™s Edition
Holt, Rinehart, and Winston, Orlando, FL
Copyright 2005
ISBN: 0-03-022263-1
696 pages

References and Resources

THE BIOLOGY BINDER, Jessica Lupold, Orange County High School, Virginia
http://www.biologybinder.com/

CELERA GENOMICS
http://www.celera.com

DECIPHERING THE GENETIC CODE, Office of NIH History
http://history.nih.gov/exhibits/nirenberg/HS1_mendel.htm

DNA EXTRACTIONS, Lana Hays, Access Excellence
www.accessexcellence.org/AE/AEC/CC/DNA_extractions.html

DNA FROM THE BEGINNING, Cold Spring Harbor Laboratory
www.dnaftb.org/dnaftb/

DOE JOINT GENOME INSTITUTE
http://www.jgi.doe.gov

FLINN SCIENTIFIC
http://www.flinnsci.com

GENETIC DISORDERS, Genetic Science Leanring Center, University of Utah
http://learn.genetics.utah.edu/units/disorders

GENETIC SCIENCE LEARNING CENTER, University of Utah
http://gslc.genetics.utah.edu

GENETICS EDUCATION CENTER, University of Kansas Medical Center
http://www.kumc.edu/gec/

HBB: GENE ASSOCIATED WITH SICKLE CELL ANEMIA, Gene Gateway, Human Genome Project
http://www.ornl.gov/sci/techresources/Human_Genome/posters/chromosome/hbb.shtml

HUMAN GENETICS ONLINE SURVEY, Vailsburg Middle School, NJ
http://www.nps.k12.nj.us/vailsburg/VMS%20Human%20Genetics/index2.htm

HUMAN GENOME PROJECT, U.S. Dept of Energy
http://genomics.energy.gov

MITOSIS IN ANIMAL CELLS, J Warner, University of North Carolina - Charlotte
http://www.bioweb.uncc.edu/1110Lab/notes/notes1/labpics/lab6pics.htm

MITOSIS IN ONION ROOT TIPS, Michael Davidson, Florida State University
http://micro.magnet.fsu.edu/micro/gallery/mitosis/mitosis.html

MITOSIS IN ONION ROOT TIPS, Paul Decelles, Johnson County Community College, KA
http://staff.jccc.net/pdecell/celldivision/oniontip.html

NATIONAL HUMAN GENOME RESEARCH INSTITUTE
http://www.genome.gov

NATIONAL SCIENCE TEACHERS ASSOCIATION SCILINKS
http://www.SciLinks.org

NIH CURRICULUM SUPPLEMENT SERIES
http://science.education.nih.gov/supplements/

NORTH CAROLINA HEALTH INFO
http://www.nchealthinfo.org

NORTH CAROLINA STANDARD COURSE OF STUDY, DEPARTMENT OF PUBLIC INSTRUCTION
http://www.ncpublicschools.org/curriculum/

NORTH CAROLINA STATE UNIVERSITY GENOMICS PROGRAM
http://www.genomics.ncsu.edu

PLANT MITOSIS, Dale Benham, Nebraska Wesleyan University
http://biology.nebrwesleyan.edu/benham/mitosis/allium.html

PUNNETT SQUARE CALCULATOR, Chang Bioscience
http://www.changbioscience.com/genetics/punnett.html

PUNNETT SQUARE EXAMPLES, Anthro Limited
http://www.athro.com/evo/gen/punexam.html

REPRODUCTION AND HEREDITY, Utah State Office of Education
http://utahscience.oremjr.alpine.k12.ut.us/sciber99/7th/genetics/sciber/intro.htm

SCIENCE JOURNAL, AAAS
http://sciencemag.org/feature/plus/sfg/human/timeline.dtl

SCIENCE OF HEREDITY, Charles Mallery, University of Miami
http://fig.cox.miami.edu/~cmallery/150/mendel/heredity.htm

SCIENTIFIC AMERICAN FRONTIERS
www.pbs.org/saf/

WEBMD
http://www.webmd.com

THE GENE MACHINE, Bill Kendrick
http://www.sonic.net/~nbs/projects/bio115l/

THE STORY OF MENDEL, Bill Kendrick
http://www.sonic.net/~nbs/projects/anthro201

WIKIPEDIA
http://en.wikipedia.org

WHITEFISH MITOSIS, Barbara Krumhardt, Des Moines Area Community College, IA
http://www.dmacc.edu/Instructors/mitosis.htm

WHITEFISH BLASTULA MITOSIS, Steven Scadding, University of Guelph, Canada
http://nte-serveur.univ-lyon1.fr/nte/EMBRYON/www.uoguelph.ca/zoology/devobio/210labs/mitosis1.html

YOUR GENES YOUR HEALTH, Cold Spring Harbor Laboratory
http://www.ygyh.org

Science Vocabulary

ACQUIRED TRAIT characteristic that is obtained during the lifetime of an individual as a result of their experiences.

ALLELE one of the variant forms of a gene at a particular locus, or location, on a chromosome. Different alleles produce variation in inherited characteristics such as hair color or blood type. In an individual, one form of the allele (the dominant one) may be expressed more than another form (the recessive one).

BIOTECHNOLOGY use of techniques that involve manipulating the biology of organisms such as bacteria, fungi, virus, and plants. One type of biotechnology involves using recombinant DNA to create modified organisms with desirable traits. Roundup Ready corn is an example of this type of genetically modified organism (GMO) which contains a recombinant gene that protects corn from the herbicide Roundup.

BREEDING application of genetic principles to improve the traits of organism. Breeding can involve both traditional and molecular techniques to create offspring with desirable traits.

CANCER diseases in which abnormal cells divide and grow unchecked. Cancer can spread from its original site to other parts of the body and can also be fatal if not treated adequately.

CENTRAL DOGMA theory developed by Francis Crick that describes the sequential transfer of genetic information from DNA (genes) ' RNA ' protein in eukaryotic organisms. Some organisms such as retroviruses are able to convert RNA back into DNA.

CHROMOSOME a structure that is made up of thread-like strands of DNA and is used to organize the genetic information in a cell. Different species have different numbers of chromosomes. For example, humans have 23 homologous pairs of chromosomes (46 total), while the fruit fly (Drosophila) only has
4 pair (8 total).

CYSTIC FIBROSIS (CF) an inherited (genetic) disease that is caused by a defect in the CFTR gene which affects mucus production. The disease affects several organ systems including the respiratory, digestive, integumentary, and reproductive systems.

CYTOPLASM a gel-like matrix between the nucleus and the cell wall which contains a cell's organelles, and is where RNA is translated into proteins.

DNA (DEOXYRIOBNUCLEIC ACID) chemical inside the nucleus of a cell that carries the genetic
instructions for making living organisms

DOMINANT ALLELE gene that almost always results in a specific physical characteristic, for example, a disease, even though the patient's genome possesses only one copy.

DOWN SYNDROME (Trisomy 21) an inherited (genetic) disease caused by a person having and extra copy of chromosome 21.

FERTILIZATION act of rendering gametes fertile or capable of further development

GAMETE a reproductive cell that has a haploid number (single set) of chromosomes (example - human sperm or egg).

GENE functional and physical unit of heredity passed from parent to offspring, most of which contain information for the production of proteins.

GENERATION class composed of all individuals removed by the same number of successive ancestors from a common predecessor.

GENE THERAPY evolving technique used to treat inheritied diseases. The medical procedure involves either replacing, manipulating, or supplementing nonfunctional genes with healthy genes.

GENETIC CODE the sequence of DNA or RNA bases that determine the sequence of amino acids in proteins of an organism.

GENETIC CROSS the intentional breeding of two individuals to obtain offspring with specific traits.

GENETIC DISEASE (INHERITED DISORDER) a pathological condition caused by aberrations in genes or chromosomes.

GENETIC ENGINEERING using molecular biological techniques to alter the genome of an organism.

GENETICS the study of genes and their heredity.

GENETICALLY MODIFIED ORGANISM (GMO) an organism whose genetic material (genome) has been altered using recombinant DNA technology (example – Roundup Ready corn).

GENOMICS study of the structure and function of the genome, including information about sequence, mapping, and expression, and how genes and their products work in organisms.

GENOTYPE genetic identity of an individual that does not show as outward characteristics.

HEMOGLOBIN the iron-containing protein in the blood that transports oxygen and carbon dioxide throughout the body.

HEREDITY genetic transmission of a particular quality or trait from parent to offspring.

HETEROZYGOUS (HYBRID) possessing two different forms of a particular gene, one inherited from each parent.

HOMOZYGOUS (PUREBRED) POSSESSING TWO IDENTICAL FORMS OF A PARTICULAR GENE, ONE INHERITED FROM EACH PARENT.

HUMAN GENOME PROJECT the coordinated scientific effort to determine the DNA sequence of humans. Primarily funded by the United State Department of Energy, with contributions from several other countries including the United Kingdom, France, Germany, and Japan. The findings from the human genome project, and similar efforts by the biotechnology company Celera, where published in 2001.

HYBRID (heterozygous) animal or plant produced from parents different in kind.

INHERITED TRAIT characteristic that is transmitted through genes from parents to offspring.

MEIOSIS method of cell division that occurs during maturation of the sex cells, and results in each daughter nucleus receiving half the number of chromosomes characteristic of the somatic cells of the species.

MITOSIS method of indirect cell division that results in two daughter nuclei receiving chromosome complements that are identical in both number and composition to that of the parent cell.

MENDEL, GREGORY Austrian biologist/monk who laid the foundations for the science of genetics by executing controlled experiments with breeding peas. He established that the heritable units we now call genes were not blends of parental traits but separate physical entities passed individually in specific proportions from one generation to the next.

MUTATION permanent structural alteration in DNA. In most cases, DNA changes either have no effect or cause harm, but occasionally a mutation can improve an organism's chance of surviving and passing the beneficial change on to its descendants.

NUCLEOTIDE (NUCLEIC ACID BASE) molecules of that consist of a nitrogen base attached to a sugar-phosphate backbone that link together into chains that make up DNA or RNA.

NUCLEUS large, membrane-bound, usually spherical structure within a living cell, containing the cell's genetic material and controlling its metabolism, growth, and reproduction.

PHENOTYPE observable traits or characteristics of an organism, for example hair color, weight, or the presence or absence of a disease. Phenotypic traits are not necessarily genetic.

PEDIGREE simplified diagram of a family's genealogy that shows family members' relationships to each other and how a particular trait or disease has been inherited.

POLLINATION process where plant pollen is transferred from the male reproductive structures to the female reproductive structures to form seeds.

PROTEIN large complex molecule made up of one or more chains of amino acids. Proteins perform a wide variety of activities in the cell.

PUNNETT SQUARE a chart-based process designed by Reginald Punnett and used by biologists to determine the probability of an offspring having a particular genotype. It is made by comparing all the possible combinations of alleles from the mother with those from the father.

PUREBRED (HOMOZYGOUS) a group of plants or animals that possess certain inherited characteristics, such as color or markings, which are deliberately chosen for using selective breeding techniques. Possessing two identical forms of a particular gene, one inherited from each parent.

RECESSIVE ALLELE the form of a gene that is not expressed (observed), unless that individual inherits two such genes.

REPLICATION the process by which a cell's DNA is copied prior to mitosis and cell division.

RNA (RIBONUCLEIC ACID) chemical similar to a single strand of DNA. RNA delivers DNA's genetic message to the cytoplasm of a cell where proteins are made.

SEXUAL REPRODUCTION process by which organisms produce offspring through the fertilization of gametes from a male and female parent.

SICKLE CELL ANEMIA blood condition caused by a single base pair change in one of the genes that codes for hemoglobin, the blood protein that carries oxygen. Red blood cells take on a sickle shape, rather than their characteristic donut shape, impeding how oxygen is carried.

TRAIT a characteristic that is determined by the genes of an organism.

TRANSCRIPTION the process by which genetic information is copied from DNA (genes) into messenger RNA (mRNA), which then goes to the cytoplasm for protein synthesis.

TRANSLATION the process by which genetic information is copied from mRNA into proteins. Translation occurs in the cytoplasm.

WHEAT GERM embryo of the wheat kernel that is separated before milling for use as a cereal or food supplement. DNA can be easily isolated from wheat germ.

Math Vocabulary

BAR GRAPH A graph which uses solid bars to represent numbers.

CIRCLE GRAPH A circular shaped graph which compares parts of an item to the tool which is 100%.

CO-ORDINATE POINTS the point identified by (x,y).

CO-LINEAR in a straight line, points/co-ordinates which line up.

CROSS MULTIPLY Also known as the cross product, proportions are equal when cross multiplied. Numbers diagonally across the equal signs are multiplied and equal to each other. [It may be useful to practice a few of these with variables]

DEPENDENT AND INDEPENDENT VARIABLES x is the independent as y relies on it for the input.

EQUATIONS A mathematical sentence containing an equal sign and other variables. Equations are solved by isolating the variable.

FREQUENCY The total of the tally makes for that interval.

FREQUENCY BAR GRAPH bar graph with the frequaency written as a percent of the total.

FREQUENCY TABLE An organized display of data showing you the given number of items within given intervals.

FUNCTION TABLE a table displaying the relationship between quantities.

HISTOGRAM A type of bar graph that has been organized in intervals. The bars are connected.

LINEAR RELATIONSHIP When a sraight line is drawn through connecting co-ordinates.

METRIC SYSTEM the units to measure in science (works in powers of 10).

PART OF A WHOLE The numerator is the part and the denominator is the whole.

PERCENT The number is represented per hundred. The percent is the part, the hundred is the whole.

PLOT POINTS draw points for the co-ordinates.

PROBABILITY The likelihood or chance of an even occurring. It may be represented as a fraction or a %.

PROPORTIONS fractions that are equal form proportions.

QUADRANTS labeled I to IV anticlockwise from the top right quadrant.

RATE OF CHANGE The same as slope. The change in y(rise) divided by the change in x(run).

RATIO A ratio is when two numbers are compared and written as a fraction. These numbers may be written in 3 ways, e.g. 6 out of 7; 7:7 and as 6/7.

SLOPE Rate, Rise over run: the change in the vertical (co-ordinate) variables divided by the change in horizontal variables (co-ordinate). This is written as a fraction. The numerator is the rise and the denominator the run.

TALLY Counters used to record individual items within an interval.

Science Table of Contents

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Overview

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Career information and high school course sequencing

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Science Activity Alignment to the North Carolina Standard Course of Study
Middle Grades Science Curriculum

Objective	Activity 1	Activity 2	Activity 3	Activity 4	Activity 5	Activity 6	Activity 7	Activity 8	Activity 9
1.01									X
1.02						X			
1.03						X			
1.04									
1.05	X	X	X	X	X	X			X
1.06		X		X					
1.07			X		X		X		
1.08							X		
1.09								X	
1.10								X	X
4.07									X
4.08									X
5.01	X	X	X	X	X	X	X	X	X
5.02	X			X	X		X	X	
5.03	X	X	X	X	X				
5.04	X		X		X				
5.05	X							X	X
5.06	X	X							X

North Carolina Standard Course of Study
Middle Grades Science Curriculum

COMPETENCY GOAL 1: The learner will design and conduct investigations to demonstrate an understanding of scientific inquiry.

Objectives

1.01 Identify and create questions and hypotheses that can be answered through scientific investigations.

1.02 Develop appropriate experimental procedures for:
- Given questions.
- Student generated questions.

1.03 Apply safety procedures in the laboratory and in field studies.
- Recognize potential hazards.
- Safely manipulate materials and equipment.
- Conduct appropriate procedures.

1.04 Analyze variables in scientific investigations:
- Identify dependent and independent.
- Use of a Control.
- Manipulate.
- Describe relationships between.
- Define operationally.

1.05 Analyze evidence to:
- Explain observations.
- Make inferences and predictions.
- Develop the relationship between evidence and explanation.

1.06 Use mathematics to gather, organize, and present quantitative data resulting from scientific investigations:
- Measurement.
- Analysis of data.
- Graphing.
- Prediction models.

1.07 Prepare models and/or computer simulations to:
- Test hypotheses.
- Evaluate how data fit.

1.08 Use oral and written language to:
- Communicate findings.
- Defend conclusions of scientific investigations

1.09 Use technologies and information systems to:
- Research.
- Gather and analyze data.
- Visualize data.
- Disseminate findings to others.

1.10 Analyze and evaluate information from a scientifically literate viewpoint by reading, hearing, and/or viewing:
- Scientific text.
- Articles.
- Events in the popular press.

COMPETENCY GOAL 5: The learner will conduct investigations and utilize appropriate technologies and information systems to build an understanding of heredity and genetics.

Objectives

5.01 Explain the significance of genes to inherited characteristics:
- Genes are the units of information.
- Parents transmit genes to their offspring.
- Some medical conditions and diseases are genetic.

5.02 Explain the significance of reproduction:
- Sorting and recombination of parents' genetic material.
- Potential variation among offspring.

5.03 Identify examples and patterns of human genetic traits:
- Dominant and recessive.
- Incomplete dominance.

5.04 Analyze the role of probability in the study of heredity:
- Role of each parent in transfer of genetic traits.
- Analysis of pedigrees.

5.05 Summarize the genetic transmittance of disease.

5.06 Evaluate evidence that human characteristics are a product of:
- Inheritance.
- Environmental factors, and
- Lifestyle choices.

Heredity & Genetics Scavenger Hunt

OVERVIEW

Problem: What is Heredity and Genetics?

Many students are apprehensive about the Heredity & Genetics Unit because they believe that it contains concepts and terminology that are difficult to comprehend. The scavenger hunt activity is designed to help students realize that they are already familiar with many of the concepts, thereby making them more comfortable with the material in the unit. The activity will introduce basic vocabulary used throughout the Exploring Genetics Kit. Finally, as students participate in the activity, teachers will be able to pre-assess how familiar and comfortable students are with the material.

ACKNOWLEDGMENTS

This activity was created for this kit with help from the authors' students.

NC STANDARD COURSE OF STUDY

Science Objectives:

- 1.05 Analyze evidence to explain observations
- 5.01 Explain the significance of genes to inherited characteristics
- 5.02 Explain the significance of reproduction
- 5.03 Identify examples and patterns of human genetic traits
- 5.04 Analyze the role of probability in the study of heredity
- 5.05 Summarize the genetic transmittance of disease
- 5.06 Evaluate evidence on the determination of human characteristics

Math Objectives:

- 1.01 Develop and use ratios, proportions, and percents to solve problems
- 1.02 Develop fluency in addition, subtraction, multiplication, and division of rational numbers
- 4.01 Collect, organize, analyze, and display data to solve problems
- 4.02 Calculate, use, and interpret the mean, median, mode, range, and frequency

SCIENCE TEXTBOOK RESOURCES

Prentice Hall (pp. 508-589)
McDougall Littell (pp. C1-C159)
Holt (pp. 328-453)

LEARNING OUTCOMES

By the end of this activity students will be able to:

1. name several basic genetics terms.
2. list the key genetics concepts.
3. identify the classroom and/or textbook location of resources related to heredity and genetics.

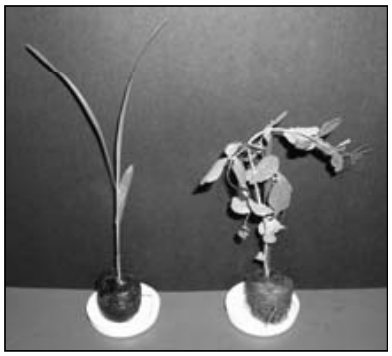
BACKGROUND

Genetics is the science of heredity, or how genes (and traits) are passed from one generation to the next. For centuries, even before we understood the molecular basis for heredity, humans have exploited genetic principles in an effort to breed crops and livestock with specific desirable traits. During the last fifty years, scientists have begun to understand how genetics works on the molecular level. Recently, scientists and physicians have been using molecular biology techniques to not only study genes, but to manipulate them as well. In 2001, the first draft of DNA sequences from the human genome was published by the Human Genome Project (http://genomics.energy.gov) and Celera Genomics (http://www.celera.com). These and subsequent publications provide a wealth of information from which we can increase our basic understanding of human genetics and apply this to finding cures and treatments for many genetically-based diseases.

This scavenger hunt will introduce students to the Heredity & Genetics Unit by exposing them to the genetics vocabulary and concepts found in their textbook and in this exploring genetics kit. Optional resources that students could access during this activity are the Genetics Science Learning Center (http://learn.genetics.utah.edu) website and the relevant web links that are mentioned in science textbooks.

MATERIALS

- Scavenger hunt worksheet included in this manuel
- Laminated pictures of corn and plants (if real plants are unavailable)
- Pea and corn seeds
- Magnifying glass
- Genetics/genomics posters available from www.genome.gov
- Internet access (optional)
- Student Science Dictionary



PREPARATION

- Set up at least two stations on different sides of the classroom.
- Distribute posters and plant pictures (or plants) to each station.
- Put seeds in a cup and an accompanying magnifying glass

PROCEDURE

Warm Up

"What do you know about DNA, genetics, and heredity?" Using your favorite brainstorming technique (e.g., Circle Map, K-W-L chart, Post-It notes, etc) ask students to answer this question. Direct the students to share their answers with the class (this will help you gauge each student's knowledge base).

A good follow up question is "How have your heard about DNA, genetics, and heredity?" Examples often include the news, internet, TV shows like CSI, and movies such as GATACA and The Incredible Hulk.

SCAVENGER HUNT

Hand out the Scavenger Hunt worksheet. Ask students to work by themselves or in pairs as they complete the worksheet. The worksheet can be collected and re-distributed later as a study guide for a Genetics Unit Exam.

REFLECTION

Using their notebooks, ask students to make a list of questions that came to mind as they were doing the scavenger hunt. Examples might include *Why are we different than plants? How does DNA cause different traits? How similar am I to other students? How big is DNA? How is DNA used in forensics?*

ASSESSMENT

Ask students to repeat the *Warm Up* questions the following day to gauge which genetics topics they easily assimilated on their own and which topics you will need to reinforce.

TIPS

- Depending on your class, you may choose for students to work individually or in teams.
- Real plants work best for the plant comparisons. Choose plants that have distinct similarities (size, color) and differences (leaf size/shape, flowers, etc).

LEARNING EXTENSION

- Human Genome Project. Ask students to find out more about the race between the U.S. government and Celera Genomics to sequence the human genome. http://genomics.energy.gov and http://www.celera.com.
- *How is the human genome database being used today?*

RELATED CAREERS

- DNA forensics technician
- Bioscience communication
- Science writer
- Science historian
- Science Education

RESOURCES

- **http://www.genome.gov**
- **http://sciencemag.org/feature/plus/sfg/human/timeline.dtl**
- **http://learn.genetics.utah.edu/**
- **http://www.kumc.edu/gec/**

Name_____ Date_____

Heredity & Genetics Scavenger Hunt Worksheet

Use your science textbook and other resources around the room to help you complete the following. After each answer, indicate where you found the answer (e.g. textbook page C43, Genomics poster, etc).

1) What is DNA?

2) What are genes?

3) What are chromosomes?

4) Write a sentence explaining the relationship between the words DNA, genes, and chromosomes.

5) On the back, draw a sketch showing where DNA is located in a cell.

6) Name three examples of genetic traits that you inherited from your parents.

7) Name two traits that you acquire during your life.

8) How are traits passed from parent to their offspring?

9) How many chromosomes do humans have?

10) Why is Gregor Mendel considered to be the “Father of Genetics”?

11) What is the difference between a dominant trait and a recessive trait?

12) What is an example of a dominant human trait?

13) What is an example of a recessive human trait?

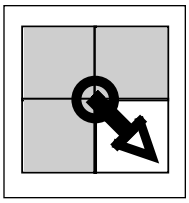
14) What is the ratio of people in the room who are female?

15) Rewrite 1:4 as a percent.

16) What percent of the room is male?

17) Is gender an inherited or acquired trait?

18) Using the Student Science Dictionary, what does DNA and RNA stand for?



19) What is the probability/likelihood of the spinner landing on a shaded region? Represent this mathematically in 3 ways.

20) What is the purpose of a Punnett square?

21) If a tall plant (TT genotype) is crossed with a dwarf plant (tt genotype), what is the probability that the offspring plants would be tall?

22) What type of plants would you have to cross to get a dwarf plant?

23) From the “Genomics” poster, what is genomics?

24) On the “Genomics” poster, how many chromosomes and genes does a human have?

25) On the “Cracking the Code of Life” poster, what did Watson and Crick discover in 1953?

26) On the “Cracking the Code of Life” poster, when was the human genome sequence published?

27) What are some differences between the corn and pea plants?

28) What causes these differences between corn and pea plants?

29) What are the large structures shown on “The Human Genome” poster?

30) From “The Human Genome” poster, what are some genes of interest found on chromo some 5?

31) The diameter of the nucleus of a cell is approximately 1/100,000 of a meter. The diameter of Earth is 12,756,000 meters. Write each of these in scientific notation.

32) How many times bigger is Earth than a nucleus?

33) Give an example of a genetic disease.

34) How do people get this genetic disease?

35) What is an example of a genetic disease that can be influenced both by human behavior and the environment?

A Personal Survey of Inherited Human Traits

OVERVIEW

Problem: Are humans alike or different?

Students will investigate some inherited and acquired human traits that are easy to observe in a classroom. Working in groups of four, students will take a personal inventory of their traits (i.e. dimples, widow's peak, pierced ears, etc) and compare their traits to the rest of the class. In addition to introducing basic genetic terminology, this activity introduces the concepts such as the relationship between molecular differences in the DNA and observed physical traits and the difference between inherited and acquired traits. Students will also have the opportunity to practice inquiry skills, make data tables, and analyze graphs.

ACKNOWLEDGMENTS

This activity was adapted from the following:

- "Take a Class Survey," *Science Explorer Grade 7*, Prentice Hall
- "Alike, But Not the Same," *Relating Genetics to Everyday Life*, The Science House, North Carolina State University
- "An Inventory of My Traits," University of Utah Genetic Science Learning Center **(http://gslc.genetics.utah.edu)**.

NC STANDARD COURSE OF STUDY

Science Objectives:

1.05 Analyze evidence to explain observations
1.06 Use mathematics to gather, organize, and present quantitative data
5.01 Explain the significance of genes to inherited characteristics.
5.03 Identify examples and patterns of human genetic traits.
5.06 Evaluate evidence on the determination of human characteristics

Math Objectives:

1.01 Develop and use ratios, proportions, and percent to solve problems.
1.03 Develop flexibility in solving problems by selecting strategies and using mental computation, estimation, calculators or computers, and paper and pencil.
4.01 Collect, organize, display and analyze date.
4.02 Calculate, use, and interpret the mean, median, mode, range, frequency distribution, and inter-quartile range for a set of data.
4.05 Solve problems involving two or more sets of data using appropriate statistical measures.

SCIENCE TEXTBOOK RESOURCES

Prentice Hall (pp. 536-537)
McDougall Littell (pp. C99-C107)
Holt (pp. 404-405)

LEARNING OUTCOMES

By the end of this activity, students will be able to:

1) name several physical genetic traits.
2) explain the difference between inherited and acquired traits.
3) make a data table and graph comparing their traits to those of the class.
4) analyze data and determine which traits are common and which are not.
5) give examples of physical human traits that are either dominant or recessive.

BACKGROUND

If you examine DNA from any two humans, you will find it to be 99.9% identical. However, if you visit any shopping mall in America you will clearly see many differences in appearance and behavior. These differences are the result of variation in only 0.1% of our DNA. On the molecular level, this 0.1% variation means that approximately 1 out of every 1000 DNA bases is different in each human.

This activity is designed to give students a chance to measure our similarities and differences using two different types of traits – inherited and acquired. This activity also will introduce students to several vocabulary terms that will be used throughout the Heredity & Genetics unit.

Inherited (genetic) traits are determined by genes that are acquired from parents (e.g., eye color and dimples). Acquired traits are characteristics that we are not born with, but that are acquired through life experiences (e.g., pierced ears, dyed hair, and scars). Inherited and acquired traits are both influenced by the environment and personal choice. For example, although a person's DNA might contain genes that code for brown hair, exposure to hair dyes or extensive sunlight might result in that person having blond hair. Other traits like intelligence and body shape can also be influenced by both genetics and life experience.

Inherited traits are further categorized into dominant and recessive traits. Any variation in a gene (genotype) can cause variation in appearance (phenotype). The different variations of specific genes are called alleles. For example, the gene coding for ear lobe shape has two alleles, one codes for unattached earlobes and the other for attached earlobes.

BACKGROUND (cont.)

- Alleles are further categorized as either recessive or dominant. Recessive alleles cause traits to be observed only if two copies of the recessive gene are present (one from each parent). For example, a person will have a widow's peak only if they inherit a recessive allele (e.g., widow's peak) from mom and a recessive allele (e.g., widow's peak) from dad. If they have a recessive allele (e.g., widow's peak) from one parent and a dominant allele (e.g., no widow's peak) from the other, they will not have a widow's peak.

- Dominant alleles cause traits to be observed when either one or two alleles of the dominant gene is present (i.e., if one dominant allele is present, it does not matter whether the other is dominant or recessive). For example, a person who inherits a dominant allele (e.g., free earlobes) from their dad, but a recessive allele (e.g., attached earlobes) from mom, will have free earlobes. Similarly, if a person inherits two dominant alleles (e.g., free earlobes), one from each parent, they will have free earlobes. In order for a person to have attached earlobes, they must receive an "attached earlobe" allele from both parents.

The "Traits Survey" will help students become familiar with different inherited and acquired traits and help them use analytical skills to determine which traits are most common in a population.

MATERIALS

- Laminated pictures of a plant, dog, fish, virus (for demonstration)
- Physical traits checklist included in this manual (each student)
- Trait examples handout (from the Internet, Getty, or Corbis)
- Mirror (each group; optional)
- Large laminated data table and graphs to collate class data
- Magazines for collage (assessment) activity

PREPARATION

- Set out materials for each group of students.
- Display the large data table and graph on the board or classroom wall.
- Set out magazines on the second day for collage (assessment) activity.

PROCEDURE

Warm Up

- Introduce the activity with the following scenario: *An alien from outer space teleports into the class. Upon seeing the class, the alien concludes that all humans look alike. It is your job as a class to assist the alien in differentiating humans from each other.*

Students might not agree that all humans look alike, but to an alien who is comparing humans to other life-forms such as plants, dogs, fish, or viruses humans clearly share more physical similarities to each other than they do with any other species.

To emphasize the relative similarity of humans to each other when compared with plants, dogs, fish etc, it will be helpful to show pictures of each of the individual organisms versus a picture of a human and then compare this with two pictures of humans.

- Ask students to create a list of questions that would help the alien learn more about what humans look like. Suggested questions include the following.
  - Do all humans look alike?
  - Are some traits more common than others?
  - Do boys have certain traits?
  - Are dominant traits more common?
  - How unique is each human?
  - Do humans look like their parents?
  - Which traits are inherited?
  - Which traits are acquired?

Data Collection

1) Ask students to form teams of four (or assign students to teams).
2) Distribute the "Traits Survey" to aid students in investigating how similar we really are. Review each trait before students start the survey.
3) Have (willing) students who have each specific trait stand up to point out the different traits. Have pictures of the traits available in case volunteers are not available.
4) Ask students to complete their personal survey and then compare their survey with their group. Each student should tally their group's results on their survey.
5) Ask a volunteer from each group to come to the board and record their group's results.
6) Once all of the results are tallied, ask students to copy the class results onto their surveys.

PROCEDURE (cont.)

7) Ask students to make a graph of the data. Traits in the A column ("yes" answers) should be indicated in one color and traits in the B column ("no" answers) should be indicated in another color. You can make an example using the large laminated graph or distribute pre-labeled graph paper to assist students.

Data Analysis

Once students are finished, ask them to look at their data tables and graphs and answer the following:

- Which traits (alleles) are most common in your group? In the class?
- Which traits (alleles) are least common in your group? In the class?
- What evidence (data) suggests that humans are similar?
- What evidence (data) suggests that humans are different?
- How do data tables and graphs differ in the way they present data?

Name_____ Date_____

How Unique Are You?

Complete this survey by putting a check in either the “yes” or “no” column for each trait.
Then compare your traits to the group’s traits by putting the number of people with that trait also in the “yes” or “no” boxes.

	Dominant Allele		Recessive Allele	
TRAIT	**YES**	**Class Frequency**	**NO**	**Class Frequency**
1) Are you male?				
2) Are you right-handed?				
3) Do you have mid-digital hair on your knuckles?				
4) Do you have detached ear lobes?				
5) Do you have naturally curly hair?				
6) Do you have a widow’s peak?				
7) Do you have freckles?				
8) Do you have dimples?				
9) Do you have a cleft chin?				
10) Can you roll your tongue?				
11) Do you have allergies?				
12) Is your index finger (pointer) shorter than your ring finger?				
13) Do you have a straight thumb (not a hitch-hiker’s thumb)?				
14) When you clasp your hands, do you cross your left thumb over your right?				
15) Can you see the colors red & green?				
16) Are you intelligent?				
17) Do you have dyed hair?				
18) Do you have pierced ears?				

REFLECTION

Uniqueness Activity. Ask students to predict how many traits on the survey it would take to identify one student as being unique. Then have all students stand. Ask a volunteer to read out their survey results, one trait at a time. Students who do not share that trait should sit down. Continue until the volunteer is the only one standing. Do this with a few volunteers then compare the students' predictions with the actual results.

Using their notebooks, ask students to write a paragraph summarizing what they did and what they found out. Were students able to answer any of the questions that they posed during step 2 (alien's questions)? Also, students should write whether they were surprised by any of the results and why they think they might have turned out that way. For example, some recessive traits such as *No cleft chin* are more common than the corresponding dominant trait.

ASSESSMENT

Students work individually or with partners to create a collage showing examples of inherited and acquired traits. Students should cut out and paste examples onto construction or other paper. To demonstrate their knowledge, students should label each trait as Inherited vs. Acquired and Dominant vs. Recessive. Students can present their posters to the class and explain their reasoning.

TIPS

- Make sure students identify the traits correctly. It might be helpful to point out students that have certain traits.
- Use pre-labeled data tables and graphs for students who need help constructing them.
- This activity involves comparing traits between students. It purposely avoids comparisons between student and family members (except as a possible follow up activity) since some students might not have access to biological family members.

FOLLOW UP ACTIVITIES

- **Math Extension.** Ask students to use their group and class data to create a frequency data table (see Math Activity 2). Students will then be able to compare different populations (i.e. group vs. class vs. school)
- **School Survey.** Ask students to survey their homerooms, grade, or school and compare the different populations (one class vs. one grade vs. one school) to see if the smaller populations reflect the larger ones.
- **Family Survey.** Ask students to give the survey to their family to see how their traits relate to those of their parents. Students can also survey their extended family to see how traits are distributed through your family tree (e.g., traits that skip generations, traits found only in the females or males in their families, etc)
- **Genes and Traits.** Ask students to complete an online search to find out which genes control specific traits. The pre-labeled data table includes information on which genes are dominant/ recessive and the number of genes that control that particular trait.
- **Human Genome Project.** Ask students to address the question of how the Human Genome Project has helped scientists and doctors learn about and track inherited human diseases. Use the North Carolina State University Genomics resource page as a starting point for their research **(http://www.genomics.ncsu.edu/resource.html)**.

RELATED CAREERS

- Genetic Counselor
- Gene Therapist
- Medical Epidemiologist
- Genomics and Bioinformatics specialist

RESOURCES

- **http://www.genome.gov** for more on inherited human traits
- **http://learn.genetics.utah.edu/units/basics/tour/** for a similar activity
- **http://www.sonic.net/~nbs/projects/bio115l/** for online traits survey
- **http://en.wikipedia.org** for more information on individual traits (ex. eye color)
- **http://www.nps.k12.nj.us/vailsburg/ VMS%20Human%20Genetics/index2.htm** for examples and an online project in which schools from around the world can participate in creating a database of human genetic traits.

Modeling Mendel: Predicting the Outcome of Genetic Crosses

OVERVIEW

Problem: Can you predict the outcome of genetic crosses?

Students will predict the traits (phenotype) of offspring from parents whose genetic composition (genotype) is known. Students will also demonstrate the difference between dominant and recessive alleles. This activity visually introduces the terms used in Punnett Squares, which are the subject of Activity 4.

ACKNOWLEDGMENTS

This activity was adapted from the following:

- "Beans and Genes" Heredity and Genetics - Middle School Support Document, http://www.ncpublicschools.org/docs/curriculum/science/middlegrades/7thsciencesupport.pdf
- "Make the Right Call!" Science Explorer Grade 7, Prentice Hall

NC STANDARD COURSE OF STUDY

Science Objectives:

1.05 Analyze evidence to explain observations.
1.07 Prepare models to test hypotheses.
5.01 Explain the significance of genes to inherited characteristics.
5.03 Identify examples and patterns of human genetic traits.
5.04 Analyze the role of probability in the study of heredity.

TEXTBOOK RESOURCES

Prentice Hall (pp. 540-545)
McDougall Littell (pp. C104-C107; C110-C115)
Holt (pp. 404-414)

LEARNING OUTCOMES

By the end of this activity, students will be able to:

1. Model the combination of alleles from each parent
2. Predict the offspring of a genetic cross
3. Predict offspring phenotype from parents' genotype
4. Demonstrate dominant and recessive alleles
5. Compare actual data with predicted results

BACKGROUND

Gregor Mendel (http://history.nih.gov/exhibits/nirenberg/HS1_mendel.htm) is considered to be the "Father of Genetics". Mendel was an Austrian monk who described the pattern of inheritance of traits (heredity) in pea plants. He determined that traits are controlled by factors (now called alleles) and that some traits can be masked (recessive). These alleles can either be identical (homozygous or purebred) or mixed (heterozygous or hybrid). By carefully recording the observable traits (phenotypes), Mendel was able to determine the genetic composition (genotype) of the plants in each generation. Using these inheritance patterns, he was further able to predict the outcome of genetic crosses.

While the terms homozygous and heterozygous are not part of the NC Standard Course of Study, and are not found in some science textbooks, they are commonly used in higher level genetics textbooks and classes and therefore are introduced in this activity. Concepts such as heterozygosity, homozygosity, dominance, and recessiveness are difficult concepts for students. This activity will give students a visual manipulative to model Mendel's experiments on pea pod color. This activity also is a great way to introduce Punnett Squares and their utility in predicting genetic outcomes.

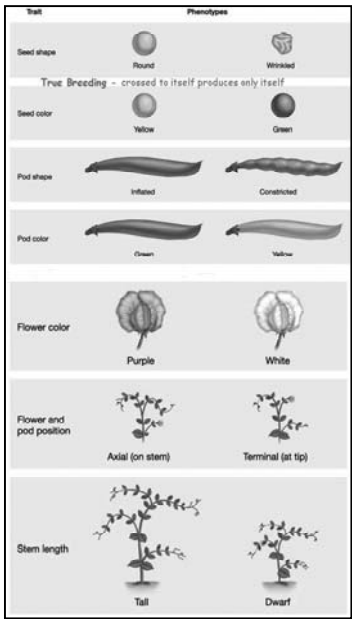
MATERIALS

(students working in groups of 4)
- 2 small paper bags (per group)
- 1 marking pen (per group)
- 4 green slides (per group)
- 4 yellow slides (per group)
- overhead showing Mendel's pea experiment results

PREPARATION

Copy handouts (optional) and distribute the materials to each group

PROCEDURE



Warm Up

Give each pair of students the "Mendel's Results" handout from http://fig.cox.miami.edu/~cmallery/150/mendel/heredity.htm

Ask students to read through the section in their science textbooks on Gregor Mendel. Using their textbooks and the Mendel Handout, students should work individually or in partners to answer the following warm up questions (also on overhead)

- Who was Gregor Mendel?
- What type of plants did Mendel study?
- What were the seven characteristics (phenotypes) that Mendel studied?
- Which traits were dominant?
- Which traits were recessive?
- Why do some traits disappear in some generations?
- What did Mendel conclude about how traits are inherited in pea plants?

Modeling Mendel

- ***Crossing Two Heterozygous Parents for Pea Pod Color***

1.) Students place one green slide (G) and one yellow slide (g) in Bag 1, and one green slide (G) and one yellow slide (g) in Bag 2.

2.) In their data table, students should predict the genotype and pheno type of the offspring.

3.) After making predictions, students remove one slide from Bag (representing the female parent) and one slide from Bag 1 (representing the male parent). These represent the alleles that the offspring inherit from each parent.

PROCEDURE (cont.)

By putting the two slides together, students can also observe the phenotype of the "offspring." In a cross with a heterozygous parent with one dominant and one recessive allele (Gg) and a homozygous parent with two dominant alleles (GG) any of the following geno- and phenotypes could occur:

- "gg" genotype: yellow phenotype
- "Gg" genotype: green phenotype
- "GG" genotype: green phenotype

The dominant allele is always written in upper case. The recessive allele is always written in lower case.

4.) After determining the genotype of each offspring, students should put the slides back into the bags and try again. They should repeat the process four times (ie, examine the genotypes of four offspring), recording their results after each trial.

- ***Crossing Two Homozygous Parents for Pea Pod Color***

1.) Students label two bags, one as "Bag 1 - Allele from Female Parent" and the other as "Bag 2 - Allele from Male Parent."

2.) Students place two green slides (labeled "G") in Bag 1. These represents the dominant green pod color alleles from the female parent (genotype = GG).

3.) Students place two yellow slides (labeled "g") in Bag 2. These represent the recessive yellow pod color alleles from the male parent (genotype = gg).

4.) Using the data table or a sheet of paper, students predict what the offspring from a cross green pod female (genotype = GG) and yellow pod male (genotype = gg) will look like.

5.) For each trial cross, students should remove one slide from Bag 1 (female parent) and one slide from Bag 2 (male parent). These represent the alleles that the offspring inherit from each parent. Record the result in the data table.

By putting the two slides together, students can also observe the phenotype of the "offspring." In a cross with two homozygous parents, one with two dominant alleles (GG) and one with two recessive alleles (gg) only a heterozygous, Gg genotype can occur, resulting in a green phenotype.

PROCEDURE (cont.)

6.) After determining the genotype of each offspring, students should put the slides back into the bags and try again. They should repeat the process four times (ie, examine the genotypes of four offspring), recording their results after each trial.

- ***Crossing Homozygous and Heterozygous Parents for Pea Pod Color***

  1.) Students place two green slides (GG) in Bag 1 (female parent) and a green (G) and yellow (g) slide in Bag 2 (male parent).

  2.) In their data table, students should predict the genotype and phenotype of the offspring.

  3.) After making predictions, students remove one slide from Bag 1 (female parent) and one slide from Bag 2 (male parent). These represent the alleles that the offspring inherit from each parent.

  By putting the two slides together, students can also observe the phenotype of the "offspring." In a cross with a heterozygous parent with one dominant and one recessive allele (Gg) and a homozygous parent with two dominant alleles (GG) any of the following geno- and pheno types could occur:
  – "Gg" genotype: green phenotype
  – "GG" genotype: green phenotype

  4.) After determining the genotype of each offspring, students should put the slides back into the bags and try again. They should repeat the process four times (ie, examine the genotypes of four offspring), recording their results after each trial.

REFLECTION

Using their notebooks, ask students to think back on their trial crosses and answer the following:

- What does the bag represent? (parents)
- What do the slides in each cross represent? (alleles/traits)
- In humans, how does each parent contribute their allele or trait to the offspring? (female→egg and male→sperm)
- What does "GG" in the offspring represent? (dominant genotype)
- What does "yellow" in the offspring represent? (recessive phenotype)

REFLECTION (cont.)

- What is the difference between homozygous and heterozygous parents? (two of the same alleles vs. two different alleles)
- How were homozygous and heterozygous genotypes represented in our genetic crosses? (two green, "G" slides, two yellow "g" slides or one of each)
- Use your textbook as a resource and try to create a Punnett Square for each of your genetic crosses.

ASSESSMENT

Ask students to design their own model to conduct genetic trials using common objects. They should answer the following questions.

- How would you represent the parent and offspring alleles?
- How would you represent homozygous vs. heterozygous parents and dominant vs. recessive traits?

TIPS

This activity was designed to visually introduce students to several difficult genetic terms. If students seem confused by so many terms, modify the activity so as to introduce only dominant/recessive or homozygous/heterozygous. The rest of the terms can be introduced in Activity 4 on Punnett Squares.

FOLLOW UP ACTIVITIES

- Ask students to create a Punnett Square for each of their genetic crosses.
- Tell students to create their own color slides to model Mendel's pea experiments and see if you they get the same results as he did.
- Encourage students to try Activity 4 (Punnett Squares) on their own.
- Ask students to find answers to the following questions:
  - Why some traits are dominant and other recessive? What does this mean at the DNA level?
  - What happens if traits are codominant or partially (incompletely) dominant?

RESOURCES

- **http://fig.cox.miami.edu/~cmallery/150/mendel/heredity.htm** (Dr. Charles Mallery's lecture notes on Mendelian Genetics. Includes several helpful images) on crossing plants as well as the Mendel's Results graphic used in this activity.
- **http://wikipedia.org/wiki/Dominant_gene** (for information on different types of recessive and dominant traits including codominance and incomplete dominance.)
- **http://www.sonic.net/~nbs/projects/anthro201** (for more on Gregory Mendel and an interactive activity in which students can conduct their own pea genetic experiments)

Punnett Squares

OVERVIEW

Problem: Can you predict patterns of heredity?

In this activity, you will present a genetic cross and students will use a laminated Punnett Square to predict the outcome of the cross. This activity can be used as a "step-by-step" guide to teach Punnett Squares, or can be done more like a bingo game.

ACKNOWLEDGMENTS

This activity was created by the authors.

NC STANDARD COURSE OF STUDY

Science Objectives:

- 1.05 Analyze evidence to make inferences and predictions.
- 1.06 Use mathematics to gather, organize, and present quantitative data.
- 5.01 Explain the significance of genes to inherited characteristics.
- 5.02 Explain the significance of reproduction.
- 5.03 Identify examples and patterns of human genetic traits.

TEXTBOOK RESOURCES

Prentice Hall (pp. 540-545; 548-549)
McDougall Littell (pp. C110-C115)
Holt (pp. 410-414)

LEARNING OUTCOMES

By the end of this activity, students will be able to:

1.) Use Punnett squares to predict the outcome of genetic crosses
2.) Determine the genotype and phenotype of both parents and offspring
3.) Calculate the ratio and probability of each genetic outcome
4.) Aetermine the pattern of heredity from both homozygous and heterozygous parents

BACKGROUND

Heredity is the study of the patterns of inheritance as traits are passed from generation to generation. A British geneticist named Reginald Punnett developed a technique, the Punnett square, for tracking patterns of inheritance in the early 1900's.

This technique has since been used by a wide array of professionals including breeders, geneticists, veterinarians, teachers, and doctors. Punnett squares have applications in designing breeding strategies that result in the generation of plants or animals with specific desirable traits and in determining the probability that offspring will acquire specific genetic diseases.

Punnett squares are particularly helpful in classroom settings. They provide a visual aid for teachers instructing students about the distribution of parental alleles to offspring and difficult genetic concepts such as dominant vs. recessive alleles, homozygous vs. heterozygous traits, and genotype vs. phenotype. Finally, Punnett squares help students to visualize how an offspring's characteristics are a product of different alleles, and how the contribution of different alleles from each parent's reproductive cell (gamete) combine to give the offspring a specific genotype and resultant phenotype. In plants the male gamete is called pollen and the female gamete is called ovule. For humans, the male gamete is the sperm and the female gamete is the egg. Each side of the Punnett square shows the possible allele that is inherited from either the male or female. Since the gametes only contain half the chromosomes, the genotype and phenotype for each trait requires a contribution from each parent (shown in each square).

MATERIALS

- Transparencies of the "Punnett Square Guide" and "Punnett Square Problems for Teacher-Led Practice".
- Punnett square homework problem handout.
- Transparency Punnett Squares Guide Questions/Answers

PREPARATION

Distribute the materials to each student and copy the homework handout.

PROCEDURE

Warm Up

Have students read in their textbooks about Punnett squares. Then use prepared paper bags for each possible genetic cross (i.e. both parents are heterozygous, heterozygous X homozygous, and both parents are homozygous). Pull slides from the male and female bags and see if students can identify the genotype and phenotype of each offspring. Review the terms alleles, traits, gametes, heterozygous, homozygous, dominant, recessive, phenotype, and genotype.

PROCEDURE (cont.)

Punnett Square Activity

- ***Demonstration***

1.) Present the information about a genetic cross (listed be low) using an overhead projector. Either you or a student volunteer can read through the basic information on the genetic cross. It may be helpful to underline or label the key information and terminology (eg, genotype, phenotype, homozygous, heterozygous, etc). Note: The "X" indicates that the two plants are involved in a genetic cross.

The tall trait is dominant (T) in pea plants, while short pea plants is a recessive trait (tt). Use a punnett square and probability table to determine the possible genotypes and phenotypes of offspring from a cross between a homozygous tall male pea plant and a homozygous short female pea plant. The cross is written below.

homozygous, tall, male pea plant (TT)
X
homozygous, short, female pea plant (tt)

2.) Students can follow along on their laminated Punnett square handouts as the presenter demonstrates how to do a Punnett square on an overhead.

First, write the genotype and phenotype of the parents:

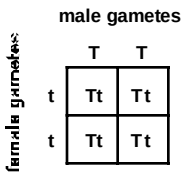
– Male genotype: TT (homozygous)
– Male phenotype: tall plants (dominant trait)

– Female genotype: tt (homozygous)
– Female penotype: short plants (recessive trait)

3.) Next write down the possible genetic contributions (gametes) that the parents can produce. Write these on the top and side of the Punnett square

– Male Gametes (pollen): T or T
– Female Gametes (egg): t or t

4.) Now complete the Punnett square by writing the alleles from the gametes in the appropriate boxes.



PROCEDURE (cont.)

5.) Next, fill in the "Probability Outcomes" table to find out the possible offspring from this genetic cross.

Genotype	Ratio	%	Phenotype	Ratio	%
Tt	4:4	100	Tall	4:4	100

6.) Make sure that everyone sees where all of information comes from and is able to answer the following questions.
- What do these results mean? (100% plants are "Tt" genotype and "Tall" phenotype)
- Why are all of the plants "Tall" even though they have the "Tt" genotype (The "Tall" allele is dominant and so it masks the effects of the "t" allele, resulting in "Tall being a dominant trait)

- ***Individual work***

1) After discussing the first cross, present information for a cross of two heterozygous, tall plants (Tt X Tt). Help the students to fill in the Punnett square and see if they can do the probability table themselves.

The Punnett square should be filled in as follows:

	T	t
T	TT	Tt
t	Tt	tt

The probability table should be filled in as follows:

Genotype	Ratio	%	Phenotype	Ratio	%
TT	1:4	25	Tall	1:4	25
Tt	2:4	50	Tall	2:4	50
tt	1:4	25	Short	1:4	25

2) Work through the Punnett square and probability table and discuss the results.

PROCEDURE (cont.)

3) Repeat the process with several different types of genetic crosses. In each genetic cross fill in less of the information on the class overhead, eventually challenging the students to do the whole process themselves.

REFLECTION

Using their notebooks, ask students to reflect on the following questions:

- What was easy about the activity and what part was difficult?
- Why are Punnett squares important tools for determining how genes are passed from one generation to the next?
- Who might benefit from knowing this information?
- What types of organisms can you think of whose reproductive process is not amenable to using Punnett squares? What makes the reproduction different than humans, other animals, and plants?

ASSESSMENT

Ask students to complete Punnett square practice problems with examples from plants, animals, and humans. Just type "Punnett square problems" in any search engine to generate a list of practice problems, use textbook examples, or use the practice problems included at the end of this activity.

Follow up with the Punnett Squares Bingo assessment activity.

TIPS

Punnett squares are easy for some students and difficult for others. It is helpful to walk through several examples to make sure students know what goes where (and why). Once students "get it" they can go around the room and help others.

FOLLOW UP ACTIVITIES

- Punnett squares "bingo" see included instructions and bingo cues on transparencies.
- Try Punnett squares with dihybrid crosses (two segregating traits)
- Do Activity 5, "Genetic Offspring Models"
- Research how Punnett squares are used in medicine or by breeders

RELATED CAREERS

- Genetic counselors
- Oncologists (cancer doctors)
- Animal and plant breeders
- Pharmacogeneticists

RESOURCES

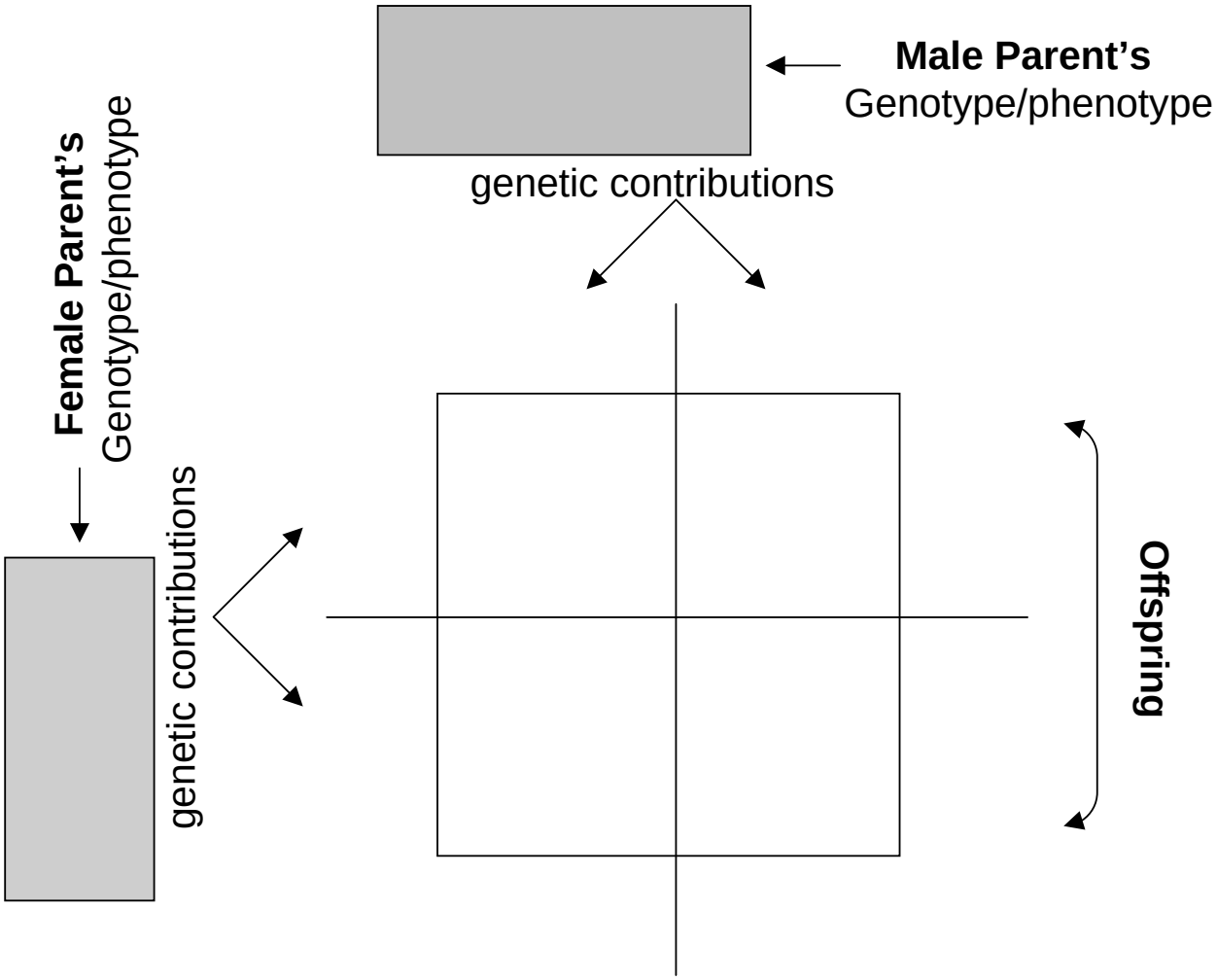
There are many online Punnett square practice problems. Just type “Punnett square problems” in any search engine. Here are a few other interesting resources.

- **http://en.wikipedia.org/wiki/Punnett_square** (online encyclopedia entry)
- **http://www.athro.com/evo/gen/punexam.html** (online quiz)
- **http://www.changbioscience.com/genetics/punnett.html** (Punnett square calculator)

Punnett Square Problems for Teacher-Led Practice

PROBLEM #1	Use a Punnett square to predict the genotypic and phenotypic outcome (offspring) of a cross between two heterozygous/hybrid tall (Tt) pea plants.
PROBLEM #2	In pea plants, yellow peas are dominant over green peas. Use a Punnett square to predict the phenotypic and genotypic outcome (offspring) of a cross between a plant heterozygous/hybrid for yellow (Yy) peas and a plant homozygous/purebred for green (yy) peas.
PROBLEM #3	In pea plants, yellow peas are dominant over green peas. Use a Punnett square to predict the phenotypic and genotypic outcome (offspring) of a cross between two plants heterozygous (hybrid) for yellow peas.
PROBLEM #4	In pea plants, round peas are dominant over wrinkled peas. Use a Punnett square to predict the phenotypic and genotypic outcome (offspring) of a cross between a plant homozygous (purebred) for round peas (RR) and a plant homozygous (purebred) for wrinkled peas (rr).
PROBLEM #5	In pea plants, round peas are dominant over wrinkled peas. Use a Punnett square to predict the phenotypic and genotypic outcome (offspring) of a cross between two plants heterozygous for round peas.

Punnett Square Guide



Probability of Outcomes from your Genetic Cross

Genotype	Ratio	Percentage	Phenotype	Ratio	Percentage

Offspring

Name_____ Date_____

Punnett Square Practice Problems

MAKE SURE THAT YOU SHOW YOUR WORK FOR FULL CREDIT!

Use Punnett squares and probability tables to answer the following questions on the back or another sheet of paper. Your textbook can assist with this assignment.

1) Imagine that you have two black dogs. One is black because it carries two dominant genes for black (BB). The other is black because it carries one dominant gene for black and one recessive gene for the recessive color liver (Bb). Use a Punnett square to predict the phenotypic and genotypic outcome (offspring) of a cross between these two dogs.

2) In humans, brown eyes (B) are dominant over blue (b). A brown-eyed man marries a blue-eyed woman and they have three children, two of whom are brown-eyed and one of whom is blue-eyed. Draw a Punnett square that illustrates this marriage.
   a) What is the man's gentoype?
   b) What are the genotypes of the children?

3) In seals, the gene for the length of the whiskers has two alleles. The dominant allele (W) codes long whiskers & the recessive allele (w) codes for short whiskers.
   a) What percentage of offspring would be expected to have short whiskers from the cross of two long-whiskered seals, one that is homozygous dominant and one that is heterozygous?
   b) If one parent seal is pure long-whiskered and the other is short-whiskered, what percent of offspring would have short whiskers?

4) Cystic fibrosis in a genetic disease that affects 30,000 Americans (0.01%). The dominant allele (N) is associated with normal health, and the recessive allele (n) is responsible for cystic fibrosis.
   a) Use a Punnett square to predict the chances that a married couple who are both carriers of the cystic fibrosis trait (Nn) will have a child that has cystic fibrosis.
   b) What is that chance that the children will be completely normal (NN)?
   c) What is the chance that the children will be carriers of the cystic fibrosis trait (Nn).

Students: create a 4 x 4 bingo board by taking a piece of notebook paper and folding it in half four times.

Next, copy 16 of the following words (in any order) into your Bingo squares

sperm	gamete	meiosis	egg
pollen	homozygous	50%	bb
blue eyes	Bb	language	gene
1:4	BB	DNA	allele
phenotype	75%	inherited	dominant
recessive	acquired	heterozygous	genotype

Use the table below to copy onto transparency paper and cut out the squares as bingo cues.

BINGO CLUES	BINGO ANSWERS
A unit of heredity that occupies a specific location on a chromosome.	gene
Various forms of the same gene.	allele
What are genes made of?	DNA
The appearance or observable characteristics of an organism.	phenotype
Name of the genes an organism possesses.	genotype
Alleles that are expressed in the phenotype, even if only one copy of the allele is present.	dominant
Alleles that are expressed in the phenotype only when two identical copies of that allele are present.	recessive
Bb, Tt, Rr, and Nn are examples of what kind of genotypes?	heterozygous
BB, tt, RR, nn are examples of what kind of genotypes?	homozygous
Natural eye and hair color, hitchhikers thumb, and freckles are examples of what kind of traits?	inherited
Dyed hair, ear piercings, and sun tans are examples of what kind of traits?	acquired
An example of a recessive phenotype.	blue eyes

BINGO CLUES	BINGO ANSWERS
An example of an acquired trait.	language
An example of a homozygous, dominant genotype.	BB
An example of a homozygous, recessive genotype.	bb
An example of a heterozygous genotype.	Bb
What is the ratio of children who might get cystic fibrosis if both parents are heterozygous (Nn)?	1:4
What is the percentage of offspring plants that will have round peas in a cross between a plant heterozygous for round peas (Rr) and a plant homozygous for wrinkled peas (rr)?	50%
What is percent chance that parents who are both carriers of the sickle cell trait will have healthy kids?	75%
Male gamete of plants.	pollen
Female gamete of humans.	egg
Special kind of cell division that produces haploid (1n) cells or gametes.	meiosis
Cells that contain half the usual number of chromosomes.	gamete
Male gamete of humans.	sperm

Genetic Offspring Models

OVERVIEW

Problem: Based on the genotype and phenotype of the parents, can you design a model of the offspring?

Students will choose chromosome pairs (one from each "bug" parent) with specific genotype and phenotype. Students will create models of bug offspring using the known traits of its parents.

ACKNOWLEDGMENTS

This activity was adapted from the following:
- "Offspring Models," Science Grade 7, McDougal Littell
- "Bug Builders, Inc." North Carolina Grade 7, Holt Science & Technology
- "Fun Bugs Activity," Utah State Office of Education http://utah science.oremjr.alpine.k12.ut.us/scriber99/7th/genetics/scriber/intro.htm

NC STANDARD COURSE OF STUDY

Science Objectives:

1.05 Analyze evidence to make inferences and predictions.
1.07 Prepare models and/or computer simulations to test hypotheses.
5.01 Explain the significance of genes to inherited characteristics.
5.02 Explain the significance of reproduction.
5.03 Identify examples and patterns of human genetic traits.
5.04 Analyze the role of probability in the study of heredity.

TEXTBOOK RESOURCES

Prentice Hall (pp. 530-535; 542-550)
McDougall Littell (pp. C100-C109; C117-118)
Holt (pp. 407-425)

LEARNING OUTCOMES

By the end of the activity, students will be able to:
1.) use parent genotype and phenotype to create an offspring
2.) use models to show inheritance of genetic traits
3.) determine the influence of dominant and recessive traits on offspring

BACKGROUND

DNA, deoxyribonucleic acid, is the key molecule in genetics and heredity. This molecule is found in every cell of every living organism and is composed of a linear array of discrete units called genes, each of which influences specific genetic traits (phenotype; eg, earlobe attachment). The composition of each gene (genotype) determines how it influences a specific trait. Different compositions of the same gene are called alleles (eg, an allele for free earlobes ["F"] and an allele for attached earlobes ["f"]).

In humans (as well as other animals and plants) DNA is packaged into thread-like bodies called chromosomes. These chromosomes are found in pairs. Humans have 23 pairs of chromosomes (a total of 46 chromosomes) in each cell except for the reproductive cells (called gametes), which have only one set of chromosomes (ie, 23 chromosomes). This means that every human cell (except the gametes) carries two copies of every gene (ie, two alleles). The alleles of a specific gene can be the same (meaning that a person is homozygous for that gene) or different (meaning that a person is heterozygous for that gene).

Sexual reproduction is at the heart of genetics and heredity. During sexual reproduction the female gamete (egg) is fertilized by the male gamete (sperm), which means that the egg and sperm fuse together. Gametes are formed during the processes of mitosis (chromosome replication) and meiosis (chromosome mixing and separation). As a result of these processes, gametes are the only cells in the human body that have only one set of chromosomes. Because each gamete has only one set of chromosomes (ie, 23 chromosomes) the fusion of the two gametes (sperm and egg) results in offspring who have a total of 46 chromosomes (23 from each parent). This means that each parent contributes one allele of each gene to its offspring. If the alleles contributed by each parent are the same (eg, each parent contributes an allele for attached earlobes; "ff"), the offspring is said to be homozygous ("ff") for the specific gene. If the alleles from each parent are different (eg, one parent contributes an allele for attached earlobes ["f"] and the other contributes and allele for free earlobes ["F"]), the offspring is heterozygous for the gene (eg, "Ff").

Being able to identify which alleles of specific genes an offspring inherits from each parent helps in predicting what an offspring might look like. Breeders develop pedigrees to follow the inheritance of specific traits from one generation to the next.

Genetic counselors or doctors that specialize in genetic diseases might analyze the genes of each parent to predict the potential that children might have a particular disease. Genetic counselors might also analyze the genes of a patient to determine which traits they possess. Knowing the genotype of a patient, can help predict which traits a patient might express (phenotype).

BACKGROUND (cont.)

This activity is designed to help students realize that genes are inherited by offspring on chromosomes that come from each parent. In addition, students should realize that chromosomes are paired (similar size, similar genes). Some of the genes contributed from each parent will be identical (homozygous) or different (heterozygous).

MATERIALS

(students in groups of four)

- Paper bags (representing male and female parents)
- Wooden popsicle sticks (chromosomes) labeled with alleles for each trait
- Styrofoam ball "body segments"
- Toothpick "antennae" and "body connectors" (two colors)
- Pipe cleaner "legs" (two colors)
- Paper clip "wings" (multiple colors)
- Push pin "eyes (two colors)
- Data table handouts (optional)

PREPARATION

Copy the data table (optional) and have the bug building materials in a central location. Can have an organized student run the material distribution table. Students must come to the materials table with a completed genotype/phenotype table to get the "bug" parts.

PROCEDURE

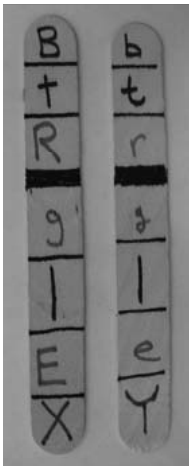
Warm Up

1.) Students should draw and label a chromosome using their text books as a resource.
- How are alleles represented on chromosomes?
- How are dominant and recessive traits represented on chromosomes?
- For each trait, how many alleles do you inherit from each parent?

2.) If you have six traits with the alleles (different forms) per trait, how many possible combinations are there? Students should write a hypothesis statement answering this question.

Fertilization: Combining Chromosomes from Bug Parents

1.) Place male and female "chromosomes" in their respective paper bags (representing male and female parents). Ask a student volunteer to go around the room, letting each group randomly choose one chromosome (wooden stick) from each bag.



2.) Ask each group to look at their paired chromosomes and record the female and male alleles for each trait on their data tables.

Building a Model of your Bug Offspring

1.) Using the parent trait information and the "Genotype/Phenotype Guide", students should determine the offspring's genotype and phenotype. This should be recorded on the data table.

2.) Students should use the data table to determine which supplies they will need to build the offspring and then collect the materials from the supply table.

Genotype/Phenotype Key

Trait	Dominant Genotype/Phenotype	Recessive Genotype/Phenotype
Body Segments	BB or Bb = 3 body segments	bb = 2 body segments
Pairs of Wings	TT or Tt= 2 pair of wings	tt = 1 pair of wings (paper clips)
Antennae Style	RR or Rr = round antennae	rr = flat antennae (toothpicks)
Color of Legs	GG or Gg = green legs	gg = pink legs (pipe cleaners)
Pairs of Legs	LL or Ll = 3 pairs of legs	ll = 2 pairs of legs (pipe cleaners)
Color of Eyes	EE or Ee = colored eyes	ee = clear eyes (push pins)
Gender	XY = male	XX = female

Parent and Offspring Family Traits (EXAMPLE)

Trait	Alleles from Male Parent	Alleles from Female Parent	Offspring Genotype	Offspring Phenotype
Body Segments	B	b	Bb	3 body segments
Pairs of Wings	t	t	tt	1 pair of wings
Antennae Style	R	R	RR	round antennae
Color of Legs	g	g	gg	pink legs
Pairs of Legs	l	L	Ll	3 pairs of legs
Color of Eyes	E	e	Ee	colored eyes
Gender	X	X	XX	female

PROCEDURE (cont.)

3.) Build a model of the offspring using the genotype and phenotypes from the data table.
- styrofoam “body segments”
- Toothpick “body connectors”
- Toothpick “antennae”
- Pipe cleaner “legs”
- Paper clip “wings”
- Push pin “eyes”

REFLECTION

Using their notebooks, ask students to reflect on whether or not their offspring might look like the parents. As a group, ask students to make a second data table with the possible genotypes/phenotypes of each parent. Individually, tell students to answer the following questions then compare their answers to the group.
- Which traits came from the male parent, which ones from the female parent?
- How many different genotypes are possible for each trait?
- How many different unique bugs could you make with these genotypes?
- How does this compare with your hypothesis statement from the warm-up?

ASSESSMENT

Students must draw a stick figure of a human offspring using the following information from the parents’ chromosomes.

A human has inherited the following genes from their parents. Use this information to sketch what this human might look like. The offspring inherited two XX chromosomes, Ee alleles (E = free ear-lobes), bb (B = brown hair, b = blond), TT (T = tall), Hh (H = hazel, h = blue), and ll (L = long arms).

TIPS

- Stale marshmallows also can be used to the body segments. Open the marshmellow bag a day before the activity and let the marshmallows dry out a little. The stale marshmallows are more stable and students less likely to eat them.
- Students should be careful working with the sharp toothpicks and pushpins.
- It may be helpful to make a class demonstration model of a bug. These models are great to save for parent conference nights. It is also a great activity to do on "science nights" or parent conference nights.

FOLLOW UP ACTIVITIES

- Create a second generation bug by "crossing" one group's bug with another. Give students a blank stick "chromosome" or slips of paper to record the alleles from each parent. Encourage students to create a Punnett square to determine the most likely offspring.
- Research how animal and plant breeders use pedigrees to create "designer offspring" with desirable traits.
- Research how scientists determine which genes and alleles on which chromosomes.

RELATED CAREERS

- Animal and plant breeders
- Plant pathologists
- Veterinarians
- Fertility specialists
- Genetic engineers
- Genetic counselors

RESOURCES

http://utahscience.oremjr.alphine.k12.ut.us/scriber00/7th/genetics/scriber/intro.htm for more genetic activities and teaching materials from the Utah State Office of Education.

Build-a-(Genetic)-Bug Handout

1) Draw a chromosome from both the male and female parents (genetic cross)
2) Align the chromosomes to determine the genotype (genes) of your bug offspring
3) Fill in the "Parent and Offspring Family Traits" table
4) Build your bug!

Genotype/Phenotype Key

Trait	Dominant Genotype/Phenotype	Recessive Genotype/Phenotype
Body Segments	BB or Bb = 3 body segments	bb = 2 body segments
Pairs of Wings	TT or Tt= 2 pair of wings	tt = 1 pair of wings (paper clips)
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Gender	XY = male	XX = female

Parent and Offspring Family Traits (EXAMPLE)

Trait	Alleles from Male Parent	Alleles from Female Parent	Offspring Genotype	Offspring Phenotype
Body Segments	B	b	Bb	3 body segments
Pairs of Wings	t	t	tt	1 pair of wings
Antennae Style	R	R	RR	round antennae
Color of Legs	g	g	gg	pink legs
Pairs of Legs	l	L	Ll	3 pairs of legs
Color of Eyes	E	e	Ee	colored eyes
Gender	X	X	XX	female

Parent and Offspring Family Traits

Trait	Alleles from Male Parent	Alleles from Female Parent	Offspring Genotype	Offspring Phenotype
Body Segments				
Pairs of Wings				
Antennae Style				
Color of Legs				
Pairs of Legs				
Color of Eyes				
Gender				

Extracting DNA from Wheat Germ

OVERVIEW

Problem: What does DNA look like? Can we extract it from cells?

In this lab activity, students will extract DNA from wheat germ, essentially in the same way scientists isolate DNA for research. This lab is easy and safe enough that it can be done using common household items. The students could even go home and show their family what DNA looks like. This protocol can be adapted to extract DNA from a variety of other sources. Students also will be able to see DNA dividing (mitosis) in plant and animal cells.

ACKNOWLEDGMENTS

This activity was adapted from the following:
- "Extract and Observe DNA" Science Grade 7, McDougal Littell
- "DNA Extraction from Wheat Germ" University of Utah Genetic Science Learning Center (http://gslc.genetics.utah.edu).

NC STANDARD COURSE OF STUDY

Science Objectives:

1.02 Develop appropriate experimental procedures.
1.03 Apply safety procedures in the laboratory and in field studies.
1.05 Analyze evidence to explain observations.
5.01 Explain the significance of genes to inherited characteristics.

TEXTBOOK RESOURCES

Prentice Hall (pp. 551-553)
McDougall Littell (pp. C74-C75;C80-85; C135-143)
Holt (pp. 390-393; 434-439)

LEARNING OUTCOMES

By the end of the activity, students will be able to:

1.) extract DNA from wheat germ cells
2.) explain the purpose of each step in extracting DNA
3.) compare properties of DNA to their observations of actual DNA
4.) identify the steps in mitosis

BACKGROUND

DNA is the fundamental unit of genetics and heredity. Surprisingly, it is not mentioned in the NC Standard Course of Study for 7th Grade Science. Because individual DNA bases are microscopic, it is often difficult for students to appreciate that all living cells contain DNA. This activity teaches students a simple procedure that can be used to extract DNA from a number of plant substances. The protocol uses simple household items, such that students could even show their families how to extract DNA and what it looks like.

In cells, DNA is present as a double-stranded nucleic acid (deoxyribonucleic acid) that is composed of four different nucleotide combinations – adenine (A), thymine (T), cytosine (C), and guanine (G). The specific combination and order of these four nucleotides in the DNA of organisms is the genetic code that contains genetic information for a cell's (and organisms) development and function.

In Eukaryotes, most DNA is located in the nucleus on chromosomes. One of first steps that scientists and doctors use in working with DNA is to extract it from cells. There are several different protocols for isolating the DNA, however, the same basic steps are used. First the cells are ruptured usually in the presence of a detergent and salt to help release the DNA from the nucleus and separate the protein and nucleic acid portions of the cell. Next, the protein and cell waste is filtered out of the mixture. Finally, the DNA is precipitated out of solution using alcohol, which results in a white, rope-like substance (DNA) that can be spoiled. In this activity, students will learn how to extract DNA from wheat germ using simple household substances, and be able to see DNA macroscopically. Since individual DNA molecules will not be visible even under a microscope, students will view DNA in dividing chromosomes (mitosis) to expose them to a microscopic view of DNA.

MATERIALS

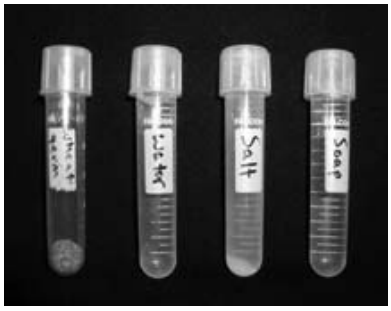
(students in groups of four)

- 15-ml culture tubes
- Wheat germ (1/8 teaspoon)
- 12 ml Distilled water
- 12 ml of 25% Detergent solution (Stock Solution: 250 ml dish detergent in 1000 ml water)
- 12 ml of 8% Salt solution (Stock Solution: 80 g table salt in 1000 ml water)
- Cold isopropyl (rubbing) alcohol (90% works best)
- Plastic droppers (labeled "water", "detergent", and "salt")

MATERIALS (cont.)

- Test tube holders
- Paper clip
- Plastic weigh dish
- Hand lenses
- compound microscope (preferably with a 100X objective lens)
- Extracting DNA from Wheat Germ handout
- Mitosis slides and identification challenge set up at a microscope station, quality images can be found at websites noted in resources

PREPARATION



Aliquot the wheat germ (1/8 teaspoon or about 1 cm high in the test tube), water, salt, and detergent solutions into the culture tubes (ask volunteer students to do this before class). Each group should get a set of goggles, four culture tubes, three droppers, one weigh dish, and a paper clip. It is strongly recommended that the alcohol be at one station and distributed by the teacher only when a group gets to that step. Since cold alcohol works best to precipitate the DNA, it is best to keep it on ice.

PROCEDURE

Warm Up

- Have students scan through their textbook sections on DNA and do the following:
  - o Sketch a DNA molecule
  - o List the properties of DNA using the reading and also the DNA picture
  - o Determine what they think DNA will like when extracted from cells
  - o List the student's answers on the board or overhead

Reviewing the Lab Procedures

1.) Distribute the student lab procedure handout.
2.) Ask students to make a flow chart of the procedure in their notebooks.
3.) Review the steps by creating a class flow chart on the board or overhead.
4.) Review safety procedures for wearing goggles, handling solutions (emphasizing no inhalation), and washing hands at the end of the activity.

PROCEDURE (cont.)

Extracting DNA from Wheat Germ

Students should complete the following steps.

1.) Each group should receive a test tube containing enough wheat germ that is about 1 cm high, and record their observations of what the wheat germ looks like.
2.) Add enough distilled water to cover all of the wheat germ (~ 2 ml).
3.) Add 25 drops of detergent solution to the wheat germ test tube.
4.) Mix for 3 minutes by gently tilting the test tube back and forth. It is important to mix gently to prevent bubbles from forming.

5.) Add 25 drops of the salt solution to the wheat germ test tube.
6.) Mix gently for 1 minute.
7.) Go to the alcohol station and add an equal volume of iso propanol. If the volume in the wheat germ tube is 4 ml, then add 4 ml of isopropanol. Add the isopropanol by tilting the wheat germ test tube at an angle and pour the alcohol slowly down the side of the tube. Two phases (layers) should be present in the tube after the isopropanol is added.

8.) Let the wheat germ test tube sit for 2 minutes. Watch for a stringy, white material to rise up from the bottom layer into the top isopropanol layer. This white material is the wheat DNA.
9.) Bend the paper clip so it forms a hook. Use the hook to remove the DNA. Be careful not to disturb the bottom layer. Transfer the DNA to the weigh dish and observe with the hand lens.
10.) Create a data table to compare what is known about DNA properties with what has been observed.
11.) Clean up the table.

PROCEDURE (cont.)

Observing DNA in Dividing Onion Cells (mitosis)

1.) Read through the textbook section on mitosis.
2.) Go to the mitosis microscope station to see magnified DNA being copied during cell division.
3.) Add these observations to the data table.

REFLECTION

Using their notebooks, ask students to use their textbooks and their data tables to compare DNA properties with their macroscopic observations of extracted DNA and the DNA that can be observed microscopically (eg, chromosomes in mitosis). Ask students to answer the following questions in their notebooks.

- Which DNA properties are easy to observe?
- Which DNA properties are only observed under the microscope?
- What is the purpose of the salt, detergent, and alcohol solutions?
- Would this experiment work with DNA from other organisms using onion cells or cells from your mouth? Why or why not?

ASSESSMENT

- Review textbook sections on DNA structure and mitosis.
- Ask students to design an experiment to extract DNA during each stage of mitosis from onion cells.
- Ask students to determine how they would recognize/identify each stage of mitosis.
- Ask students to address what is the purpose of looking at DNA during different stages of cell division? (Ex. to study genetic diseases such as cancer)

TIPS

- Students should take their time and make sure they follow the procedures.
- Students can check off steps on their flow charts as they are complete. They can also use the flowcharts to write observations and problems they encounter along the way.
- Students should mix the wheat germ gently. If they are too rough, the DNA will shear.
- Use ice cold 90% isopropanol.
- The mitosis activity is added to give students a chance to observe DNA under microscope. If time does not permit, the slides can be used just to observe DNA, leaving the mitosis exploration for an other day.

FOLLOW UP ACTIVITIES

- Repeat the DNA extraction using a variety of plant sources such as onion, spinach, peas, etc. Do not use human, insect, or animal cells.
- Research how scientists determined that DNA is double-stranded and twisted like a ladder.
- Research what scientists do with the DNA once it is extracted (ie, how do scientists determine the exact DNA sequence?)

RELATED CAREERS

- Molecular biologist
- Cytogeneticist
- DNA forensic tecnician
- Molecular anthropologist
- Virus hunters

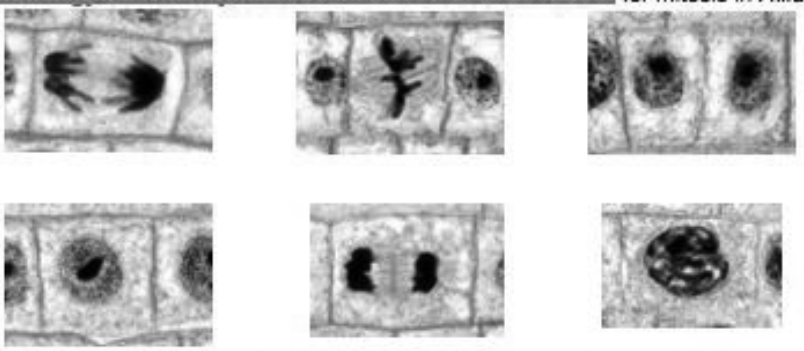
RESOURCES

- **http://learn.genetics.utah.edu/units/activities/** for two different extraction protocols and explanation on how the procedure works.
- **www.accessexcellence.org/AE/AEC/CC/DNA_extractions.html** for protocols to comparatively extract DNA from onion, wheat germ, bacteria, and yeast.
- **www.dnaftb.org/dnaftb/ DNA** From The Beginning by Cold Spring Harbor for awesome animations and great information on DNA and it's role in both classical and modern genetics.
- **http://nte-serveur.univ-lyon1.fr/nte/EMBRYON/www.uoguelph.ca/zoology/devobio/210labs/mitosis1.html** for mitosis in whitefish blastula cells
- **http://staff.jccc.net/pdecell/celldivision/oniontip.html** for mitosis in onion cells
- **http://biology.nebrwesleyan.edu/benham/mitosis/allium.html** for mitosis in Allium (onion) cells
- **http://www.bioweb.uncc.edu/1110Lab/notes/notes1/labpics/lab6pics.htm** for mitosis in animal cells
- **http://www.dmacc.edu/Instructors/mitosis.htm** for mitosis in whitefish
- **http://micro.magnet.fsu.edu/micro/gallery/mitosis/mitosis.html** for mitosis in onion cells

Name_____ Use your textbook to help you identify the stages.

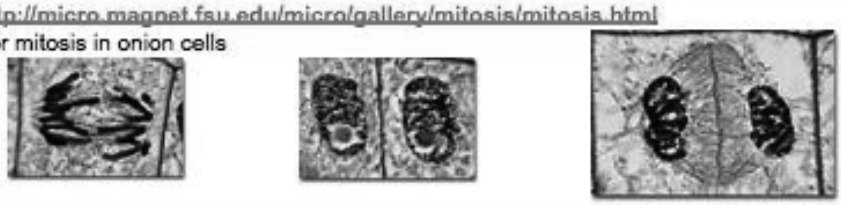
Label each cell with the stage of mitosis shown

http://biology.nebrwesleyan.edu/benham/mitosis/allium.html for mitosis in *Allium* (onion) cells

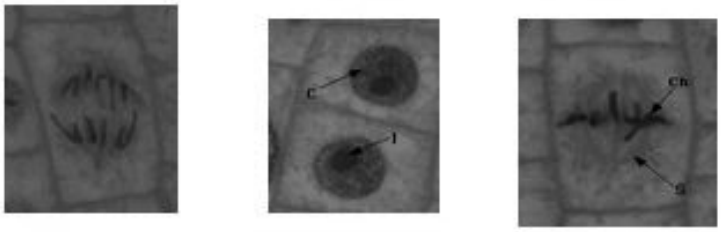


http://www.bioweb.uncc.edu/1110Lab/notes/notes1/labpics/lab6pics.htm
For mitosis in animal cells

http://micro.magnet.fsu.edu/micro/gallery/mitosis/mitosis.html
for mitosis in onion cells

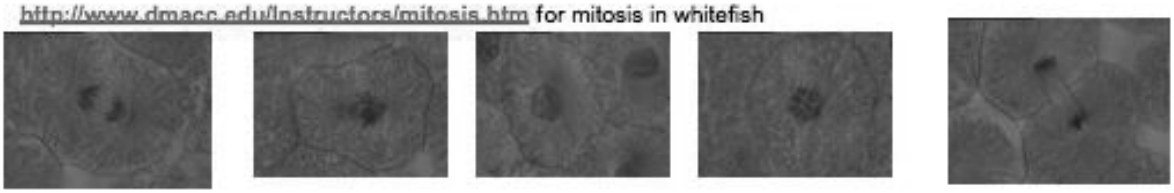


http://staff.jccc.net/pdecell/celldivision/onionip.html for mitosis in onion cells



http://www.uoguelph.ca/zoology/devobio/210labs/mitosis1.html
http://ntesenseur.univ-lyon1.fr/ntel/EMBRYON/
for mitosis in whitefish

http://www.dmacc.edu/instructors/mitosis.htm for mitosis in whitefish



DNA, Genes, and Proteins

OVERVIEW

Problem: How does DNA resemble a code that tells the cell/body what to do?

In this class collaborative activity, students will investigate how DNA is a "blueprint for life". Each group will focus on a particular process using a specific DNA sequence from the gene that encodes hemoglobin (including the mutation that causes sickle cell anemia). The processes will include the following:

- DNA replication and transfer to offspring
- Gene transcription and translation-RNA and protein production
- Mutations that cause genetic disease

Groups will create visual models and make presentations to the rest of the class. The models can be displayed on the classroom wall as illustrations of "A day in the life of DNA." This activity will help students see the bigger picture of DNA's role in Genetics & Heredity, and provide an introduction into mutations and genetic disease.

ACKNOWLEDGMENTS

This activity was adapted from "DNA – A Double Helix Model" Scientific American Frontiers: The Gene Hunters (http://www.pbs.org/saf/1202/teaching/teaching3.htm) and also from the "Reading DNA" activity http://learn.genetics.utah.edu/units/basics/print-and-go/reading_DNA.cfm

NC STANDARD COURSE OF STUDY

Science Objectives:

1.07 Prepare models and/or computer simulations.
1.08 Use oral and written language to communicate findings.
5.01 Explain the significance of genes to inherited characteristics.
5.02 Explain the significance of reproduction.

TEXTBOOK RESOURCES

Prentice Hall (pp. 522, 546-557)
McDougall Littell (pp. C74-C75;C102-103; C117-122; C135-141)
Holt (pp. 362; 390-391; 416-422; 434-441)

LEARNING OUTCOMES

By the end of the activity students will be able to:

1.) create and explain models of DNA-related processes
2.) demonstrate how complimentary DNA strands pair with themselves
3.) explain how DNA (genes) encodes proteins.
4.) explain how genes (alleles) are passed from parent to offspring.

BACKGROUND

The NC Standard Course of Study presents a diverse overview of Heredity and Genetics. Surprisingly, it does not mention DNA, which is the basis for understanding the genetics behinds how, why, and which traits are inherited. DNA is a unique molecule that makes up genes and contains signals to indicate which genes will be expressed throughout life. Any damage to the DNA (mutation) may have either negative or positive consequences for humans.

DNA (deoxyribonucleic acid) is a double-stranded nucleic acid that stores the genetic information of a cell and provides the instructions to build proteins and carry out the functions of that particular cell. These instructions are arranged in genes on chromosomes found in each cell's nucleus. Human cells contain 46 chromosomes. Because children inherit 23 chromosomes from each parent, our traits reflect a combination of influences from both parents. The completion of the Human Genome Project in 2000, has helped make it possible to determine which specific genes each human possesses and help to predict which traits might be expressed. The DNA molecule consists of an arrangement individual nucleotide bases (adenine, guanine, cytosine, or thymine) that together create the genetic code. In 2000, the arrangement of the entire genetic code (genome) for humans was determined through the Human Genome project. Genes contain a unqiue sequence of the nucleotide bases (ex. ATGGCCATG….) that determine which proteins are made by the cell.

DNA does not directly make proteins, but instead acts as the "instructions" to build proteins. To read these instructions, cells first must copy the instructions (transcription) into a form that can leave the nucleus (messenger RNA or mRNA), and be translated (translation) into amino acids which join to form a protein in the cell's cytoplasm. This process where DNA is transcribed into mRNA and translated into proteins occurs throughout life to produce nearly every protein found in the human body. This concept is known as the Central Dogma, and is true for all living organisms, except for viruses with RNA genomes (ex. HIV).

BACKGROUND (cont.)

Red blood cells (RBCs) contain the protein hemoglobin, which is the oxygen-carrying component of RBCs. The genetic information to make hemoglobin is found in two hemoglobin genes located on chromosomes 16 (alpha subunit) and 11 (beta subunit). Sickle Cell Anemia is a genetic disorder that results from a DNA mutation in the beta subunit gene (http://www.ornl.gov/sci/techresources/Human_Genome/posters/chromosome/hbb.shtml). This change causes a single amino acid substitution in the sixth protein residue from a glutamic acid (Glu) to a valine (Val) in the hemoglobin beta subunit. This change affects the shape of the hemoglobin protein and affects its ability to carry oxygen throughout the body.

This activity will explore how DNA acts as the instructions to make the blood protein hemoglobin using the information (DNA sequences) found in the hemoglobin gene. In addition, students will be able to see how a single change in the DNA sequence (mutation) can alter the resulting protein, leading to a genetic disease – sickle cell anemia.

HBB Sequence in Normal Adult Hemoglobin (Hb A):

Nucleotide	CTG	ACT	CCT	GAG	GAG	AAG	TCT
Amino Acid	Leu	Thr	Pro	Glu	Glu	Lys	Ser
	3			6			9

HBB Sequence in Mutant Adult Hemoglobin (Hb S):

Nucleotide	CTG	ACT	CCT	GTG	GAG	AAG	TCT
Amino Acid	Leu	Thr	Pro	Val	Glu	Lys	Ser
	3			6			9

MATERIALS

(students in groups of four)
Because each group has a different DNA sequence, it may be best
to leave the supplies in a central location.

- Science textbook as a resource
- Colored DNA “flags”
- Colored RNA “flags”
- Straws
- Scotch tape
- Colored circles
- String
- Construction paper
- Scissors

PREPARATION

- Set up the supplies table.
- Make copies of the "A Day in the Life of DNA" (included in this manual)
- Write down textbook page numbers corresponding to DNA-related processes (see textbook resource sections).

PROCEDURE

Warm Up

- Show overhead transparencies or online animations of DNA-related processes (DNA replication, meiosis, transcription, and translation)
- Use "Translating Hemoglobin Protein" overhead to review the process and also show how a DNA mutation can lead to sickle cell-associated hemoglobin.
- Ask students how they would model these processes.
- Show supplies and demonstration poster of the various DNA processes.

Creating Models in the Life of DNA

1.) Assign each group to a specific DNA sequence from the Hemoglobin gene. Groups should look at the guide for creating their models and plan what supplies they will need.
2.) Groups should assemble their models and prepare a short presentation.
3.) Once all models are complete, they can be affixed to the wall and each group can do a short presentation of their model and how their specific process works. Students should make sure they include where their process occurs in the cell.
4.) As each group presents their information, other students should listen closely so that they can complete their "A Day In the Life of DNA" table.

REFLECTION

Using their notebooks, ask students to complete their "A Day In the Life of DNA" table and answer the following questions.

- What properties of DNA allow it to be copied easily?
- What DNA clues indicate the beginning and end of a gene?
- How is RNA like a message between DNA (genes) and proteins?
- How does the cell "know" which amino acids to add to a protein?
- What could happen if one of the DNA bases is mutated (changed)? Explain using the terms DNA, RNA, amino acid, and protein.

TIPS

While each group has a relatively small process on which to focus, the bigger picture has a lot of details. It may be helpful to give students and additional day to do presentations, synthesize the information, and complete the Reflection and Assessment sections.

FOLLOW UP ACTIVITIES

- Do the "From Gene to Protein Web Quest" activity developed by the Genetics Science Learning Center (http://learn.genetics.utah.edu)
- Research how scientists determine DNA sequences, genes, and proteins using computer technology
- Find our more about sickle cell anemia and how DNA is used to track genetic diseases

RELATED CAREERS

- Molecular biologist
- Biophysicist
- DNA forensics
- Protein biochemist
- Virologist
- Genetic engineer

RESOURCES

- **http://learn.genetics.utah.edu/** (for "From Gene to Protein Web Quest" activity, animations, and other information on DNA-related processes)
- **www.dnaftb.org/dnaftb/** (DNA From The Beginning by Cold Spring Harbor for awesome animations and great information on DNA and it's role in both classical and modern genetics)

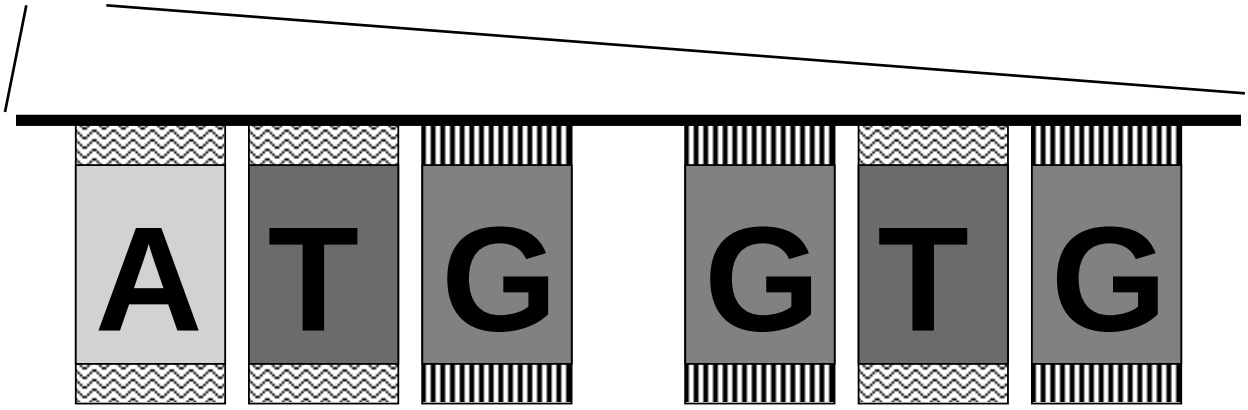
A Day in the Life of DNA Teacher Guide

The HBB gene codes for one of the hemoglobin subunits that is involved in allowing red blood cells to carry oxygen and carbon dioxide throughout the body. A single point mutation in the HBB gene changes the shape of the hemoglobin protein, which in turn affects the shape of the red blood cell and its ability to carry oxygen. This point mutation causes a genetic disorder called Sickle Cell Anemia. This activity will involve using the hemoglobin gene to create a wall-sized visual story of how DNA is replicated (copied), transcribed, and translated into the hemoglobin protein. In addition, you will see how a single DNA mutation in the hemoglobin gene (instructions) can affect the final hemoglobin protein product.

Each group will be given a portion of the hemoglobin gene. Follow the example (below) based upon the first 30 DNA bases (nucleotides) to create you own model of how genes get copied and turned into proteins.

Translating Hemoglobin Protein Overhead
Modeling the coding (top) strand of the hemoglobin gene
Use the DNA flags to create the coding strand of this portion of the hemoglobin gene. Attach a straw to each flag and then slide the DNA flags in the correct order to the wooden skewer.

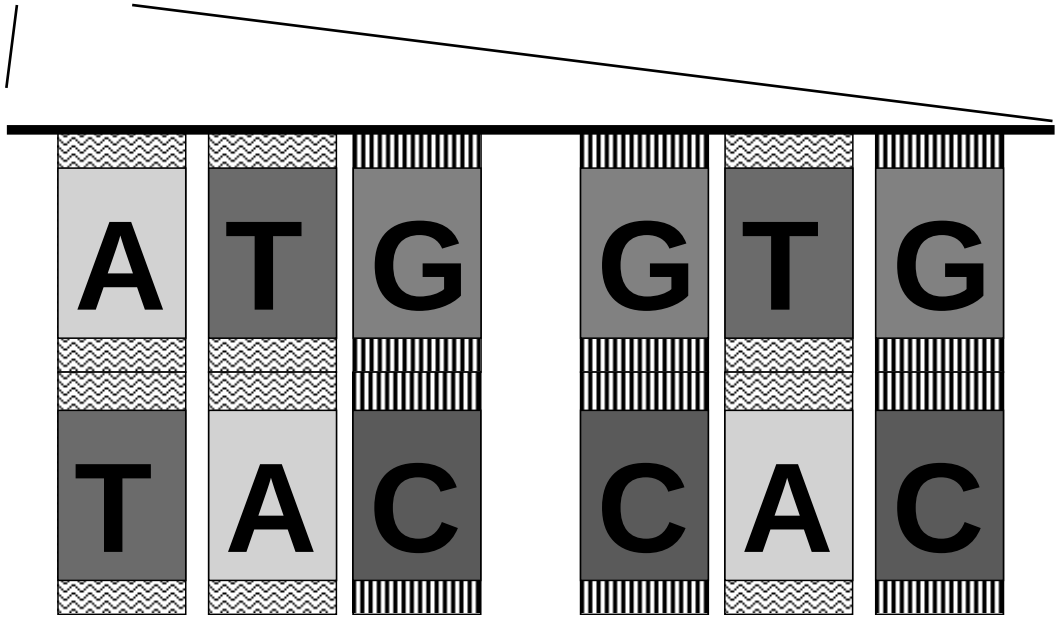
1/1 Hemoglobin DNA sequence (nucleotides #1-30)
|
ATG GTG CAT CTG ACT CCT GAG GAG AAG TCT



DNA Replication in the nucleus (DNA is copied). Once you have assembled the top strand (coding strand), assemble the complementary strand (template strand). Use your textbook if you can't remember which DNA bases pair with each other.

1/1 Hemoglobin DNA sequence (nucleotides #1-30)

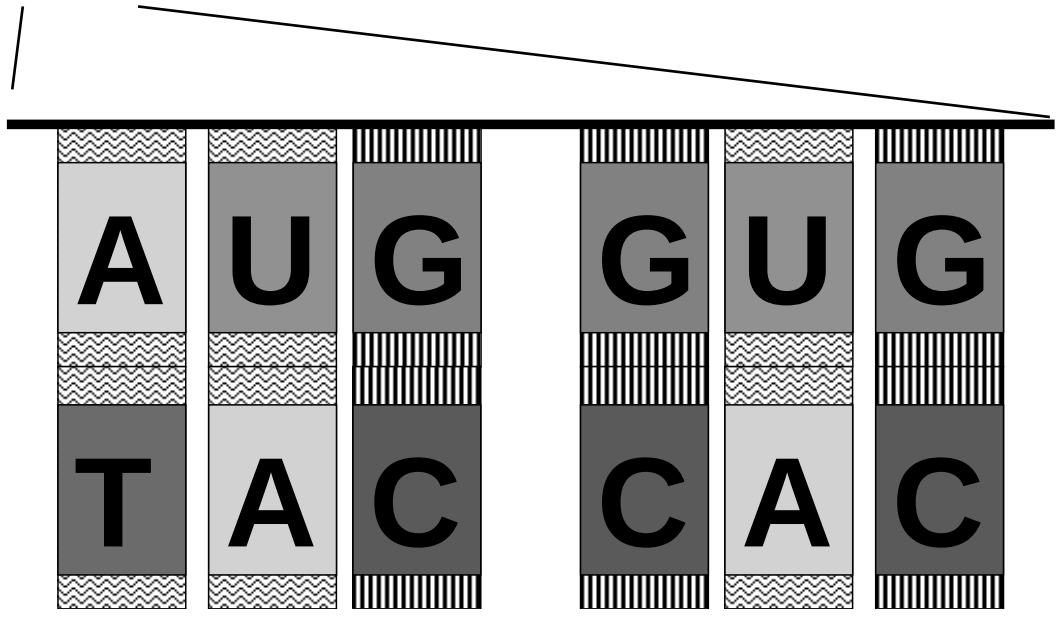
```
 |
ATG GTG CAT CTG ACT CCT GAG GAG AAG TCT    coding strand
TAC CAC GTA GAC TGA GGA CTC CTC TTC AGA    template strand
```



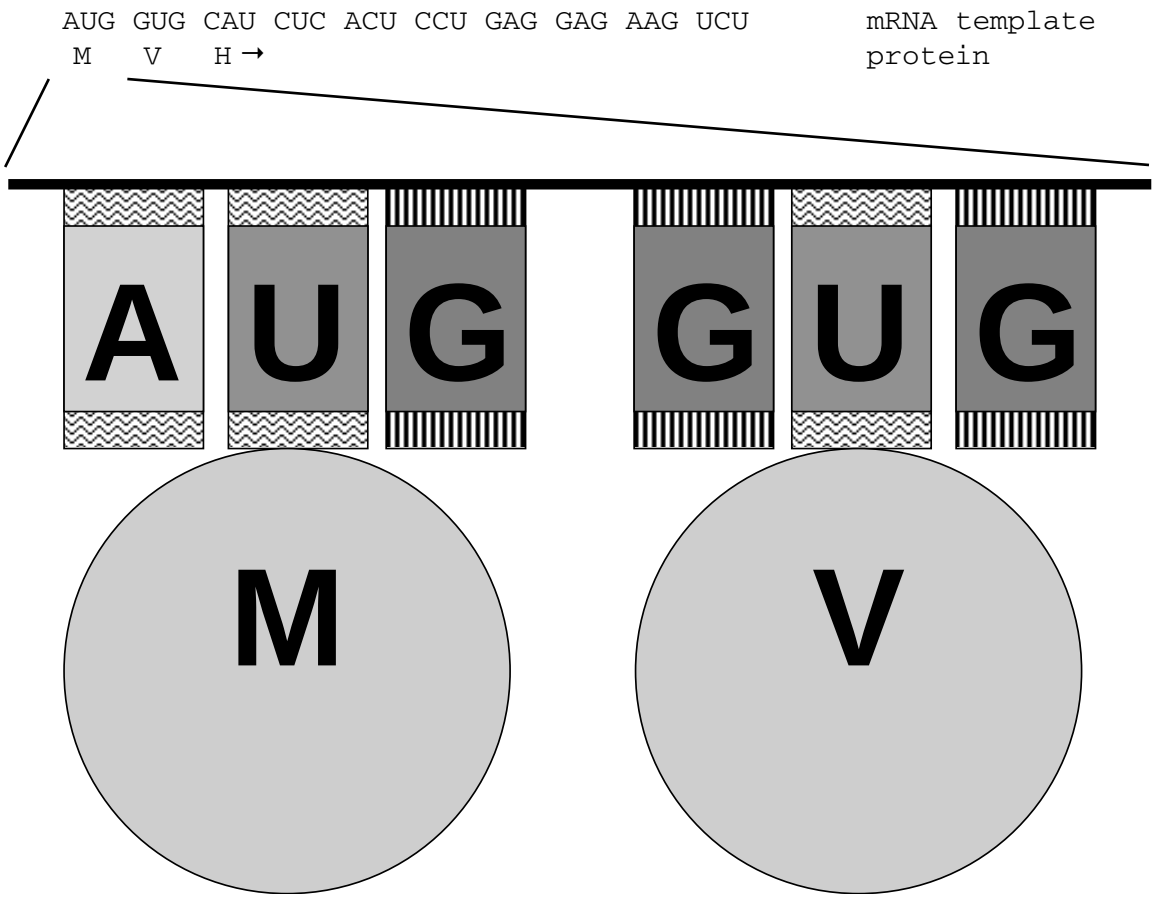
DNA is transcribed in the nucleus. The template (bottom) strand of DNA copied into messenger RNA (mRNA). Assemble the mRNA strand, which will be complementary to the DNA template strand. Remember RNA uses “U” instead of “T”.

1/1 Hemoglobin DNA sequence (nucleotides #1-30)

```
 |
AUG GUG CAU →                              mRNA
TAC CAC GTA GAC TGA GGA CTC CTC TTC AGA    DNA template
```



mRNA translated into hemoglobin protein in the cytoplasm. The mRNA detaches from the DNA and travels to the cytoplasm where it is used as a template to assemble amino acids into the hemoglobin protein. Use the Genetic Code Translation Table to determine which amino acid (plastic disks) should be attached to each mRNA triplet.



Cut out each set of nucleotides from the different sections of the hemoglobin (HBB) gene. Each group will be given one or more sections to complete the DNA life cycle stages of replication, transcription, and translation. It may be easiest for the same group to assemble both the normal gene and the sickle cell mutated gene (nucleotides #1-30).

HBB Gene nucleotides #1-30
ATGGTGCATCTGACTCCTgagGAGAAGTCT

HBB Gene with Sickle Cell mutation nucleotides #1-30
ATGGTGCATCTGACTCCTgagGAGAAGTCT

HBB Gene nucleotides #31-60
GCCGTTACTGCCCTGTGGGGCAAGGTGAAC

HBB Gene nucleotides #61-90
GTGGATGAAGTTGGTGGTGAGGCCCTGGGC

HBB Gene nucleotides #91-120
AGGCTGCTGGTGGTCTACCCTTGGACCCAG

HBB Gene nucleotides #121-150
AGGTTCTTTGAGTCCTTTGGGGATCTGTCC

HBB Gene nucleotides #151-180
ACTCCTGATGCTGTTATGGGCAACCCTAAG

HBB Gene nucleotides #181-210
GTGAAGGCTCATGGCAAGAAAGTGCTCGGT

HBB Gene nucleotides #211-240
GCCTTTAGTGATGGCCTGGCTCACCTGGAC

HBB Gene nucleotides #241-270
AACCTCAAGGGCACCTTTGCCACACTGAGT

HBB Gene nucleotides #271-300
GAGCTGCACTGTGACAAGCTGCACGTGGAT

HBB Gene nucleotides #301-330
CCTGAGAACTTCAGGCTCCTGGGCAACGTG

HBB Gene nucleotides #331-360
CTGGTCTGTGTGCTGGCCCATCACTTTGGC

HBB Gene nucleotides #361-390
AAAGAATTCACCCCACCAGTGCAGGCTGCC

HBB Gene nucleotides #391-420
TATCAGAAAGTGGTGGCTGGTGTGGCTAAT

HBB Gene nucleotides #420-444
GCCCTGGCCCACAAGTATCACTAA

Complete DNA and protein sequences for the hemoglobin beta gene (HBB). The three nucleotides (GAG) that code for the amino acid E (Glutamic acid) are indicated by lower case. A person who has sickle cell anemia has a GTG (instead of GAG), which results in a V (valine) at this position in the protein. This single amino acid change affects the shape of the hemoglobin protein, which in turn changes the shape of the red blood cell – affecting its ability to efficiently carry oxygen throughout the body.

```
1/1                                 31/11                               61/21
 |                                   |                                   |
ATG GTG CAT CTG ACT CCT gag GAG AAG TCT GCC GTT ACT GCC CTG TGG GGC AAG GTG AAC GTG GAT GAA GTT GGT GGT GAG GCC CTG GGC
M   V   H   L   T   P   E   E   K   S   A   V   T   A   L   W   G   K   V   N   V   D   E   V   G   G   E   A   L   G

 91/31                              121/41                              151/51
 |                                   |                                   |
AGG CTG CTG GTG GTC TAC CCT TGG ACC CAG AGG TTC TTT GAG TCC TTT GGG GAT CTG TCC ACT CCT GAT GCT GTT ATG GGC AAC CCT AAG
R   L   L   V   V   Y   P   W   T   Q   R   F   F   E   S   F   G   D   L   S   T   P   D   A   V   M   G   N   P   K

 181/61                             211/71                              241/81
 |                                   |                                   |
GTG AAG GCT CAT GGC AAG AAA GTG CTC GGT GCC TTT AGT GAT GGC CTG GCT CAC CTG GAC AAC CTC AAG GGC ACC TTT GCC ACA CTG AGT
V   K   A   H   G   K   K   V   L   G   A   F   S   D   G   L   A   H   L   D   N   L   K   G   T   F   A   T   L   S

 271/91                             301/101                             331/111
 |                                   |                                   |
GAG CTG CAC TGT GAC AAG CTG CAC GTG GAT CCT GAG AAC TTC AGG CTC CTG GGC AAC GTG CTG GTC TGT GTG CTG GCC CAT CAC TTT GGC
E   L   H   C   D   K   L   H   V   D   P   E   N   F   R   L   L   G   N   V   L   V   C   V   L   A   H   H   F   G

 361/121                            391/131                             421/141
 |                                   |                                   |
AAA GAA TTC ACC CCA CCA GTG CAG GCT GCC TAT CAG AAA GTG GTG GCT GGT GTG GCT AAT GCC CTG GCC CAC AAG TAT CAC TAA
K   E   F   T   P   P   V   Q   A   A   Y   Q   K   V   V   A   G   V   A   N   A   L   A   H   K   Y   H   *
```

Genetic Code Translation Table
http://asterix.cs.gsu.edu/~weber/code.gif
Note: the triplets are in DNA form. Remember RNA uses “U” instead of “T”

	T	C	A	G
T	TTT Phe (F) TTC " TTA Leu (L) TTG "	TCT Ser (S) TCC " TCA " TCG "	TAT Tyr (Y) TAC TAA **Ter** TAG **Ter**	TGT Cys (C) TGC TGA **Ter** TGG Trp (W)
C	CTT Leu (L) CTC " CTA " CTG "	CCT Pro (P) CCC " CCA " CCG "	CAT His (H) CAC " CAA Gln (Q) CAG "	CGT Arg (R) CGC " CGA " CGG "
A	ATT Ile (I) ATC " ATA " **ATG** Met (M)	ACT Thr (T) ACC " ACA " ACG "	AAT Asn (N) AAC " AAA Lys (K) AAG "	AGT Ser (S) AGC " AGA Arg (R) AGG "
G	GTT Val (V) GTC " GTA " GTG "	GCT Ala (A) GCC " GCA " GCG "	GAT Asp (D) GAC " GAA Glu (E) GAG "	GGT Gly (G) GGC " GGA " GGG "

Genetic Disorders

OVERVIEW

Problem: What is the genetic basis of disease?

This activity will expose students to a variety of genetic diseases and disorders through guided research mini-projects. Using print and online resources, students will research about the causes and consequences of a specific genetic disease, and present their findings to the class.

ACKNOWLEDGMENTS

This activity was created by the authors using resources from the following websites:

- **http://www.ygyh.org**
- **http://learn.genetics.utah.edu/units/disorders**
- **http://www.nchealthinfo.org**
- **http://www.webmd.com**

NC STANDARD COURSE OF STUDY

Science Objectives:

1.08	Use oral and written language to communicate findings
1.09	Use technologies and information systems to [conduct] research
1.10	Analyze and evaluate information from a scientifically literate viewpoint
5.01	Explain the significance of genes to inherited characteristics
5.05	Summarize the genetic transmittance of disease

TEXTBOOK RESOURCES

Prentice Hall (pp. 571-575)
McDougall Littell (pp. C144-148; B152)
Holt (pp. 421-422; 442-443)

LEARNING OUTCOMES

By the end of the activity students will be able to

- research genetic diseases using the internet
- determine the causes and consequences of different genetic diseases
- present their findings on paper and orally to the class

BACKGROUND

Genetic disorders are diseases that are caused by a defect in a person's DNA. There are three basic types of genetic disorders: single-gene disorders, chromosome abnormalities, and multifactorial disorders. *Single-gene disorders* occur when a mutation in a gene results in the change of the encoded amino acid, altering the final protein product. Sickle cell anemia and Cystic fibrosis are classic examples that are often cited in science textbooks. *Chromosome abnormalities* are disorders that occur when chromosomes or portions of chromosomes are either deleted, duplication, or damaged (re-arrangements, etc). Down syndrome, which occurs when a person has an extra copy of chromosome 21, is the most widely known example of this type of disorder. Instead of inheriting two copies of chromosome 21 (one from each parent), a person with Down syndrome has three copies. Hence, the disease is also called Trisomy 21. This extra chromosome results in more Chromosome 21-encoded proteins being made leading to distinct facial features and increased risk for several medical problems. *Multifactorial disorders* result from mutations occurring in mutiple genes, often associated with environmental causes. Alzheimer's disease and several cancers (breast, ovarian, colon) are examples of multifactorial disorders. Because these type of disorders have multiple genetic and environmental factors, they are difficult to diagnosis and treat early in disease development. Recently several genetic tests have been developed to determine if a person possesses genes, which are often found in people with these disorders. For example, women who inherited mutated copies of either the BRCA1 gene (on Chromosome 17) and BRCA2 gene (on Chromosome 13), is at high risk for developing breast or ovarian cancer. These genes are known as tumor suppressors, and appear to help repair damaged DNA (which can cause cancer). Men who inherit either mutated gene are at high risk for developing breast or protate cancer. However, other influences such as diet, lifestyle, and environmental exposure are other risk factors that contribute to these disorders.

This activity will give students a chance to research one of several genetic disorders - learning about causes, diagnosis, and treatment. Students will create a one-page Disease Fact Sheet, similar to one that might be given to a patient who needs to quickly find out the basic facts about a particular genetic disease. For classrooms with Internet access, research will be conducted using easy to use Internet sites.

MATERIALS

- Internet access (if available)
- Class set of disease fact sheets from the Internet
  http://www.ygyh.org (not included in this kit)
  http://learn.genetics.utah.edu/units/disorders
- Sickle cell anemia and Cystic fibrosis Punnett square overhead
- Genetic Disorder Mini Research Project (overhead, and class set)

PREPARATION

- Set up Internet access (if available)
- Copy or print a class set of Genetic Disorders Mini Research Project and disease fact sheets

PROCEDURE

Warm Up

- Punnett square practice problems on sickle cell anemia and cystic fibrosis to introduce students to two genetic diseases that primarily affect African Americans (sickle cell anemia) and Caucasians (cystic fibrosis).

Genetic Diseases Fact Sheets

1.) Students will use either "Your Genes, Your Health" or the "Genetic Disorders Library" to research a specific genetic disorder.
2.) Students should put their findings of a "Disease Fact Sheet" worksheet.

REFLECTION

Students should listen to the news or read the news on the Internet or newspaper for a week and write a sentence about each story that relates to a genetic disorder. Students can share their articles in class as a way of gauging which genetic disorders garner the most attention in the news.

ASSESSMENT

Students may use their genetic disorder data table and Punnett squares to diagnose and suggest treatment options based upon four patient case studies.

TIPS

Some students may have a hard time pulling out information from long reading passages. If copies are available, allow students to use highlighters to help identify key information (causes, incidence, symptoms, treatments, etc).

FOLLOW UP ACTIVITIES

- Find our more about genetic disorders and how DNA is used to track specific genetic diseases in populations (elderly, ethnic groups, regions, etc).
- Explore how the human genome project has opened doors in the diagnosis and understanding of genetic disorders.
- **Math Extension:** create pie chart that shows the percentage of people who have specific genetic disorders in the United States vs. your state or county.

RELATED CAREERS

- Genetic counselor
- Genetic researcher
- Medical geneticist
- Population biologist
- Epidemiologist

RESOURCES

- **http://www.ygyh.org**
- **http://learn.genetics.utah.edu/units/disorders**
- **http://www.nchealthinfo.org**
- **http://www.webmd.com**

Sickle Cell Anemia and Cystic Fibrosis
Punnett square overheads

Answer the following in you science notebook. You DO NOT need to copy the questions.

Sickle Cell Anemia in a recessive genetic disease that affects 75,000 Americans (0.025%). People who are heterozygous (Ss) are healthy, but carriers of the sickle cell trait. What are the chances of a child having sickle cell anemia if the dad has sickle cell anemia (ss), and the mom is heterozygous for the sickle cell trait?

a). What is the genotype of the male parent? **ss (homozyogous)**
b). What is the phenotype of the male parent? **disease**
c). What is the genotype of the female parent? **Ss**
d). What is the phenotype of the female parent? **healthy carrier**
e). Use a Punnett square to predict the genotypic and phenotypic outcome of this cross.

		Male Parent **s**	**s**
Female Parent	**S**	**Ss**	**Ss**
	s	**ss**	**ss**

Genotype	Ratio	Percentage	Phenotype	Ratio	Percentage
Ss	**2:4**	**50%**	**Healthy**	**2:4**	**50%**
ss	**2:4**	**50%**	**Disease**	**2:4**	**50%**
-	**-**	**-**	**-**	**-**	**-**

Answer the following in you science notebook. You DO NOT need to copy the questions.

Cystic fibrosis in a genetic disease that affects 30,000 Americans (0.01%). The dominant allele (N) is associated with normal health, and the recessive allele (n) is responsible for cystic fibrosis. What is the chance that their children will have cystic fibrosis (nn) if both parents are heterozygous for the cystic fibrosis trait?

a). What is the genotype of the male parent? **Nn**
b). What is the phenotype of the male parent? **Healthy**
c). What is the genotype of the female parent? **Nn**
d). What is the phenotype of the female parent? **Healthy**
e). Use a Punnett square to predict the genotypic and phenotypic outcome of this cross.

		Male Parent **N**	**n**
Female Parent	**N**	**Nn**	**Nn**
	n	**Nn**	**nn**

Genotype	Ratio	Percentage	Phenotype	Ratio	Percentage
NN	**1:4**	**25%**	**Healthy**	**-**	**-**
Nn	**2:4**	**50%**	**Healthy**	**3:4**	**75%**
nn	**1:4**	**25%**	**CF**	**1:4**	**25%**

Genetic Disorders Mini-Research Projects

Disease Name: _____

ATTACH RELEVANT PICTURES

What is _____?

How do you get the disease?

How is the disease spread?

What are the signs & symptoms?

How is the disease diagnosed?

How can you prevent the disease?

How do you treat the disease?

References for more information?

Genetic vs. Environmental Influences on Traits

OVERVIEW

Problem: Are traits a product of heredity or environment?

This activity will challenge students to determine which traits are controlled by genetics, by the environment, or a combination of both. Using corn plants, students will be able to visually and mathematically determine the influence of nature (genetics) vs. nurture (environmental). In addition, the activity will connect concepts from previous activities, helping students determine how human traits are influenced by heredity, environment, and lifestyle. This activity includes topics that may be helpful in teaching portions of the Human Body Systems curriculum (NCSCOS Objectives 4.07 and 4.08), and corresponding pages are indicated for each of the three main Science textbooks.

TIPS

This activity takes several weeks and should be started soon after receiving the genetics kit. As students complete other activities in the kit, they should begin to relate the different concepts to this activity. Be the time the corn plants are several weeks old, students should be able to see both genetic and environmental effects on the corn plants. Students may need help relating plant traits to human traits. The background includes several examples of human traits that are influenced by genetic and/or environmental factors.

ACKNOWLEDGMENTS

This activity was adapted from the “Heredity and Environment Kit” (using tobacco) available through Flinn Scientific (http://www.flinnsci.com). The Human Traits portion is adapted from “The Faces of Cancer” activity part of the Cell Biology and Cancer NIH Curriculum Supplement Series (http://science.education.nih.gov/supplements/nih1/cancer/default.htm).

NC STANDARD COURSE OF STUDY

Science Objectives:

1.01 Identify and create questions and hypotheses that can be answered through scientific investigations.
1.05 Analyze evidence to explain observations and develop relationship between evidence and explanation
1.10 Analyze and evaluate information from a scientifically literate viewpoint
4.07 Explain the effects of environmental influences on human development and health
4.08 Explain how understanding human body systems can help make informed decisions regarding health
5.01 Explain the significance of genes to inherited characteristics

NC STANDARD COURSE OF STUDY (cont.)

5.05 Summarize the genetic transmittance of disease
5.06 Analyze evidence that human characteristics are a product of inheritance, environmental factors, and lifestyle choices

TEXTBOOK RESOURCES

Prentice Hall (pp. 332-333, 396-400, 420-424, 571-575, 536-543, 564-575)
McDougall Littell (pp. B140-153, C101-116, C144-149)
Holt (pp. 302-316, 410-415, 442-443)

LEARNING OUTCOMES

By the end of the activity students will be able to:

- identify factors that affect plant and human traits
- design an experiment to differentiate between environmental and genetic influences
- begin making informed decisions about how environmental factors and lifestyle choices affect human traits and subsequent health

BACKGROUND

An organism's characteristics, or phenotype, is a product of both heredity (genetic) and environment (non-genetic) factors. Determining which plays a bigger role throughout an organism's life is complicated, but has been considered by scientists, philosophers, clergy, and the public in the "Nature vs. Nurture" debate. Human characteristics are further complicated by a third category of factors – lifestyle choices. The advancements in understanding human genetics, especially through the Human Genome Project, have shown that traits are a result of interactions between genes, environment, and lifestyle choices.

Traits can be organized into three basic types: predominantly environmental, interactional, and predominantly genetic. (http://en-wikikpedia.org/wiki/Nature_versus_nurture). For example, traits such as language and religion have predominantly environmental (and lifestyle) influences. Even these, however, may be affected by certain genetic traits such as ones ability to learn new languages (ie. Intelligence). Other traits such as blood type and sickle cell anemia are predominantly genetic. For sickle cell anemia, which is caused by a point mutation in the hemoglobin beta gene, symptom development also may be dependent upon environment and lifestyle choices (diet, exercise, medication). Most traits are a combination of factors (interactional) such as height, weight, skin color, and intelligence. For example, natural skin color (inherited trait) can be affected by tanning, bleaching, or disease (acquired traits).

The nature vs. nurture debate is particularly important in understanding human disease and health. When the human genome project was completed in 2000, many hoped that specific disease-

BACKGROUND (cont.)

causing genes would be identified potentially lead to cures. In reality, while many genes have been found to be associated with specific diseases, they are not the only factor that determines the onset and severity of disease. For example, women who harbor mutated copies of the BRCA genes are at high risk for developing breast cancer, but its presence (or absence) does not determine if a person has or will get breast cancer. Many environmental factors such as diet, exercise, mental health, and environmental exposure (smoking, pollution, etc) influence development of breast cancer. All humans (including men) have a risk of developing breast cancer. By examining all of the genetic, environmental, and lifestyle influences, doctors can determine if a person is at low, medium, or high risk for developing breast cancer.

Many human traits are a result of complicated interactions between heredity, environment, and lifestyle, leading to student's becoming frustrated and confused. This activity will involve a teacher-led experiment to examine the genetic and environmental factors that affect plant color and height using corn plants.

The seeds come from two different corn plants that are heterozygous for normal height and color. However, one set harbors a recessive allele for albino (white) leaf color and segregates 3 normal seedlings to 1 albino (white) seedling. The albino leaf color is a result of a mutation in the lw1 (lemon white) gene on chromosome 1. This mutation affects chlorophyll production leading to seedling with white leaves that will die after a few weeks since they cannot carry out photosynthesis. In addition, because the plants are segregating, students can use Punnett squares to calculate the number of plants that should exhibit each trait. To examine environmental affects, plant will be grown in either light or dark.

MATERIALS

- Segregating albino seeds (Flinn Scientific #AB1447)
- 2 Mini-greeenhouse containing 12 peat pellets
- Shoe Box for "dark" (no light) environmental conditions
- Sample data sheet for observations and height measurements

PREPARATION

- Plant corn seeds about 1 week before activity OR have students observe the whole process from planting to observation.
- Place germinating seeds in the light or dark containers
- Have markers, color pencils, and other poster making materials available for follow-up activity

PROCEDURE

Warm Up

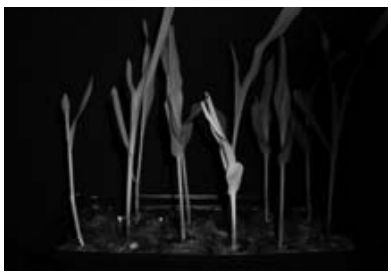
- Students should complete Punnett squares and probabilities tables for the following scenarios:
  - **Cross #1 (Green vs. Albino Leaves)** The ability to pro duce chlorophyll (green pigment) is a dominant trait (G), and it allows the plants to undergo photosynthesis. Plants that inherit two mutated copies of the chlorophyll gene (genotype = gg) do not produce chlorophyll and have white leaves (phenotype = albino). Use a Punnett square and probability table to predict the genotype and pheno type of the offspring from a cross between two heterozygous corn plants for the chlorophyll trait.
    - What percent of the offspring will be albino?
    - What percent of the offspring will have green leaves?
    - What environmental conditions also could affect the color of the leaves?

Growing the corn plants (Teacher Demonstration)

1.) Add water to two mini-green house chambers to re-hydrate the peat pellets.
2.) Place one corn seed per peat pellet. Each chamber will contain 6 seeds from the Cross #1 Cross (Green/albino leaves) Note: Since the seeds come from corn parent plants that are segregating for each trait (heterozygous parents), several seeds are needed to ensure that enough plants germinate to compete Punnett squares and the environmental experiments.
3.) Place the greenhouse containers in a warm, lighted area of the room. Once the seeds begin to germinate (3-5 days), remove the plastic lid to prevent too much moisture from building up.

Changing the environmental factors (Teacher Demonstration)

4.) Cover one of the greenhouses with the shoebox or place in the dark so that the plants will continue growing in darkness.
5.) About 2 weeks after first planting the corn seeds, The class should view the plants and record treatment, plant height and leaf color (see data sheet). The data should be collected on a central data sheet, but each student also should re cord plant data in their note-books.



PROCEDURE (cont.)

6.) If obvious differences are apparent (leaf height and color), students should use the data to see if their Punnett square predictions for the leaf color traits was correct.
7.) Record plant data again during the third week.

Human Traits influenced by Genetics and the Environment (Cancer)

1.) Ask students to count off in sets of 6. Have students write down their numbers to they do not forget.
2.) Ask students who are numbered 2, 4, 5, and 6 to stand. This represents the percentage of the U.S. population that will have children (60%).
3.) Ask students who are numbers 1 and 3 to stand. This represents the percentage of the U.S. population that will develop cancer during their life (33%).
4.) Ask one-fourth of the standing students to sit. This represents the percentage of the U.S. population who will die of cancer (25%).
5.) All students should sit. Ask the class if it is possible to determine who will develop cancer and who will not. List answers such as genetics, diet, toxic exposure, and lifestyle choices on the board.

REFLECTION

Students should go back and re-evaluate their Punnett squares to see how the genetic influences (parent genotype) compare with the environmental effects (light conditions).

- What effect do genetic factors (genotype) have on plant appearance (phenotype)?
- What environmental factors (non-genetic) factors were tested in our experiments?
- What effect do environmental factors have on plant appearance?
- Which has more influence traits, genetic or environmental factors?
- What some risk factors that make humans susceptible to lung cancer?

ASSESSMENT

Students should work individually or in groups to make a poster that illustrates the different types of factors (environmental, interactional, and genetic) that influence appearance. Students may use their textbooks, magazines, Internet, and/or print resources (included). The poster should include examples from both plants and humans. A sample poster is included as an example.

FOLLOW UP ACTIVITIES (cont.)

- Students learn about the medical lives of fictitious patients using the NIH curriculum supplement series on Cancer found at http://science.education.nih.gov/supplements/nih1/cancer/default.htm
  - o Students should pair off into six groups depending on their number.
  - o Hand out the "Identity Envelopes" and Team Summary.
  - o Students should open the envelopes and read through the description of life of the fictitious patient that they received.
    - – What happened during each period of life?
    - – What factors contributed to your patient getting cancer?
    - – What was the cause of death?

  Each group should summarize their results on a Team Summary Sheet and share their results with the rest of the class.
- Conduct a similar plant experiment comparing the affects of temperature, fertilizer, and/or salt on plant growth and appearance.
- Find out more about some of the plant or human traits that were included in the assessment poster.
- Math Extension: Use the data from the 2000 New England Journal of Medicine article to create graphs showing the genetic vs. environmental factors that cause different types of cancers.
- http://content.nejm.org/cgi/content/short/343/2/78

RELATED CAREERS

- Genetics researcher
- Oncologist
- Microbiologist
- Molecular biologist
- Animal or plant breeder
- Horticulturalist
- Population biologist
- Epidemiologist

RESOURCES

- **http://science.education.nih.gov/supplements/nih1/cancer/default.htm**
- **http://www.ygyh.org**
- **http://learn.genetics.utah.edu/units/disorders**
- **http://www.webmd.com**

Sample Data Table

	Plants in Light				Plants in Dark			
	Plant Number							
Days After Planting	#1	#2	#3	#4	#5	#6	#7	#8
Day 10								
Height (cm)								
Color								
Day 12								
Height (cm)								
Color								
Day 14								
Height (cm)								
Color								
Day 16								
Height (cm)								
Color								
Day 18								
Height (cm)								
Color								
Day 20								
Height (cm)								
Color								

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Overview

Using the Exploring Genetics Across the Middle Grades Science and Math Curriculum Manual

This manual was designed to leverage the interdisciplinary and inquiry based learning potential of genetics within science and math. In studying genetics within the context of both science and math, students will be able to increase their understanding and the application of genetic science within their world. While we focus on the "what" of learning, this manual also focuses on the "why" of genetic science. Students will be required to conduct experiments within the science activities and analyze the data within the math activities. Their learning will parallel the research being conducted at NC State which funded the development of this manual. Genetic scientists generate raw data through their research. They must work in collaboration with statisticians and computer scientists to process and analyze the data in order to draw conclusions. If students can grasp the overlap of the two disciplines, they will understand the current state of scientific research.

There are two distinct sections to the manual; science and math. To increase the effectiveness of the material, the two subjects would be implemented at the same time. However, realizing the diverse nature of public school schedules, teaching loads, and the many obstacles teachers face each day, the manual is designed with two options for implementation. The nine activity science portion is a stand alone set of activities. It can be implemented within the science curriculum and meet the objectives of many strands of the North Carolina Standard Course of Study. The math activities analyze data generated through the science activities, and are therefore dependent upon the activity taking place within the science curriculum. We encourage the interaction of the science and math departments as you undertake the activities within this kit and manual.

Alignment to the North Carolina Standard Course of Study

Both the science and the math activities are aligned to the North Carolina Standard Course of Study. The alignment is noted on the content specific chart included within this manual. Additionally, the Standard Course of Study objectives are listed within each activity. Science activities are aligned to the 7th grade Standard Course of Study. The math activity alignment encompasses 6th to 8th grade increasing the flexibility of the classroom application.

Using the Genetics Science in a Suitcase Kit from the Museum of Life and Science

This manual is designed to be used with supplies provided through the Museum of Life and Science titled Genetics Science in a Suitcase. All of the supplies listed in the Materials List are included in the kit. If you received a copy of this manual without renting the kit from the Museum, it is possible to conduct the activities with basic supplies found at local department stores. If you would like to rent the kit, please contact: Nancy Dragotta-Muhl, Phone: 919.220.5429 (x362), Email: nancy.dragotta-muhl@ncmls.org.

Career information and high school course sequencing

Included within the kit from the NC Museum of Life and Science is a Career Pathways book published by the North Carolina Biotechnology Center and the NC Department of Public Instruction. We encourage you to incorporate this career information, because it assists them with planning their course sequence for the high school curriculum. The Career Pathways book is available online at: http://www.ncpublicschools.org/cte/publications/career_pathways/biotechnology_career_publication.pdf. Parents may also be interested in this information as it relates to planning the high school course curriculum.

Math Activity Alignment to the North Carolina Standard Course of Study Middle Grades Science Curriculum

6th grade Objective	Activity 1	Activity 2	Activity 3	Activity 4	Activity 5	Activity 6	Activity 7	Activity 8	Activity 9
1.01			X						
1.06					X				
2.01					X	X			
2.02						X			
3.01						X			
3.04						X			
7th grade Objective	Activity 1	Activity 2	Activity 3	Activity 4	Activity 5	Activity 6	Activity 7	Activity 8	Activity 9
1.01		X	X						X
1.02			X						X
1.03	X	X							
1.04	X								
1.07			X						
2.01					X				
2.02						X			
3.01						X			
4.01		X							X
4.03	X	X							
4.04	X								
4.05		X		X					
5.01				X	X		X		
5.02					X		X		
5.03					X		X		
5.04					X				
8th grade Objective	Activity 1	Activity 2	Activity 3	Activity 4	Activity 5	Activity 6	Activity 7	Activity 8	Activity 9
1.08								Science X	
1.09									
1.10								Science X	
5.01				X					
5.03				X					

NORTH CAROLINA STANDARD COURSE OF STUDY MIDDLE GRADES MATHEMATICS CURRICULUM

GRADE 6

COMPETENCY GOAL 1: The learner will understand and compute with rational numbers.

Objectives

1.01 Develop number sense for negative rational numbers.
   a) Connect the model, number word, and number using a variety of representations, including the number line.
   b) Compare and order.
   c) Make estimates in appropriate situations.

1.02 Develop meaning for percents.
   a) Connect the model, number word, and number using a variety of representations.
   b) Make estimates in appropriate situations.

1.03 Compare and order rational numbers.

1.04 Develop fluency in addition, subtraction, multiplication, and division of nonnegative rational numbers.
   a) Analyze computational strategies.
   b) Describe the effect of operations on size.
   c) Estimate the results of computations.
   d) Judge the reasonableness of solutions.

1.05 Develop fluency in the use of factors, multiples, exponential notation, and prime factorization.

1.06 Use exponential, scientific, and calculator notation to write very large and very small numbers.

1.07 Develop flexibility in solving problems by selecting strategies and using mental computation, estimation, calculators or computers, and paper and pencil.

COMPETENCY GOAL 2: The learner will select and use appropriate tools to measure two- and three-dimensional figures.

Objectives

2.01 Estimate and measure length, perimeter, area, angles, weight, and mass of two- and three- dimensional figures, using appropriate tools.

2.02 Solve problems involving perimeter/circumference and area of plane figures.

COMPETENCY GOAL 3: The learner will understand and use properties and relationships of geometric figures in the coordinate plane.

Objectives

3.01 Identify and describe the intersection of figures in a plane.
3.02 Identify the radius, diameter, chord, center, and circumference of a circle; determine the relationships among them.
3.03 Transform figures in the coordinate plane and describe the transformation.
3.04 Solve problems involving geometric figures in the coordinate plane.

COMPETENCY GOAL 4: The learner will understand and determine probabilities.

Objectives

4.01 Develop fluency with counting strategies to determine the sample space for an event. Include lists, tree diagrams, frequency distribution tables, permutations, combinations, and the Fundamental Counting Principle.
4.02 Use a sample space to determine the probability of an event.
4.03 Conduct experiments involving simple and compound events.
4.04 Determine and compare experimental and theoretical probabilities for simple and compound events.
4.05 Determine and compare experimental and theoretical probabilities for independent and dependent events.
4.06 Design and conduct experiments or surveys to solve problems; report and analyze results.

COMPETENCY GOAL 5: The learner will demonstrate an understanding of simple algebraic expressions.

Objectives

5.01 Simplify algebraic expressions and verify the results using the basic properties of rational numbers.
  a) Identity.
  b) Commutative.
  c) Associative.
  d) Distributive.
  e) Order of operations.
5.02 Use and evaluate algebraic expressions.
5.03 Solve simple (one- and two-step) equations or inequalities.
5.04 Use graphs, tables, and symbols to model and solve problems involving rates of change and ratios.

GRADE 7

COMPETENCY GOAL 1: The learner will understand and compute with rational numbers.

Objectives

1.01 Develop and use ratios, proportions, and percents to solve problems.

1.02 Develop fluency in addition, subtraction, multiplication, and division of rational numbers.
- a) Analyze computational strategies.
- b) Describe the effect of operations on size.
- c) Estimate the results of computations.
- d) Judge the reasonableness of solutions.

1.03 Develop flexibility in solving problems by selecting strategies and using mental computation, estimation, calculators or computers, and paper and pencil.

COMPETENCY GOAL 2: The learner will understand and use measurement involving two- and three-dimensional figures.

Objectives

2.01 Draw objects to scale and use scale drawings to solve problems.

2.02 Solve problems involving volume and surface area of cylinders, prisms, and composite shapes.

COMPETENCY GOAL 3: The learner will understand and use properties and relationships in geometry.

Objectives

3.01 Using three-dimensional figures:
- a) Identify, describe, and draw from various views (top, side, front, corner).
- b) Build from various views.
- c) Describe cross-sectional views.

3.02 Identify, define, and describe similar and congruent polygons with respect to angle measures, length of sides, and proportionality of sides.

3.03 Use scaling and proportional reasoning to solve problems related to similar and congruent polygons.

COMPETENCY GOAL 4: The learner will understand and use graphs and data analysis.

Objectives

4.01 Collect, organize, analyze, and display data (including box plots and histograms) to solve problems.

4.02 Calculate, use, and interpret the mean, median, mode, range, frequency distribution, and inter-quartile range for a set of data.

4.03 Describe how the mean, median, mode, range, frequency distribution, and inter-quartile range of a set of data affect its graph.

4.04 Identify outliers and determine their effect on the mean, median, mode, and range of a set of data.

4.05 Solve problems involving two or more sets of data using appropriate statistical measures.

COMPETENCY GOAL 5: The learner will demonstrate an understanding of linear relations and fundamental algebraic concepts.

Objectives

5.01 Identify, analyze, and create linear relations, sequences, and functions using symbols, graphs, tables, diagrams, and written descriptions.

5.02 Translate among different representations of algebraic expressions, equations and inequalities.

5.03 Use and evaluate algebraic expressions, linear equations or inequalities to solve problems.

5.04 Develop fluency in the use of formulas to solve problems.

GRADE 8

COMPETENCY GOAL 1: The learner will understand and compute with real numbers.

Objectives

1.01 Develop number sense for the real numbers.
   a) Define and use irrational numbers.
   b) Compare and order.
   c) Use estimates of irrational numbers in appropriate situations.

1.02 Develop flexibility in solving problems by selecting strategies and using mental computation, estimation, calculators or computers, and paper and pencil.

COMPETENCY GOAL 2: The learner will understand and use measurement concepts.

Objectives

2.01 Determine the effect on perimeter, area or volume when one or more dimensions of two- and three-dimensional figures are changed.

2.02 Apply and use concepts of indirect measurement.

COMPETENCY GOAL 3: The learner will understand and use properties and relationships in geometry.

Objectives

3.01 Represent problem situations with geometric models.

3.02 Apply geometric properties and relationships, including the Pythagorean theorem, to solve problems.

3.03 Identify, predict, and describe dilations in the coordinate plane.

COMPETENCY GOAL 4: The learner will understand and use graphs and data analysis.

Objectives

4.01 Collect, organize, analyze, and display data (including scatterplots) to solve problems.

4.02 Approximate a line of best fit for a given scatterplot; explain the meaning of the line as it relates to the problem and make predictions.

4.03 Identify misuses of statistical and numerical data.

COMPETENCY GOAL 5: The learner will understand and use linear relations and functions.

Objectives

5.01 Develop an understanding of function.

a) Translate among verbal, tabular, graphic, and algebraic representations of functions.
b) Identify relations and functions as linear or nonlinear.
c) Find, identify, and interpret the slope (rate of change) and intercepts of a linear relation.
d) Interpret and compare properties of linear functions from tables, graphs, or equations.

Heredity & Genetics Scavenger Hunt

OVERVIEW

This activity ties in well with the science scavenger hunts. Students will use TV shows and movies to hunt/serach for genetic terms. This may also open up various class dicussions to see what students perceive regarding genetics.

NORTH CAROLINA STANDARD COURSE OF STUDY OBJECTIVES MET

7th grade

- 1.03 Develop and use ratios, proportions, and percents to solve problems
- 1.04 Develop fluency in addition, subtraction, multiplication, and division of rational numbers
- 4.03 Collect, organize, analyze, and display data to solve problems
- 4.04 Calculate, use, and interpret the mean, median, mode, range, and frequency

LEARNING OUTCOMES

Students will be able to:

1.) Record data from various resources
2.) Represent this data on a table
3.) Use a circle graph to visually represent this data.

HINTS

- Allow 5-7 days to gather resources
- For extra credit ask students to draw bar graphs form the data or a relative frequency bar graph.

PREREQUISITES

- ratio
- calculating a percent of a number

INSTRUCTIONS

1.) Brainstorm movies, TV shows or books/newpaper articles where genetic terms have been mentioned.
(Here are a few suggestions: CSI, Spiderman I, The Hulk, Fantastic 4, The Island, X-men, New York Times, Herald, Encyclopedia, National Geographic)
2.) Record these terms/words on the table provided.
3.) While students are gathering into, reteach/teach the following: bar graphs, circle graphs, how to calculate a percent of a number, and frequency table.
4.) Once students bring in their complied sheets make a frequency table on the borad with an additional column for the words found as follows:

INSTRUCTIONS (cont.)

	Words	Tally	Frequency
TV Shows			
Movies			
Books			
Newspaper			

5.) Ask students which category represented the highest percent? Ask how they know this.
6.) Hand out compass/circle stencils and a protractor. Explain how the protractor works and use the frequency table on the board to explain how to draw a circle graph. (The degrees are calculated by multiplying the percent by 360°)
7.) Have students complete their circle graph on the back of their chart and discuss how theirs is different/similar.
8.) Ask them the benefits of displaying data on a circle graph as aposed to the frequency table or a bar graph.

Name_____ Date_____

TV and Genetics Scavenger Hunt

Resource (Newspaper, TV Show, Movie, Books)	Time Spent	Genetic terms used	Number of terms from resource Total ___	% x 360° (Degrees of Circle)

Understanding and using data from the inherited Human Traits survey/activity.

OVERVIEW

There are numerous Scientific challenges that may be solved or investigated with the help of mathematical tools.

Challenge #1: Is it possible to use a class survey of character traits to make calculated and accurate predictions of larger population groups?

Challenge #2: How unique are we? (Mathematically speaking?)

Challenge #3: Which representations of data are best suited for given situations?

This activity will show students the practical application of data analysis, it helps students to work with data and to represent real life situations mathematically.

NORTH CAROLINA STANDARD COURSE OF STUDY OBJECTIVES MET

- 1.01 Develop and use ratios, proportions, and percent to solve problems.
- 1.03 Develop flexibility in solving problems by selecting strategies and using mental computation, estimation, calculators or computers, and paper and pencil.
- 4.01 Collect, organize, display and analyze date.
- 4.02 Calculate, use, and interpret the mean, median, mode, range, frequency distribution, and inter-quartile range for a set of data.
- 4.05 Solve problems involving two or more sets of data using appropriate statistical measures.

LEARNING OUTCOMES

Students will be able to:

1.) Represent gathered date in various ways [bar graphs, circle graphs, frequency tables.]
2.) Convert numbers from decimals to percent and percent to decimals.
3.) Calculate the probability of events.
4.) Use the mathematical data to reason various real life situations.

Pre-requisite skills

Students need to review probability.

The teacher needs to atempt to make students connect probability to percent.

LEARNING OUTCOMES (cont.)

Students should know how to convert percents to decimals and decimals to percents.

[Students may teach each other, be resourceful or apply work they have already been taught in order to complete this activity].

Students need to be able to construct *[or follow instructions how to]* Frequency tables, Bar graphs, and Circle graphs.

Students need to know the meaning of Histogram, tally, and frequency.

Students need to be able to calculate experimental probability *[This objective is from the 6th grade standard course of study]*.

Students need to be able to convert decimals to percent and percent to decimals.

MATERIALS

Overhead projector with the class survey data displayed.

A copy of the Math activity 1 sheet for each student.

Answer sheet for each student [optional].

Resources *[textbooks, dictionaries, Math study guides, class math notes, etc.]* for students to be resourceful.

THE LESSON PROCEDURE

Review worksheets

Briefly explain each of the characteristics displayed (the Science teacher should have already explained these).

Allow students to complete the chart (which is in the front of the class) by making tallys in the correct places. (Do this while students are completing the review worksheets.)

Once the class has all completed the chart and you have reviewed the required math, divide the class into pairs. It's useful if the abilities of the students in the pair can draw upon each others strengths. Explain to your students that today they are going to use mathematics to display scientific data, analyze and make predictions; discover how unique each individual is although we are 99.9% similar.

Hand out the Math Activity 2 sheet and monitor student progress. Allow 30 - 35 minutes for this activity *[depending on the ability of the class]*.

Allow questions #3 & 10 to stimulate a class discussion.

Name_____ Date_____

1. Select any 5 characteristics from the trait table (displayed on the overhead projector or front of the class) and complete a frequency table using this data. Once you have decided on the 5 traits complete the table below.

Characteristic	Tally male	Tally female	Frequency male	Frequency female

2. Use the date from question 1 to determine the mode for the data. Why do you think this is the most common trait? Is this trait more common in males or females? Why do you think this is the case?

_____

_____

_____

_____

_____

3.1 Rewrite each of your chosen characteristics as a percentage of the whole class. Remember in order to write a number as a percent, you need to divide the numerator by the denominator and multiply this quotient by 100.

Characteristic 1.

_____

Characteristic 2.

_____

Characteristic 3.

_____

Characteristic 4.

_____

Characteristic 5.

_____

3.2 Would you expect these characteristics to be similar to the rest of the classes in your school? Why do you say that?

_____

_____

_____

3.3 If you were in a class in a different country would you expect the results to be the same? Why do you say this?

_____

_____

_____

3.4 Use the data on the overhead projector to estimate how many left handed pairs of scissors you would need to order if you had to order scissors for a school with 1200 students. (Show your calculations).

_____

_____

_____

4. To write a percent as a decimal you need to divide the percent by 100. Rewrite each characteristic you have chosen as a decimal.

Characteristic 1.
_____

Characteristic 2.
_____

Characteristic 3.
_____

Characteristic 4.
_____

Characteristic 5.
_____

5. What do you notice about your answer to question 2 and your highest percent in question 4?

_____

_____

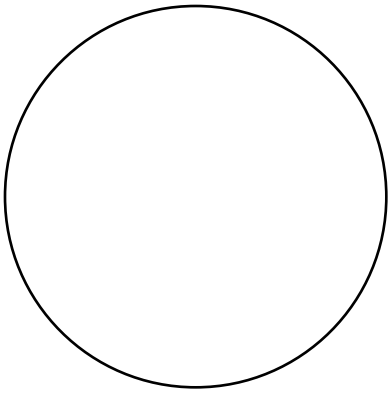
_____

6. Arrange your traits from least common to most common.

_____

_____

7. If your class consisted of 26 students, and 12 were males. Represent this data on a circle graph and shade in the dominant trait region. Remember to multiply each % by 360° to find the degrees of the circle. Use the protractor and compass from activity 1 to complete this activity.



8. Make a double bar graph for the five traits you have selected. Label the vertical axis (y) with the number of students in the class, and the horizontal axis (x) with the character traits for male and female.

9. Would you be able to graph the double bar graph in question 8 as a Histogram? Why would you say that?

_____

_____

_____

10.1 If your class had 28 students, 16 could roll their tongue, 12 had dimples and 8 had attached earlobes. What would the probability be that a student could roll their tongue, have dimples and have attached earlobes?

_____

_____

10.2 Is 10.1 experimental or theoretical probability? Why do you say this? How does this compare to your classes data?

_____

10.3 Rewrite this probability as a percent and a decimal.

_____

11. Rewrite and complete the following text by replacing each percent (in bold) with a decimal. Our DNA is 99.9% identical. Variation in human traits is caused by differences in 0.1% of our DNA. 0.1% roughly means 1 out of _____DNA bases is different.

_____

_____

_____

Overview: How Punnet squares may be used as a Mathematical tool.

NC STANDARD COURSE OF STUDY

7th Grade

1.01 Develop and use ratios, proportions, and percent to solve problems.

1.03 Develop flexibility in solving problems by selecting strategies and using mental computation, estimation, calculators or computers, and paper and pencil.

1.02 Develop meaning for percent.

From 6th grade

1.) Connect the model, number word, and number using a variety of representations.

2.) Make estimates in appropriate situations.

PREREQUISITES

- How to read a ratio.
- What is a ratio.
- Reducing ratios/fractions
- Dividing/multiplying by 100.

OVERVIEW

Problem: Can Punnet squares predict Mathematical outcomes? What is the significance of those outcomes.

LEARNING OUTCOMES

Students will be able to:

1.) calculate ratios and probability of each outcome

2.) represent each outcome as a decimal, percent and fraction

3.) use the evidence in Punnet squares to make sound mathematical predictions.

BACKGROUND ESSENTIALS

Before starting this activity, be sure that students know how to draw up and complete a Punnet square and correctly identify the dominant trait for each of the four squares. As this connects with the Science activity, students should know how to complete Punnet squares but may not see the Mathematical connection neccessarily.

WARM UP ACTIVITY

On the overhead[or on the board], have a blank Punnet square and ask the students to copy it out and complete it. Place the following Genotype in your Punnet square. Ask them for the Phenotype for each genotype. [TT and tt}. Ask them the following questions to make sure they understand how it presents mathematical evidence: What is the ratio of Tall [T] plants to short [t] plants? Write that as a percent.

What would happen in the second generation when Tt crosses with Tt? How would this ratio change from the first? Hand out the Math activity sheet 3. Allow students 20 - 25 minutes to complete this. Allow them to use their books for assistance if the class responds well to groupwork allow them to work in pairs.

Name_____ Date_____

1.

AA	Aa
Aa	aa

The Punnet square above symbolizes potential Albinism [the inability to produce melanin which gives skin, hair and eyes color]. Normal pigmentation is symbolized by A while another allele codes for
albinism is symbolized by a.

1.1 What is the ratio for having Albinism to not having it?

_____

1.2 What fraction of children will have normal skin pigmentation?

_____

1.3 Write each example in 1.2 as a decimal and a percent.

_____

1.4 Write and then solve an equation to determine how many children would most likely have albinism if the parents had 8 children. Hint: your equation may be solved by setting up a proportion and cross multiplying.

_____

_____

2. The Punnet square in question 1 may also be represented as a ratio of 1:2:1 [as ¼ or 1 genotype is AA, ½ or 2 are Aa and ¼ or 1 is aa.]

2.1 Using the same method for expressing ratios express the following Punnet square in the same way.

AA	Aa
aa	aa

Why is this ratio also in three parts? Name them and write them as a ratio.

_____

_____

2.2 Which fraction of the parents' children will most likely have Albinism?

_____

2.3 Express this as a decimal and a percent.

_____

2.4 How many children out of 6 would most likely have normal pigmentation? Express this as a numerical expression. (Write out a number sentence to explain how you found your answer.)

_____

_____

_____

Solving Real World Problems through Math and Science

OVERVIEW

Problem: How to determine whether crossbreeding is beneficial through analyzing graphs.

NC STANDARD COURSE OF STUDY

7th grade

4.05 Solve problems involving two or more sets of data using appropriate statistical measures.

5.01 Identify, analyze, and create linear relations, sequences, and functions using symbols, graphs, tables, diagrams, and written descriptions.

8th grade

5.02 Develop an understanding of function.

1.) Translate among verbal, tabular, graphic, and algebraic representations of functions.

2.) Identify relations and functions as linear or nonlinear.

3.) Find, identify, and interpret the slope (rate of change) and intercepts of a linear relation.

4.) Interpret and compare properties of linear functions from tables, graphs, or equations.

5.03 Solve problems using linear equations and inequalities, justify symbolically and graphically.

PREREQUISITES

Students need to be able to:

1.) identify quadrants in a co-ordinate plane
2.) understand and use function tables
3.) identify the change of increase/decreasing slopes
4.) plot co-ordinates
5.) know how to identify the co-ordinates and their meaning in the context of a graph/.

LEARNING OUTCOMES

Students will be able to:

1.) identify graphs, slope of graphs, and dependant and independent variables;
2.) interpret properties of linear functions;
3.) solve problems involving linear functions.

WARM UP

Ask students to take out their “bugs” which they have designed. Ask them if they look similar to each other? Ask them which ones in particular look more similar than others? Ask them if they think it would be possible to crossbreed any of them and discover a similar bug?

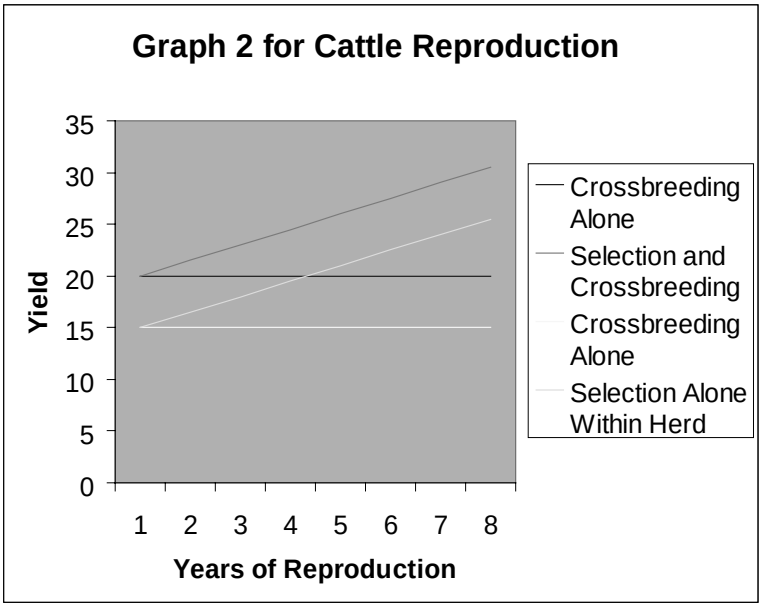
Ask students how they know the bugs may all be from the same family? Ask them what other creatures appear to be from the same species but look different.

Ask students what potential benefits there are to crossbreed species? Ask them if they know of any plants that have been cross bred?Let them know that today they will investigate crossbreeding in cattle.

Hand out and complete the worksheet.

Name_____ Date_____

Crossbreeding alone is no guarantee that increased production will occur. As always, genetic selection plays a vital role in improving production. The diagram below emphasizes your crossbreeding program.



1.1 How many graphs are you able to see? _____
(label them with letters starting with the letter A)

1.2 Do all the graphs have slopes? If not which don't? _____

_____

1.3 Label each axis correctly with an x and a y.

1.4 Which axis is dependent and which is independent? Explain your reasoning.

_____

_____

1.5 Why do two sets of graphs appear to have parallel lines? _____

_____

2.1 If you were a farmer who had never practiced crossbreeding and were shown this graph, how would you react? What changes would you implement? _____

_____

_____

Background experience in the laboratory.

OVERVIEW

Problem: many student have a limited concept of measurement and in particular the metric system.

This activity will allow students to work with grams and milliners and see the connection between the two.
It provides valuable laboratory practice before extracting DNA.

NC STANDARD COURSE OF STUDY

6th grade

- 1.06 Use exponential, scientific, and calculator notation to write very large and very small numbers.
- 2.01 Estimate and measure length, perimeter, area, angles, weight, and mass of two- and three- dimensional figures, using appropriate tools.

7th grade

- 5.01 Identify, analyze, and create linear relations, sequences, and functions using symbols, graphs, tables, diagrams, and written descriptions.
- 5.02 Translate among different representations of algebraic expressions, equations and inequalities.
- 5.03 Use and evaluate algebraic expressions, linear equations or inequalities to solve problems.
- 5.04 Develop fluency in the use of formulas to solve problems.

LEARNING OUTCOMES

Students will be able to:

1.) measure the mass of various quantities of water and enter these relative readings into a function table;
2.) graph the co-ordinates for these points;
3.) conclude a result given the evidence of the graph and the pattern of the table;
4.) determine the slope of the given line, predict the weight of an unknown container.

ACTIVITY

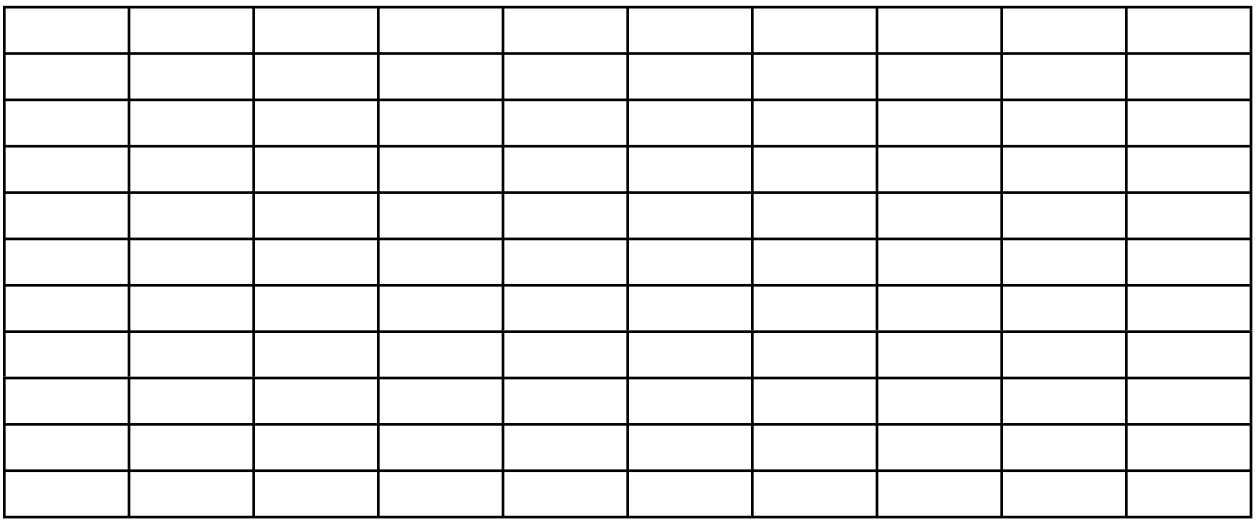
Supply each group with Math activity 5 worksheet, a balance, a container which is able to hold at least 500 ml water, a pouring container with ml clearly marked. This activity may precede the Science activity as it prepares students for some very basic lab work before extracting DNA.

Name_____ Date_____

1.1 Place your empty container on the balance. Pour 50ml, 100ml, 150ml, 300ml, 500ml of water into the container and take a reading in grams for each amount poured. Record your results on the table below.

(x) Volume (y) Mass						
x	**50ml**	**100ml**	**150ml**	**300ml**	**400ml**	**500ml**
y						

1.2 Plot the points on the graph below. Choose a suitable scale and label each axis.



1.3 Is your graph linear? What does this mean? What is the slope of your line? The slope formula is (y2 - y1) / (x2 - x1).

_____

_____

_____

1.4 What does the y co-ordinate indicate when the x co-ordinate is zero?

_____

(x) Volume (y) Mass						
x	**50ml**	**100ml**	**150ml**	**300ml**	**400ml**	**500ml**
y	**50**	**100**	**150**	**300**	**400**	**500**

2.1 Graph the second function table on the same graph- is this function table on the same co-ordinate plane as number 1? What is the difference between the two gaps? _____

_____

2.3 What is similar about the two graphs? _____

_____

2.4 Which graph do you think more accurately represents the relationship between x and y? Why do you say that?

_____

_____

3.1 Using the data that you have discovered or the graph, what is the mass of 1000ml? Which graph did you use? Why did you use that graph?

_____

_____

3.2 What is the volume of one ton? How many grams is one ton? Represent this in scientific notation.

_____

_____

_____

_____

Identifying Various Views

BACKGROUND/ PREREQUISITES

6th grade

3.01 Identify and describe the intersection of figures in a plane.
3.04 Solving problems involving geometric figures.
2.01 Estimate and measure length, perimeter, area and angles of 2 & 3 dimensional figures.
2.02 Solved problems involving perimeter/circumference and area of plane figures.

7th grade

3.01 Using three-dimensional figures:
1. Identify, describe, and draw from various views (top, side, front, corner).
2. Build from various views.
3. Describe cross-sectional views.

2.02 Solve problems involving volume and surface area of cylinders, prisms, and composite shapes.

OVERVIEW

Problem: How to identify the op view of various objects.

In the 7th grade, students are required to draw top, side and front views of the 3 dimensional objects. This is a useful skill in science when identifying various 3 dimension figures to draw the top, side and front view of certain objects. Secondly they will be given the top view of certain objects and identify the object. They will use their models from Science activity 7 to accompany the worksheet that is included in this Activity.

MATERIALS/ EQUIPMENT

- DNA model
- Overhead projector
- Transparencies
- Worksheet

PREPARATION

- Place warm up transparency on overhead or board
- Make copies of the handout
- Display students models/ in the front of the class.

PROCEDURE/ WARM UP

- Allow students 5-10 minutes to complete warm up/overhead activity.
- Discuss possible answers/solutions
  Ask students “How they would be able to identify various cell structures under a microscope?” Ask if we always see the top

PROCEDURE/ WARM UP (cont.)

view of objects when looking through a microscope? Discuss the importance of being able to identify various views. (Relate why this skill is important fort Scientists/Builders and even Pilots.)

- Hand out the worksheet. Walk them through the first questions by showing them how various views of objects look on the overhead projectors by projecting their shadow for the various views.
- Walk them through the first activity. Show them the solution on the overhead.
- Allow them to complete the activity worksheet while circulating the room (15 - 20 minutes).

CLOSURE

Display the answers on the overhead or make several copies and allow them to check their answers in graphs.

HINT

Often students are able to identify the outline of the various views but forget/don't see the detail. Emphasize this. A good example is the side view of a coffee cup that has a rectangle (the handle) which they often leave out.

Name_____ Date_____

1. Choose the correct word from the list to label each object. [the pictures of the following will be handed out on a separate sheet of paper]

   List: Funnel Beaker
   Bunsen Burner Test Tube

2. Draw the top, front and side views for each object.

3. What are the formulas for the volume and surface area of rectangle prisms and cylinders?

_____

_____

_____

BONUS 1 *(extra credit)*

4.1 If a rectangle prism shaped fish tank with dimensions 1m, 2m, and 3m leaks into a bucket with a height of 25 cm and a radius of 30 cm and fills the bucket, how much water is left in the fish tank?

_____

_____

_____

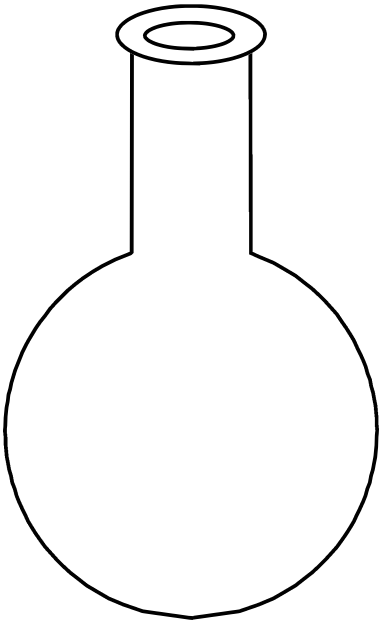
_____

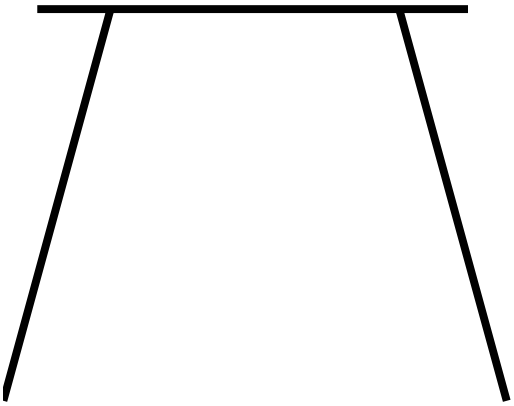
4.2 If 2 buckets are filled every three hours, how long will it take before the fishtank is empty?

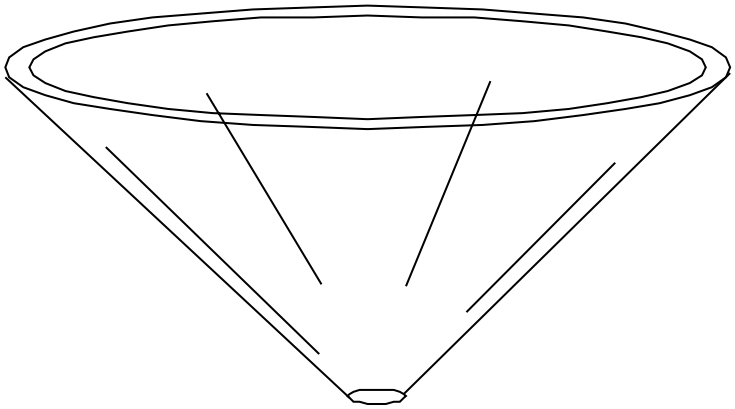
_____

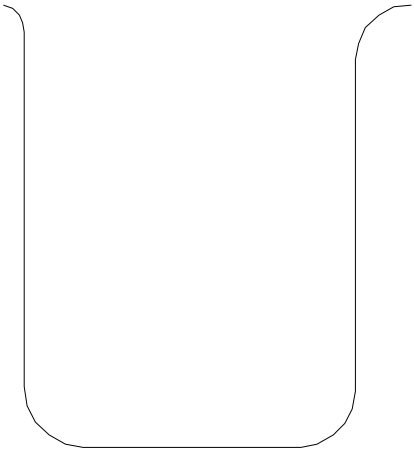
_____

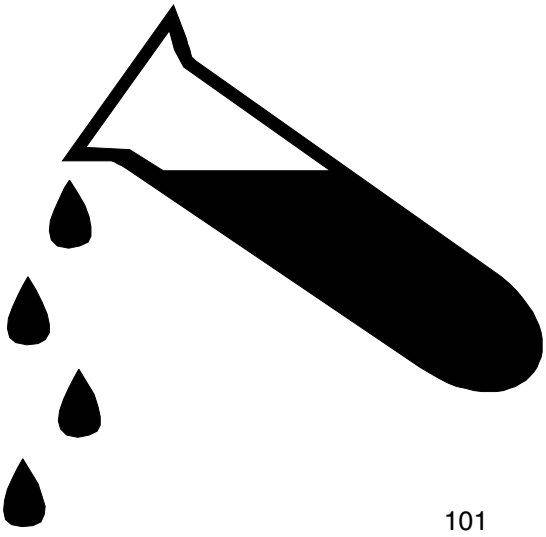
(Hint: When asking students to draw various views, allow them to use isometric dot paper.)











Data Analysis to further scientific reasoning

OVERVIEW

Problem - This is a mathematical follow up to the guided research mini project from the Science Activity 8. The aim is for students to be able to analyze data from various graphs and charts to further their knowledge, draw conclusions and analyze various forms of data related to diseases.

NC STANDARD COURSE OF STUDY

5.01 Identify, analyze and create linear relations, sequences and functions using symbols, graphs, tables, diagrams, and written descriptions.
5.02a. Calculate, use and interpret mean, median, mode, range and frequency distribution.
5.02b. Translate among different representations of algebraic expressions, equations and inequalities.
5.03 Use and evaluate algebraic expressions, linear equations or inequalities.

PRE-REQUISITES

Students need to remember how to:

1. plot points
2. identify co-ordinates

EQUIPMENT/ MATERIALS

- Calculator
- Graphing paper
- Worksheets
- Warm up: diagram of 3 linear functions 2 of which are parallel.

PROCEDURE

Warm up.
Review work required with quick checkpoint quiz (on overhead or board).

1. Which line is steeper?
2. What is the slope of each line?
3. Why does the one seem to be parallel to the other, what does that mean?

Hand out the worksheet package with the 4 graphs.

After 10 - 12 minutes for each graph, discuss each of the 4 solutions.

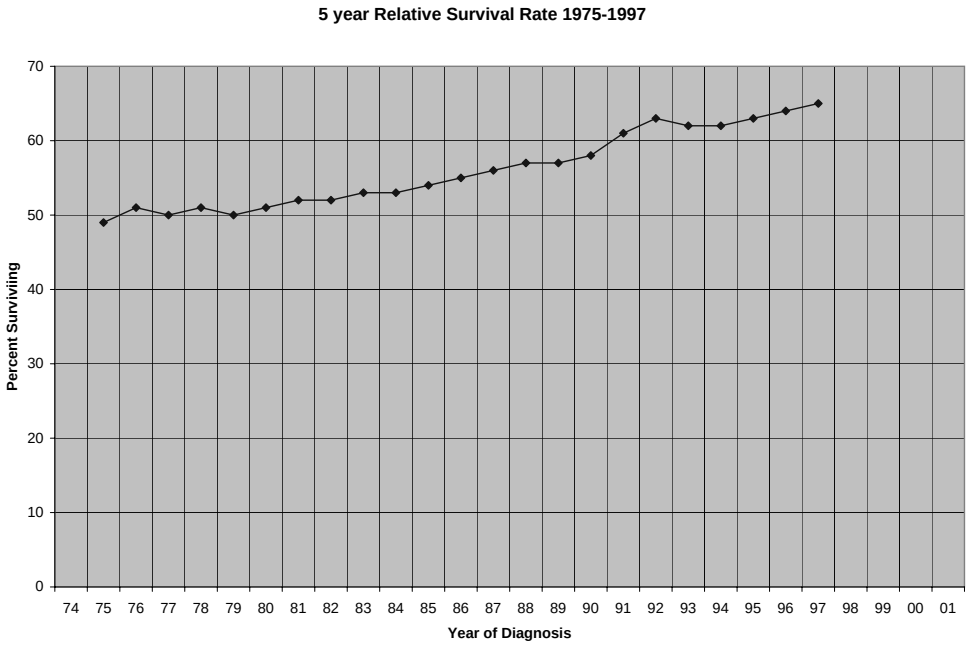
CLOSURE

Here are a few suggested questions to stimulate students' thinking about each graph.

1. Compare and contrast the graphs.
2. Why are the graphs useful?
3. Why would they vary from region and race to race?

Hint: (The last three questions will be a useful homework assignment).

Name_____ Date_____



1. Does this graph have a trend/pattern? If so, what is it saying?

_____

_____

2. What is the steepest part of the graph, what does this mean?

_____

_____

3. 1975-1979, compare with 1983-1987.

_____

_____

4. What is the target line for healthy people?

_____

_____

5. Predict when this target/goal will be reached.

_____

_____

6. Slope is measured by change in y (percent surviving) and dividing it by change in x (years of diagnosis). What is the linear slope from 1974-1997 or from the co-ordinates (1974, 50) (1997. 65). What does the slope represent?

_____

_____

7. Is it possible to determine a function rule for this graph if you were only given the co-ordinates from question 6? What would this rule be?

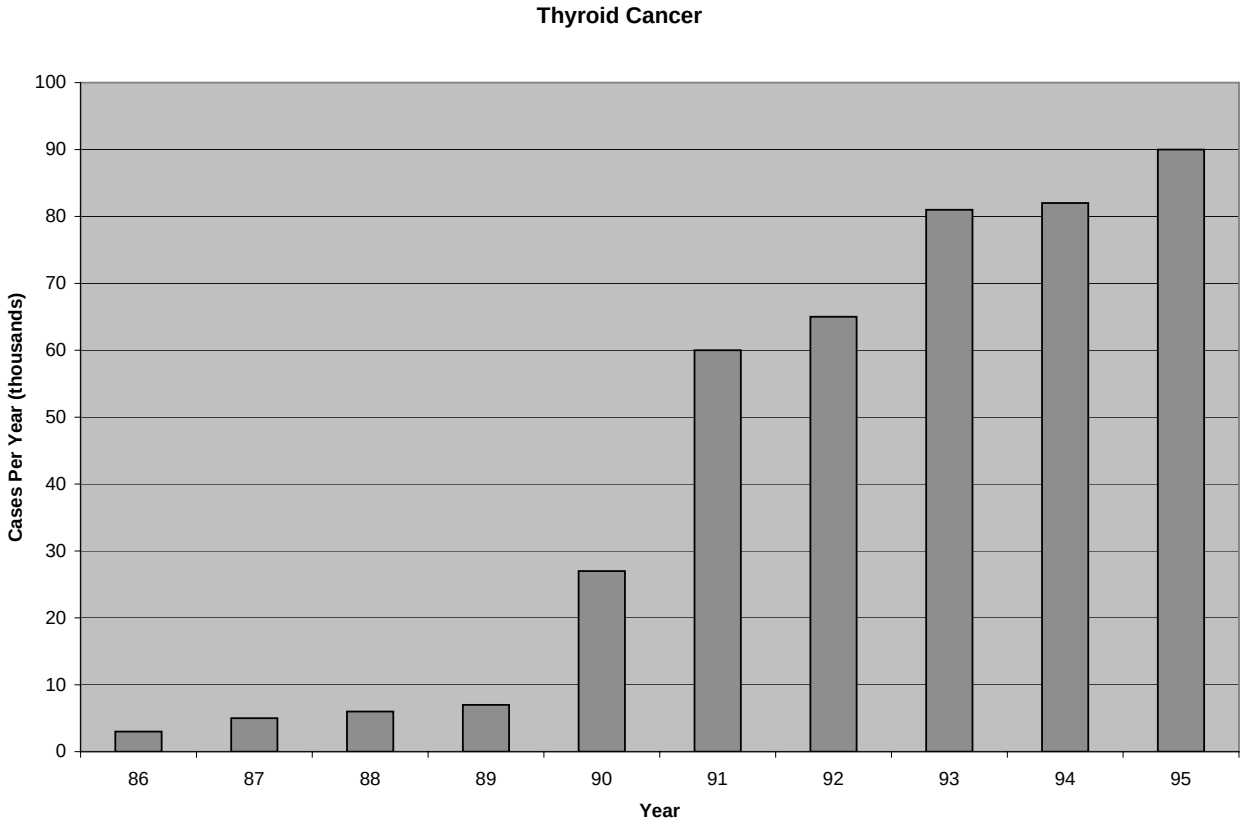
_____

_____

_____

_____

Name_____ Date_____



1. What is this graph indicating as far as thyroid cancer?

_____

_____

_____

2. What would you expect the cancer cases to be in 2000?

_____

_____

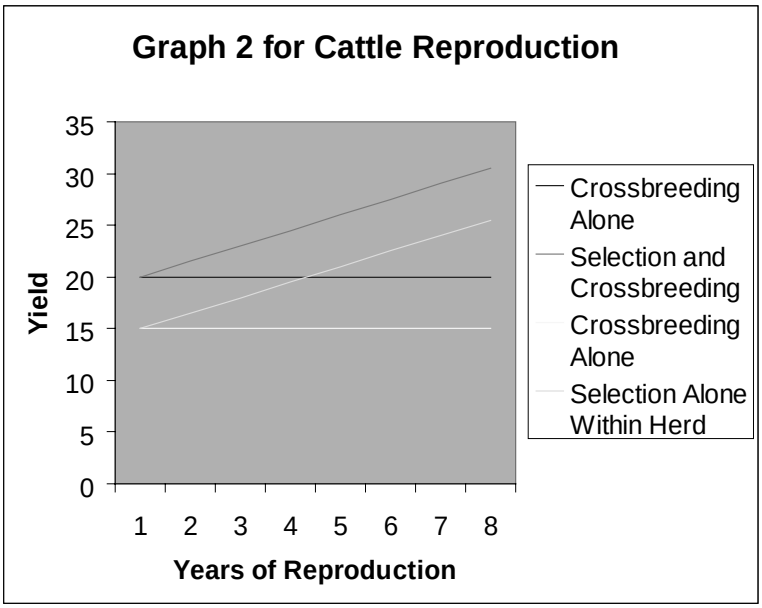
_____

3. Why do you think there appears to be such a huge increase from 1990-1991?

_____

_____

Name_____ Date_____



1. How many graphs do you see? _____

2. How many have slopes? _____

3. Which is the dependent/independent variables? _____

_____

4. Label the x, y, axis.

5. Explain why selection plus crossbreeding and selection alone within a herd have the same slope.

_____

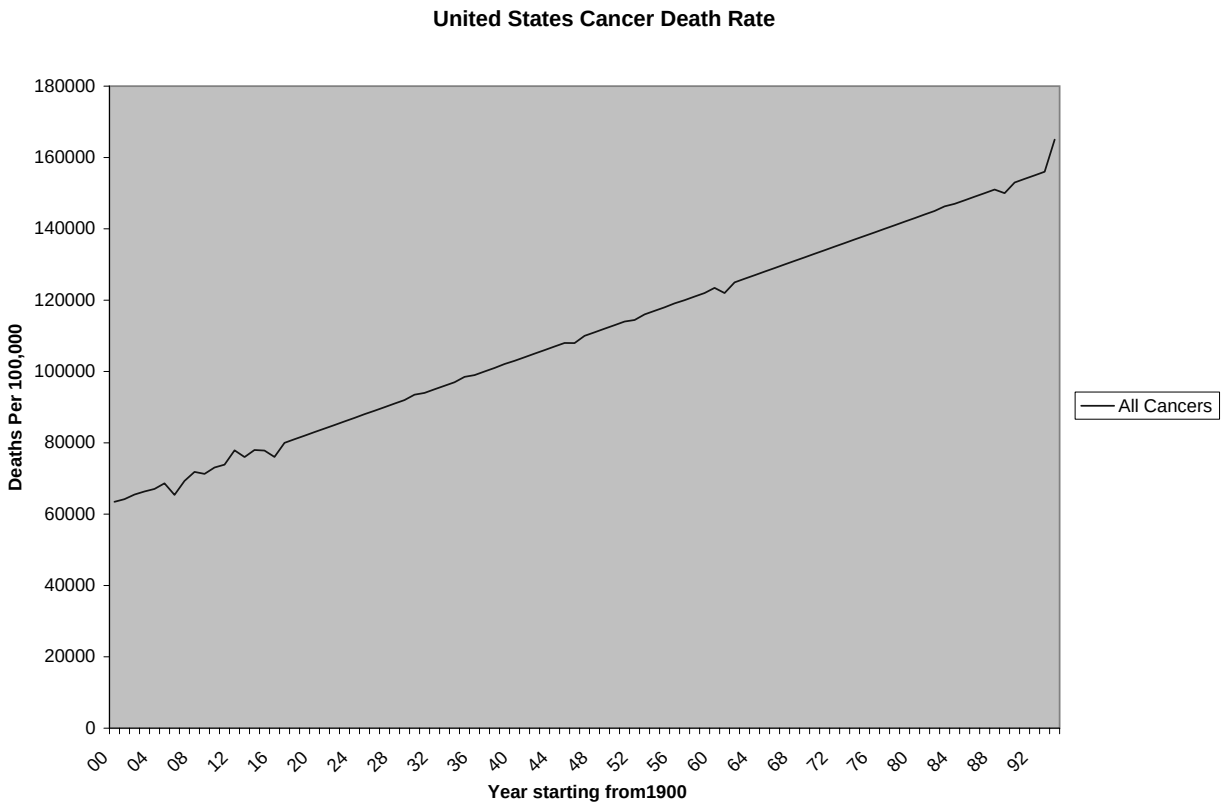
_____

_____

6. As a farmer, what does selective crossbreeding suggest?

_____

Name_____ Date_____



1. If this data showed a linear pattern, it would be represented by the following equation. (y= 3/2x + 68). Complete a function table below. Remember 1920 is represented as 20 for x.

1920	1940	1960	1982	1990		

2. Now plot your 5 new co-ordinates on your graph, how close are they to being on the line?

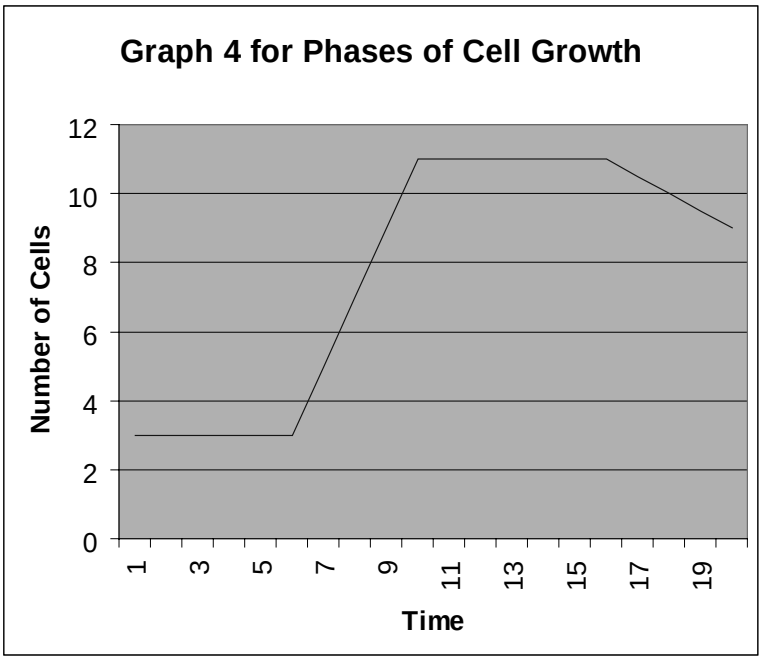
_____

_____

_____

_____

Name_____ Date_____



1. Break this graph up into 4 stages and explain each step.

_____

_____

_____

2. Which has positive stage slopes?

_____

_____

3. Which has negative slopes?

_____

_____

4. Describe the possible reasons for the death stage.

_____

_____

GATTACA

This is a great activity to stimulate class discussion.

SCIENCE OBJECTIVES

[Although the movie may not be Scientific, it presents useful practice for the following objectives]:

1.10 Analyze and evaluate information from a Scientifically literate viepoint.

1.08 Use Oral & Written language to communicate findings and defend conclusions of scientific investigations.

PROCEDURE

Day 1 -- 60 minute lesson

Watch the first 40 - 45 minutes of the DVD with the following (all the relevant themes, discussions and viewpoints are in this time and two disturbing scenes are not viewed) questionnaire to ensure that the DVD is being analyzed correctly and students are attentive.

1. Why was Vincent not given his father's name?
2. What sacrifices did Vincent make to become Jerome?
3. What is the3 difference between "Valids" and Invalids"?
4. The quote from Ecclesiastes 7:13 "Consider what God has done: Who can straighten, what he has made crooked." Who is attempting to straighten the crooked? How is this being done?
5. What is symbolic about the spiral staircase in Jerome's apartment?

Answers may vary. Here are a few possible answers:

1. His son was not the "best" of him.
2. Change of identity; lengthen his legs, contact lenses, daily sacrifices.
3. Natural vs. unnatural birth.
4. The Genetics are strengthening human flaws.
5. Same shape as the double helix.

After the DVD, spend some time answering the above mentioned five questions.

Day 2 -- Allow 6 - 7 minutes to discuss each theme.

Themes to discuss [5 - 6 minutes each]

[This may be used as a class discussion or in small groups, I prefer to allow my students to briefly discuss each theme in pairs and then conduct a class discussion]

PROCEDURE (cont.)

- The Valids are genetically perfect yet seem unhappy? Do you agree or disagree? Justify your viewpoint.
- For Vincent to obtain freedom, he became a slave. Who did he become a slave to?
- How does knowledge of the future effect the way Vincent was treated? Think about how the future of the world is in our hands. What dangers are there ahead? What are we doing about it?
- If everyone in the world was a Valid, what would the world be missing or would have missed already? Would the world be a better place?
- The human spirit has no DNA, true or false? Justify your answer.
- What are your goals? What sacrifices did Vincent make? Are you willing to make any?

Name_____ Date_____

1. The word Gattaca is 'composed' of four nucleotide bases. Name these 4 bases.

_____

_____

2. In Greek "Eugene" means "well born" and Vincent means "to overcome." How applicable are these names for characters?

_____

_____

_____

3. How would medical aide companies and employees treat you if they knew what your DNA consisted of?

_____

_____

_____

4. Vincent says in the movie that his heart is already 10,000 beats overdue. How long is this? (The average heart rate is 72 beats per minute.)

_____

_____

Bonus/extra credit questions.

5. The following famous people had "defective" DNA. Who were they and what form of disease did they have? Abraham Lincoln, John F. Kennedy, Rita Hayworth, and Stephen Hawking.

_____

_____

_____

_____

6. How would the world be different if (Describe the person and their type of disease) were changes/altered?

_____

_____

_____

_____

7. Compare/contrast the two main characters.

_____

_____

_____

_____

8. What would you do if you were an Invalid in a Valids world? How would you react/respond?

_____

_____

_____

9. “My real resume is in my cells. They have discrimination down to a science.” Discuss how applicable this is to the movie.

_____

_____

_____

_____

Math Extension for Science Activity 9
[Nature Vs Nurture]

OVERVIEW

Problem: Is there Scientific evidence we can use to determine whether disease is a result of heredity or environment?

This activity will encourage students to read various Scientific articles and substantiate their opinion by representing their findings both verbally and Mathematically.

NCSCS GOALS

Math

- 4.01 Collect, organize, analyze and display data to solve problems.
- 1.01 Develop and use ratios, proportions and percents to solve problems.
- 1.02 Develop fluency in addition, subtraction, multiplication and division of rational numbers.

Science

- 1.06 Use Mathematics to gather, organize and present quantative data resulting from Scientific investigations.
- 1.08 Use oral and written language to communicate findings; defend conclusions of Scientific investigations.
- 5.01 Explain the significance of genes to inherited characteristics
- 5.06 Evaluate evidence that human characteristics are a product of human environment/lifestyle.

This activity is a culmination of the first 8 Math and Science activities.

During this activity students should:

1. Use evidence to offer descriptions, predictions and models.
2. Think critically and logically to bridge the relationships between evidences and theory.
3. Formulate questions leading to further investigations.
4. Evaluate Scientific data
5. Represent Scientific articles Mathematically/graphically
6. Justify Scientific findings

MATERIALS

Use the following articles [the url is given]

1. Cancer-Nature, Nurture or Both
   http://www.mindfully.org/Health/Cancer-Nature-Nurture-Both.htm
2. The New Nature Vs Nurture [first page only]
   http://www.wired.com/wired/archive/11.03/start_pr.html

MATERIALS (cont.)

3. Puberty and Genetic Susceptibility to Breast Cancer in a case-control study in twins http://content.nejm.org/cgi/content/abstract/348/23/2313
4. Nature Vs Nurture Revisited http://www.pbs.org/wgbh/nova/genome/debate.html
5. Nature Vs Nurture: The debate http://www.cancer.org/docroot/NWS/content/NWS_1_1x_Nature_vs_Nurture_The_Debate.html
6. Sibling Rivalry http://pinker.wjh.harvard.edu/articles/media/2002_10_13_bostonglobe.html

WARM UP

Give each student a copy of the first article mentioned. Allow them 5-7 minutes to read this article.
Ask them the following questions:

1. What gives this study a few advantages over similar studies? What can we learn from this when we conduct a study?
2. If this study were to have any flaws, what would they be?
3. What mathematical evidence is used in this article. How effective could mathematics be used to enhance the debate?

PROCEDURE

Explain to your students that today they are going to be given 5 additional articles. They are to decide whether they believe in the Nature or the Nurture side of the debate. [They must decide on one at this point]. They have to validate their opinions with facts from the relevant articles. They may use as many different Mathematical/visual graphs, charts or conversions of numbers to further validate their opinion.

Remind students that part of agreeing with one side is to disagree with the other side or to see potential flaws[just like in the warm up].Remind them about the mathematical tools they used in activities 1-8 and encourage visual representations of the text. Allow the class 45-60 minutes to work in pairs or individually. Once the class completes this, allow 3-5 minutes for each presentation.

CLOSURE

After the class has completed their presentations discuss why health style choices may reduce the risks of certain diseases. Ask if they know of any [smoking, working with asbestos etc.] A great homework assignment will be to ask students to design a 20 point health plan to potentially limit the risks of various diseases.