Exploring Genetics Across the Middle School Science and Math Curricula

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Carol Cutler White, Editor

2nd Edition
July 2014

NC STATE UNIVERSITY
College of Agriculture and Life Sciences

NSF Award #1025830
Epigenome Dynamics
During DNA Replication

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Dear Middle Grades Educator,

Exploring 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 developed and tested the activities in a school setting. The activities are easily implemented and follow current Common Core Math standards, the North Carolina Essential Science Standards and the former North Carolina Standard Course of Study standards 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 curriculum was developed as an outreach project for a National Science Foundation research project in plant genomics (DBI-0421651 in 2007 and DBI-1025830 in 2014). We are very grateful to the Foundation for continuing support. In addition, we want to thank our NCSU colleagues, Drs. Bryon Sosinski and George Allen, for their many contributions. Dr. Allen, especially, coordinated much of our educational outreach effort. We also wish to thank the postdoctoral associates and graduate students who contributed their time and expertise during the past decade of exciting research and without whom this project would have been impossible. Dr. Randall Shultz, then a graduate student, helped conceive the project and contributed to its first phase. Drs. Tae-Jin Lee and Sharon Settlage also made major contributions to the first phase of the research, as did Drs. Miguel Flores and Mariana Franco-Ruiz, who were then graduate students. Drs. Tae-Jin Lee, Pete Pascuzzi and Lorenzo Concia, together with Mss. Emily Wear and Leigh Mickelson-Young, were important contributors to the second phase, along with graduate students Ashley Brooks and Emily Markham.

Credit for the activities contained within this project goes to science teacher Dr. Jeff Batten at Hawley Middle School (Granville County, N.C.) and to math teacher Rob Caine at Franklin Academy (Wake County, N.C.) for 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 NC State enjoyed getting to know these two talented and dedicated teachers.

This second edition incorporates North Carolina Essential Standards for Science and Common Core standards for Math to expand the reach of the curriculum beyond North Carolina. Our goal is to make this important resource available as widely as possible to engage the next generation of genetic scientists in early discovery. We encourage you to join other middle grade educators teaching genetic science by following the project on Twitter (@MidSchlgenesci), through the project's wiki https://exploringgenetics.wikispaces.com, or through Pinterest Plant Science.

Finally, a very important word of thanks goes to Carol Cutler-White for developing the concept, creating the collaboration and managing the project. She has been a great colleague and essential member of the team. We trust you will find this curriculum to be highly valuable as you teach science and math at your school.

Sincerely,

Dr. William F Thompson
University Distinguished Professor
Department of Plant and Microbial Biology

Dr. Linda Hanley-Bowdoin
William Neal Reynolds Distinguished Professor
Department of Molecular and Structural Biochemistry

Social Media Outreach

The Second Edition intends to leverage the power of social media to distribute the curriculum broadly within the middle grade science teacher community. Please join in the conversation of this very important topic of understanding plant genetic science. This NSF project is complete, but we look forward to a third edition!

Twitter:

@MidSchlgenesci

Pinterest:

Plant Science pins

Join Dr. Batten for this project's wiki:

https://exploringgenetics.wikispaces.com

Share the complete *Exploring Genetics Across the Middle School Science and Math Curriculum* with your fellow teachers! The manual can be downloaded from the Cold Spring Harbor Plant Replication website:

http://bonaire.cshl.edu/plantrep/ppt/ExploringGenetics.pdf.

We recommend you follow NC State, the premier research institution in North Carolina.

NC State Twitter

@NCState

#ThinkandDo

@ncsu_cals

The National Science Foundation is very active on Twitter and provides a great resource for finding out about new discoveries!

National Science Foundation Twitter

@NSF_BIO

@NSF

Acknowledgments and Biography

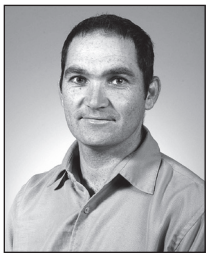
Special thanks to:

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.

Dr. Batten's students who assisted development and testing of the curriculum including Samantha Capps, Ben McCuiston, Lizandra Valdes, Ashley Carrion, Devonte Terry, Misty Riley, Taylor Upchurch, Alea Satterwhite, Michaela Howell, Thomas Campbell, Michael Foster, and Matthew Higgs.

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 is at G.C. Hawley Middle School in Granville County, where he teaches middle school science and math EOG test prep, and is a mentor and team leader. He was selected as Hawley's Teacher of the Year in 2014. Dr. Batten also teaches biology and environmental science courses at the University of Phoenix – Raleigh Campus.



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 completed his National Boards in mathematics. Robert currently teaches math at Franklin Academy in Wake Forest, NC.

Erin Batten-Hicks is an eighth grader at Hawley Middle School in Creedmoor, N.C. While in elementary school, Erin helped her father, Dr. Jeff Batten, develop a series of science outreach projects for families called Saturday Morning Experiments. Erin also helped test most of the science activities in this manual. She helped design and test the DNA Forensics Activity (#10). In 2011 and 2012, Erin assisted with summer teacher-training workshops, demonstrating genetics activities and working with teachers and museum staff.

Overview of the Second Edition

The second edition of *Exploring Genetics Across the Middle School Science and Math Curriculum* builds upon nearly 10 years of collaboration through the previously successful curriculum and teacher training outreach from National Science Foundation Plant Genome Research Project (NSF PGRP) DBI-0421651. The North Carolina Museum of Life and Science in Durham, North Carolina served as the primary partner for outreach for the PGRP project from 2006-2013 where the curriculum was presented through summer teacher workshops. Dr. Batten and Mr. Cain worked with Nancy Dragotta-Muhl and Shawntel Landavazo from the Museum in packaging the genetics curriculum for distribution through the Museum's Science in a Suitcase outreach program. These museum staff provided initial guidance and workshop space for demonstrating this curriculum to public and homeschool teachers throughout North Carolina. Thousands of public school students in the Research Triangle Park region of North Carolina benefitted from the Science in a Suitcase program.

COMMON CORE STANDARDS

With the nationwide movement toward Common Core standards, the NC State University outreach team realized an opportunity to expand the impact of the NSF PGRP genetics curriculum. This second edition realizes this goal by aligning each of the Science and Math activities to the Common Core.

The second edition (NSF DBI-1025830) incorporates the Common Core Standards, thereby expanding the reach of the curriculum to a national audience of middle grade teachers. Both the science and the math activities were originally aligned to the former (prior to 2012) North Carolina Standard Course of Study This revised edition incorporates realignment with the Essential Standards (Science) and Common Core (Math) adopted by North Carolina in 2012. Additionally, the Essential Standards, Common Core, and former Standard Course of Study objectives are listed within each activity. Both science and math activities encompass elements of the 6th – 8th grade curricula, with an emphasis on 7th grade.

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 University, 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.

CONNECTING SCIENCE AND MATH FOR INTERDISCIPLINARY LEARNING

The activities contained within this manual are intended to be used for interdisciplinary purposes. The activities correlate as follows:

Science Activity	Math Activity
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
10	n/d

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 North Carolina Triangle-area school districts: Prentice Hall, McDougal Littell, and Holt.

McDougal Littell Science Integrated Course 2, Teacher'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, Teacher'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, Student's Edition™
Holt, Rinehart, and Winston, Orlando, FL
Copyright 2005
ISBN: 0-03-022263-1
696 pages

North Carolina Science Essential Standards and former Standard Course of Study

6.L.1 Understand the structures, processes and behaviors of plants that enable them to survive and reproduce.

6.L.1.1 Summarize the basic structures and functions of flowering plants required for survival, reproduction and defense.

6.L.1.2 Explain the significance of the processes of photosynthesis, respiration and transpiration to the survival of green plants and other organisms.

7.L.2 Understand the relationship of the mechanisms of cellular reproduction, patterns of inheritance and external factors to potential variation and survival among offspring.

7.L.2.1 Explain why offspring that result from sexual reproduction (fertilization and meiosis) have greater variation than offspring that result from asexual reproduction (budding and mitosis).

7.L.2.2 Infer patterns of heredity using information from Punnett squares and pedigree analysis.

7.L.2.3 Explain the impact of the environment and lifestyle choices on biological inheritance (to include common genetic diseases) and survival.

7.L.1 Understand the processes, structures and functions of living organisms that enable them to survive, reproduce and carry out the basic functions of life.

7.L.1.1 Compare the structures and life functions of single-celled organisms that carry out all of the basic functions of life including:
- Euglena
- Amoeba
- Paramecium
- Volvox

7.L.1.2 Compare the structures and functions of plant and animal cells, including major organelles (cell membrane, cell wall, nucleus, chloroplasts, mitochondria, and vacuoles).

8.L.2 Understand how biotechnology is used to affect living organisms.

8.L.2.1 Summarize aspects of biotechnology including:
- Specific genetic information available
- Careers
- Economic benefits to North Carolina
- Ethical issues
- Implications for agriculture

8.L.4 Understand the evolution of organisms and landforms based on evidence, theories and processes that impact the Earth over time.

8.L.4.2 Explain the relationship between genetic variation and an organism's ability to adapt to its environment.

North Carolina Standard Course of Study Middle Grades (former) 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.

North Carolina Math Common Core Standards and former Standard Course of Study

6.RP Understand ratio concepts and use ratio reasoning to solve problems.

6.RP.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

6.RP.3 Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.

6.EE Represent and analyze quantitative relationships between dependent and independent variables.

6.SP Develop understanding of statistical variability.

6.SP.1 Recognize a statistical question as one that anticipates variability in the data related to the question and accounts for it in the answers.

6.SP.2 Understand that a set of data collected to answer a statistical question has a distribution, which can be described by its center, spread, and overall shape.

6.SP.3 Recognize that a measure of center for a numerical data set summarizes all of its values with a single number, while a measure of variation describes how its values vary with a single number.

6.SP.4 Display numerical data in plots on a number line, including dot plots, histograms, and box plots.

6.SP.5 Summarize numerical data sets in relation to their context.

7.RP Analyze proportional relationships and use them to solve real-world and mathematical problems.

7.RP.2 Recognize and represent proportional relationships between quantities.

7.RP.3 Use proportional relationships to solve multistep ratio and percent problems.

7.NS Apply and extend previous understandings of operations with fractions to add, subtract, multiply, and divide rational numbers.

7.NS.3 Solve real-world and mathematical problems involving the four operations with rational numbers.

7.EE Solve real-life and mathematical problems using numerical and algebraic expressions and equations.

7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

7.G Draw, construct, and describe geometrical figures and describe the relationships between them.

7.G.1 Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.

7.G.2 Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions.

7.G.3 Describe the two-dimensional figures that result from slicing three dimensional figures, as in plane sections of right rectangular prisms and right rectangular pyramids.

7.G.4 Know the formulas for the area and circumference of a circle and use the to solve problems; give an informal derivation of the relationship between the circumference and area of a circle.

7.G.6 Solve real-world and mathematical problems involving area, volume and surface area of two and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.

7.SP Use random sampling to draw inferences about a population.

7.SP.1 Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid inferences.

7.SP.2 Use data from a random sample to draw inferences about a population with an unknown characteristic of interest. Generate multiple samples (or simulated samples) of the same size to gauge the variation in estimates or predictions.

7.SP.3 Informally assess the degree of visual overlap of two numerical data distributions with similar variabilities, measuring the difference between the centers by expressing it as a multiple of a measure of variability.

7.SP.4 Use measures of center and measures of variability for numerical data from random samples to draw informal comparative inferences about two populations.

7.SP.5 Understand that the probability of a chance event is a number between 0 and 1 that expresses the likelihood of the event occurring. Larger numbers indicate greater likelihood. A probability near 0 indicates an unlikely event, a probability around indicates an event that is neither unlikely nor likely, and a probability near 1 indicates a likely event.

7.SP.6 Approximate the probability of a chance event by collecting data on the chance process that produces it and observing its long-run relative frequency, and predict the approximate relative frequency given the probability.

7.SP.7 Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy.

7.SP.8 Find probabilities of compound events using organized lists, tables, tree diagrams, and simulation.

8.EE Work with radicals and integer exponents. Understand the connections between proportional relationships, lines, and linear equations.

8.EE.4 Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of very large or very small quantities (e.g., use millimeters per year for seafloor spreading). Interpret scientific notation that has been generated by technology.

8.EE.5 Graph proportional relationships, interpreting the unit rate as the slope of the graph. Compare two different proportional relationships represented in different ways.

8.EE.6 Use similar triangles to explain why the slope m is the same between any two distinct points on a non-vertical line in the coordinate plane; derive the equation $y = mx$ for a line through the origin and the equation $y = mx + b$ for a line intercepting the vertical axis at b.

8.EE.8 Analyze and solve pairs of simultaneous linear equations.

8F Use functions to model relationships between quantities.

8.F.4 Construct a function to model a linear relationship between two quantities. Determine the rate of change and initial value of the function from a description of a relationship or from two (x, y) values including reading these from a table or from a graph. Interpret the rate of change and initial value of a linear function in terms of the situation it models, and in terms of its graph or a table of values.

8.F.5 Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally.

8.G Understand congruence and similarity using physical models, transparencies, or geometry software.

8.G.1 Verify experimentally the properties of rotations, reflections, and translations:

8.G.2 Understand that a two dimensional figure is congruent to another if the second can be obtained from the first by a sequence of rotations, reflections, and translations; given two congruent figures, describe a sequence that exhibits the congruence between them.

8.G.3 Describe the effect of dilations, translations, rotations, and reflections on two-dimensional figures using coordinates.

8.G.4 Understand that a two dimensional figure is similar to another if the second can be obtained from the first by a sequence of rotations, reflections, translations, and dilations; given two similar two dimensional figures, describe a sequence that exhibits the similarity between them.

8.G.9 Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real world and mathematical problems.

8.SP Investigate patterns of association in bivariate data.

8.SP.1 Construct and interpret scatter plots for bivariate measurement data to investigate patterns of association between two quantities. Describe patterns such as clustering, outliers, positive or negative association, linear association, and nonlinear association.

8.SP.2 Know that straight lines are widely used to model relationships between two quantitative variables. For scatter plots that suggest a linear association, informally fit a straight line, and informally assess the model fit by judging the closeness of the data points to the line.

8.SP.3 Use the equation of a linear model to solve problems in the context of bivariate measurement data, interpreting the slope and intercept.

8.SP.4 Understand that patterns of association can also be seen in bivariate categorical data by displaying frequencies and relative frequencies in a two-way table. Construct and interpret a two-way table summarizing data on two categorical variables collected from the same subjects. Use relative frequencies calculated for rows or columns to describe possible association between the two variables.

North Carolina Standard Course of Study Middle Grades (former) 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 fi t 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.

Science Activities

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 also will introduce basic vocabulary that will be used throughout the Heredity & 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 Essential Standards (Science) and Common Core (Math)

Science Standards:

7.L.2.1 Genetic variation
7.L.2.2 Patterns of heredity
7.L.2.3 Influences of the environment, lifestyle choice, and biological inheritance

Math Standards:

6.RP.1 Understand the concept of a ratio and use ratio language
6.RP.3 Use ratio and rate reasoning to solve real-world and mathematical problems
7.RP.2 Recognize and represent proportional relationships between quantities.
7.SP.6 Approximate the probability of a chance event
7.SP.2 Use data from a random sample to draw inferences about a population

NC Standard Course of Study (former curriculum)

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

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 (https://www.celera.com/celera/history). 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 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 weblinks that are available on the websites of that accompany most science textbooks.

Materials

- Scavenger hunt worksheet
- Laminated pictures of corn and plants (if real plants are unavailable)
- Pea and corn seeds
- Magnifying glass
- Genetics/genomics posters
- Internet access (optional)

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 gage 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

Handout 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 gage 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).

Follow Up Activities

- Math Extension. Ask students to keep track of the number of hours that they television during a given time period (a week, a day, etc), the specific shows that they watch during the time period, and also how many times genetic terms are mentioned during these each show. Questions that students should be able to answer include the following.
- What is the average number of genetic terms mentioned/ hour of television watched.
- Graph how many terms were mentioned on each show. Is there a connection between the type of show and the number of terms used?
- 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. How is the human genome database being used today?

Related Careers

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

Resources

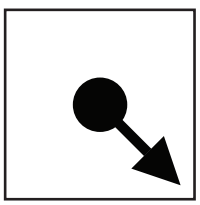
- **http://www.genome.gov**
- **http://www.sciencemag.org/content/291/5507/1195.summary**
- **http://learn.genetics.utah.edu**
- **http://www.kumc.edu/gec**
- **https://www.celera.com/celera/history**

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.



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).

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 chromosome 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 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://teach.genetics.utah.edu/content/begin/traits/inventory.html).

NC Essential Standards (Science) and Common Core (Math)

Science Standards:

7.L.2.1 Genetic variation
7.L.2.2 Patterns of heredity

Math Standards:

7.RP.2 Recognize and represent proportional relationships between quantities.
7.RP.3 Use proportional relationships to solve multistep ratio and percent problems.
7.SP.1 Understand that statistics can be used to gain i Information about a population by examining a sample of the population.
7.SP.2 Use data from a random sample to draw inferences about a population.

NC Standard Course of Study (former curriculum)

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.

NC Standard Course of Study (former curriculum) (cont.)

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
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

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 Wal-Mart 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

Background (cont.)

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.

- 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 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.

Note: A recent online article (http://udel.edu/~mcdonald/mythintro.html) published by Dr. John McDonald at the University of Delaware warns that many of the standard inherited traits used in this and similar activities may not be inherited in a simple Mendelian pattern. Some traits in fact might not be inherited at all. Dr. McDonald does an

Background (cont.)

excellent job of researching the background of many of the traits that are used to introduce students to Mendelian genetics. We believe teachers can use this is survey as an introduction to the traits typically used to introduce the subject. However, teachers may want to use Dr. McDonald's article to show that science is not static and ever evolving as more information and understanding of genetics occurs. Alternatively, teachers may wish to take Dr. McDonald's suggestion of using cat genetics instead as many such traits do follow a Mendelian pattern of inheritance.

Materials

- laminated pictures of a plant, dog, fish, virus (for demonstration)
- physical traits checklist (each student)
- trait examples handout (from the internet and Carolina Biological Sciences)
- 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.

Procedure (cont.)

- 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?

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?				

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.
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?

Procedure (cont.)

- 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?

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.

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 attached example). Students will then be able to compare different populations (i.e. group vs. class vs. school)

Follow Up Activities (cont.)

- **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 (eg, 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.

Related Careers

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

Resources

- **http://www.genome.gov** for more on inherited human traits
- **http://teach.genetics.utah.edu/content/heredity** for a similar activity
- **http://www.sonic.net/~nbs/projects/bio115l/** for online traits survey
- **http://en.wikipedia.org/wiki/List_of_Mendelian_traits_in_humans** for more information on individual traits (ex. eye color)
- **http://udel.edu/~mcdonald/mythintro.html** excellent article on the Myths of Human Genetics

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 also will 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 Essential Standards (Science) and Common Core (Math)

Science Standards:

7.L.2.1 Genetic variation
7.L.2.2 Patterns of heredity
8.L.2.1 Biotechnology use in breeding

Math Standards:

6.RP.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.
6.RP.3 Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.
7.RP.2 Recognize and represent proportional relationships between quantities.
7.RP.3 Use proportional relationships to solve multistep ratio and percent problems.
7.NS.3 Solve real-world and mathematical problems involving the four operations with rational numbers.
7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.
7.SP Use random sampling to draw inferences about a population.

NC Standard Course of Study (former curriculum) (cont.)

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.

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.
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.

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 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 be 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.

Background (cont.)

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)
- data table handouts (optional; per student)
- overhead showing Mendel's pea experiment results
- overhead with "Mendel warm up" questions

Preparation

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

Procedure

Warm Up

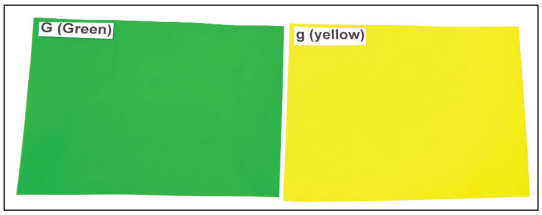
- Ask students to read through the section in their science textbooks on Gregor Mendel. Using their textbooks (delete the reference to the handout), students should work individually or in partners to answer the following warm up questions (also on overhead)
  - Who was Gregor Mendel?
  - What type of 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?

Procedure (cont.)

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 phenotype of the offspring.

3) After making predictions, students remove one slide from Bag 1 (representing the female parent) and one slide from Bag 2 (representing the 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 phenotypes could occur:

- "gg" genotype: yellow phenotype
- "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.

- *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). Note: The dominant allele is always written in upper case.

Procedure (cont.)

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). Note: The recessive allele is always written in lower case.

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.

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 phenotypes could occur:

   – "Gg" genotype: green phenotype

   – "GG" genotype: green phenotype

Procedure (cont.)

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 complete 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)
- 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 Essential Standards (Science) and Common Core (Math)

Science Standards:

- **7.L.2.1** Genetic variation
- **7.L.2.2** Patterns of heredity
- **7.L.2.3** Influences of the environment, lifestyle choice, and biological inheritance

Math Standards:

- **6.RP** Understand ratio concepts and use ratio reasoning to solve problems.
- **7.RP.2** Recognize and represent proportional relationships between quantities.
- **7.RP.3** Use proportional relationships to solve multistep ratio and percent problems.
- **7.EE.3** Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically
- **7.SP.6** Approximate the probability of a chance event by collecting data on the chance process that produces it and observing its long-run relative frequency, and predict the approximate relative frequency given the probability.
- **7.SP.8** Find probabilities of compound events using organized lists, tables, tree diagrams, and simulation.

NC Standard Course of Study (former curriculum)

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.

NC Standard Course of Study (former curriculum) (cont.)

Math Objectives:

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.

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) determine 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.

Background (cont.)

Punnett squares are particularly helpful in classroom settings where they provide a visual aid for teachers that are 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 gametes 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

Note: students can use the laminated worksheets or use the same format to create Punnett squares and probability tables in their notebooks.

- class set of laminated Punnett square worksheets
- class set of black dry erase markers
- dry erase erasers
- baby wipes (if needed) to clean worksheets
- transparencies with information on each genetic cross
- Punnett square homework problem handout

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.

Punnett Square Activity

- Demonstration
  1) Present the information about a genetic cross (listed below) using an overhead projector. Either you or a student volunteer can read through the basic

Procedure (cont.)

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

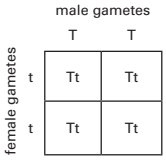
   First, write the genotype and phenotype of the parents:

   - **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.



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

Procedure (cont.)

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.

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?

Reflection (cont.)

- 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.

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.

See textbook pages_____ to help you complete 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 whom 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.

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

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 Sate Office of Education **http://utahscience.oremjr.alphine.k12.ut.us/scriber00/7th/genetics/scriber/intro.htm**

NC Essential Standards (Science) and Common Core (Math)

Science Standards:

7.L.2.1 Genetic variation
7.L.2.2 Patterns of heredity
7.L.2.3 Influences of the environment, lifestyle choice, and biological inheritance
8.L.2.1 Genetic information, breeding, and biotechnology careers

Math Standards:

7.RP Analyze proportional relationships and use them to solve real-world and mathematical problems.
8F Use functions to model relationships between quantities.
8.SP Investigate patterns of association in bivariate data.

NC Standard Course of Study (former curriculum)

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.

Math Objectives:
7th grade

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

NC Standard Course of Study (former curriculum) (cont.)

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.

8th grade
5.02 Develop an understanding of function.
5.03 Solve problems using linear equations and inequalities, justify symbolically and graphically.

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).

Background (cont.)

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).

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

Note: (students in groups of four)

- paper bags (representing male and female parents)
- wooden popsicle sticks (chromosomes) labeled with alleles for each trait
- stale marshmallow "body segments" (let marshmallows dry out the day before)
- toothpick "antennae" and "body connectors" (two colors)
- pipe cleaner "legs" (two colors)

Materials (cont.)

- paper clip "wings" (multiple colors)
- push pin "eyes (two colors)
- laminated "Genotype/Phenotype Guide" per group
- 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. Stale (or partially dried) marshmallows seem to work the best; just open the marshmallow bags up the day before.

Procedure

Warm Up

1) Students should draw and label a chromosome using their textbooks 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.

Procedure (cont.)

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

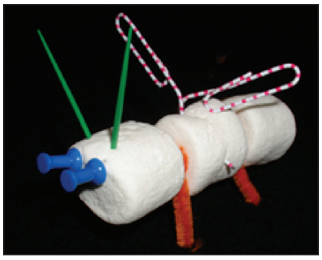
Trait	Dominant Genotype/ Phenotype	Recessive Genotype/ Phenotype
Body Segments	BB or Bb = 3 body segments	bb = 2 body segments
Pairs of Wings	TT or Tt= 2 pair of wings	tt = 1 pair of wings (paper clips)
Antennae Style	RR or Rr = round antennae	rr = flat antennae (toothpicks)
Color of Legs	GG or Gg = 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.



- Marshmallow "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 work the best for the body. Open the marshmallow 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.alpine.k12.ut.us/Sciber08/7th/Heredity/html/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)
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

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 or Strawberry

Since testing this activity, the authors have found DNA extraction from fresh strawberries to be more reliable than from wheat germ. The same extraction materials and procedures work also work with strawberries or teachers my use the following procedures: http://gemsclub.org/yahoo_site_admin/assets/docs/StrawberryDNAExtra.4395135.pdf

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 onion cells.

Acknowledgments

This activity was adapted from the following:

- "Extract and Observe DNA" Science Grade 7, McDougal Littell
- "How to extract DNA from Anything Living" University of Utah Genetic Science Learning Center http://learn.genetics.utah.edu/content/labs/extraction/howto/
- Strawberry DNA Extraction Lesson Plan http://gemsclub.org/yahoo_site_admin/assets/docs/StrawberryDNAExtra.4395135.pdf

NC Essential Standards (Science) and Common Core (Math)

Science Standards:

7.L.2.1 Genetic variation
7.L.2.2 Patterns of heredity
6.L.1.1 Structures and functions required for reproduction in plants
8.L.2.1 Genetic information and biotechnology careers

Math Standards:

7.G.1 Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.
7.G.2 Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions.
7.G.3 Describe the two-dimensional figures that result from slicing three dimensional figures, as in plane sections of right rectangular prisms and right rectangular pyramids.

NC Essential Standards (Science) and Common Core (Math) (cont.)

7.G.4 Know the formulas for the area and circumference of a circle and use them to solve problems; give an informal derivation of the relationship between the circumference and area of a circle.

7.G.6 Solve real-world and mathematical problems involving area, volume and surface area of two and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.

8.EE.4 Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of very large or very small quantities (e.g., use millimeters per year for seafloor spreading). Interpret scientific notation that has been generated by technology.

8.G.3 Describe the effect of dilations, translations, rotations, and reflections on two-dimensional figures using coordinates.

8.G.4 Understand that a two dimensional figure is similar to another if the second can be obtained from the first by a sequence of rotations, reflections, translations, and dilations; given two similar two dimensional figures, describe a sequence that exhibits the similarity between them.

8.G.9 Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real world and mathematical problems.

NC Standard Course of Study (former curriculum)

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.

Math Objectives:
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.

NC Standard Course of Study (former curriculum) (cont.)

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.

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

Background (cont.)

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

For group of four students

- 15-ml culture tubes
- Wheat germ (1/8 teaspoon)
- 12 ml Distilled water
- 12 ml Detergent solution (25% detergent in distilled water)
- 12 ml Salt solution (8% salt in distilled water)
- Cold isopropyl (rubbing) alcohol (90% works best)
- Plastic droppers (labeled "water", "detergent", and "salt")
- Test tube holders
- Paper clip
- Plastic weigh dish
- Hand lenses
- Goggles
- Lab procedures handout
- Mitosis slides and identification challenge set up at a microscope station

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.

Preparation (cont.)

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:
  - Sketch a DNA molecule
  - List the properties of DNA using the reading and also the DNA picture
  - Determine what they think DNA will like when extracted from cells
- 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.

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.

Procedure (cont.)

7) Go to the alcohol station and add an equal volume of isopropanol. 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.

DNA Extraction From Strawberry
(http://gemsclub.org/yahoo_site_admin/assets/docs/StrawberryDNAExtra.4395135.pdf)

Wheat germ was originally used in the genetics kits as it is not perishable. However, strawberry reliably yields much more DNA.

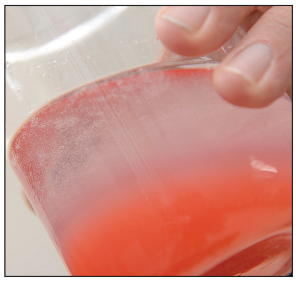
1) Place 1-2 strawberries in a Ziploc bag containing about 50 ml of DNA Extraction Buffer (500 ml water, 50 ml dishwashing detergent, 1 teaspoon salt).

2) Gently mash the strawberries for 1-2 minutes.

3) Filter strawberry mix by pouring through a cheesecloth-lined funnel into a beaker.

4) Gently pour an equal volume (If 100 ml of strawberry mix, add 100 ml of alcohol) of iced cold ethanol or isopropanol down the sides of the beaker to prevent mixing.

You will begin to see a white precipitate form in the to alcohol layer. If you were gentle while mushing the strawberry, the DNA will appear as strands. If not, the white precipitate will be more clumpy indicating that you sheared (broke) the DNA strands.



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.

Assessment (cont.)

Ask students to address what is the purpose of looking at DNA during different stages of cell division?

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 (colder and higher percentage alcohol precipitates DNA best)
- 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 another 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

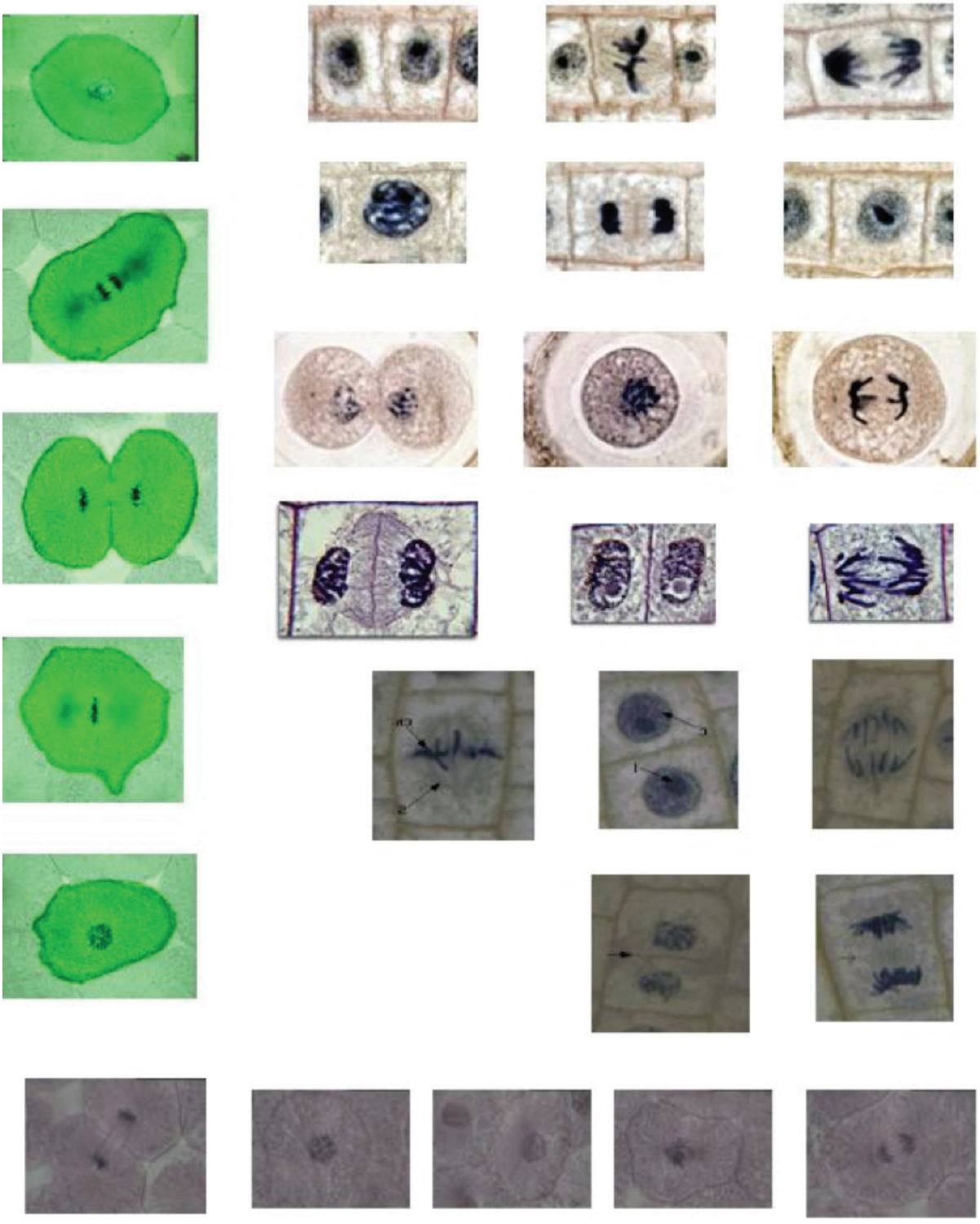
- Molecular biologist
- Cytogeneticist
- DNA forensic technician
- Molecular anthropologist
- Virus hunters

Resources

- **http://learn.genetics.utah.edu/content/labs/extraction/howto** for 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** *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.

Name_____ Date_____

Use your textbook to help you identify the stages.
Label each cell with the stage of cell division or mitosis shown.



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 (**www.pbs.org/saf/1202**).

NC Essential Standards (Science) and Common Core (Math)

Science Standards:

7.L.2.1 Genetic variation
7.L.2.3 Inheritance of disease
8.L.2.1 Genetic information and biotechnology careers

Math Standards:

N/A

NC Standard Course of Study (former curriculum)

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.

Math Objectives:

N/A

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 specific proteins is made by a 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

Background (cont.)

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).

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. 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.

HBB Sequence in Normal Adult Memoglobin (Hb A):							
Nucleotide	CTG	ACT	CCT	GAG	GAG	AAG	TCT
Amino Acid	Leu 1 3	Thr	Pro	Glu 1 6	Glu	Lys	Ser 1 9
HBB Seguence in Mutan Adult Hemoglobin (Hb S):							
Nucleotide	CTG	ACT	CCT	GTG	GAG	AAG	TCT
Amino Acid	Leu 1 3	Thr	Pro	Val 1 6	Glu	Lys	Ser 1 9

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. In addition, students will be able to see how a single change in the DNA sequence (mutation) can significantly alter the resulting protein, leading to a genetic disease – sickle cell anemia.

Materials

Note: (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"
- Wooden skewers
- Straws
- Scotch tape
- Colored Protein circles
- String
- Construction paper
- Scissors

Preparation

- Set up the supplies table.
- Make copies of the "Student's Guide."
- 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 "In the Life of DNA" table.

Reflection

Using their notebooks, ask students to complete their "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?

Reflection (cont.)

- 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.

Assessment

Review textbook sections on DNA-related processes. Give students a series of DNA or RNA sequences and ask them to do the following.

- write down the complementary DNA sequence.
- write the transcribed mRNA sequence.
- write the translated amino acid sequence.
- show what happens when a single DNA bases is mutated (changed)

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://teach.genetics.utah.edu/content/begin/dna/gene_to_protein.html**
- 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://teach.genetics.utah.edu/content/begin/dna/gene_to_protein.html** (for "From Gene to Protein Web Quest" activity, animations, and other information on DNA-related processes)
- **www.dnaftb.org** (*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)

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/content/disorders/**

NC Essential Standards (Science) and Common Core (Math)

Science Standards:

- **7.L.2.1** Genetic variation
- **7.L.2.2** Patterns of heredity
- **7.L.2.3** Inheritance of disease
- **6.L.1.1** Structures and functions required for reproduction in plants
- **8.L.2.1** Genetic information and biotechnology careers

Math Standards:

- **7.NS.3** Solve real-world and mathematical problems involving the four operations with rational numbers.
- **7.EE** Solve real-life and mathematical problems using numerical and algebraic expressions and equations.
- **7.SP** Use random sampling to draw inferences about a population.
- **8.EE** Work with radicals and integer exponents. Understand the connections between proportional relationships, lines, and linear equations.

NC Standard Course of Study (former curriculum)

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

NC Standard Course of Study (former curriculum) (cont.)

Math Objectives:

4.01 Collect, organize, analyze and display data to solve problems.

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.

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

1) research genetic diseases using the internet
2) determine the causes and consequences of different genetic diseases
3) 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 multiple 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

Background (cont.)

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 prostate 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. For those classrooms without Internet access, a hardcopy disease fact sheet for each disorder is also included in the kit.

Materials

Note: (students in groups of two)

- Internet access (if available)
- Class set of disease fact sheets from the Internet
  - **http://www.ygyh.org**
  - **http://learn.genetics.utah.edu/content/disorders/**
- Sickle cell anemia and Cystic Fibrosis Punnett square overhead
- Disease Fact Sheet worksheets (overhead, and class set)

Preparation

- Set up Internet access (if available)
- Copy or print a class set of 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

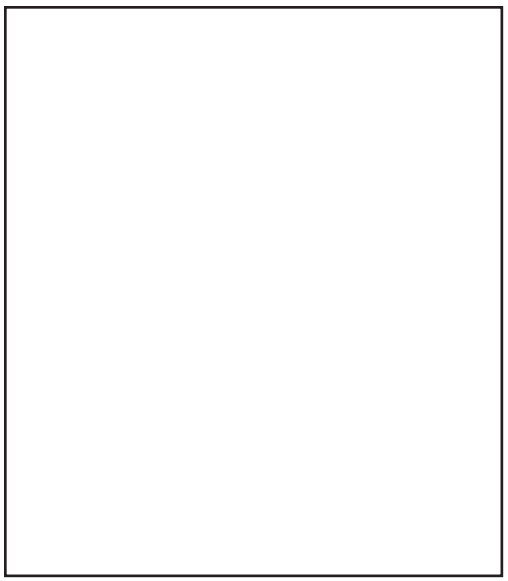
Resources

- **http://www.ygyh.org**
- **http://learn.genetics.utah.edu/content/disorders**
- **http://www.nchealthinfo.org**
- **http://www.webmd.com/a-to-z-guides/genetics-topic-overview**

Genetic Disorders Mini-Research Projects

Disease Name: _____

What is _____?



How do you get the disease?

How is the disease spread?

How can you prevent the disease?

What are the signs & symptoms?

How do you treat the disease?

How is the disease diagnosed?

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.

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 Essential Standards (Science) and Common Core (Math)

Science Standards:

- **7.L.2.1** Genetic variation
- **7.L.2.2** Patterns of heredity
- **7.L.2.3** Impact of environment, lifestyle choice, and genetics on disease
- **8.L.2.1** Genetic information and biotechnology careers

Math Standards:

- **7.RP** Analyze proportional relationships and use them to solve real-world and mathematical problems.
- **7.NS.3** Solve real-world and mathematical problems involving the four operations with rational numbers.
- **7.EE.3** Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically

NC Standard Course of Study (former curriculum)

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

NC Standard Course of Study (former curriculum) (cont.)

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
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

Math Objectives:

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.

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

1) identify factors that affect plant and human traits
2) design an experiment to differentiate between environmental and genetic influences
3) 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.wikipedia.org/wiki/Nature_versus_nurture). For example, traits such as language and religion have

Background (cont.)

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-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 human (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

Background (cont.)

leaves that will die after a few weeks since they cannot carry out photosynthesis. The other set of plants segregates 3 normal seedlings to 1 dwarf (short) seedling. The dwarf trait is a result of a mutation on the d1 gene on chromosome 3, which affects production of the growth hormone, gibberillic acid (GA). 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, and with and without addition of gibberellic acid.

Materials

Note: (per class)
To simplify the activity, teachers may wish to only use the segregating albino seeds. This also will eliminate the need for the gibberellic acid.

- Segregating dwarf seeds (Flinn Scientific #AB1449)
- Segregating albino seeds (Flinn Scientific #AB1447)
- 2 Mini-greeenhouse containing 12 peat pellets
- Shoe Box for "dark" (no light) environmental conditions
- Gibberellic acid (Carolina Biological Supply Co)
- 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
- Add gibberillic acid to select dwarf seedlings 1-2 days after they germinate
- 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 produce 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 phenotype of the offspring from a cross between two heterozygous corn plants for the chlorophyll trait.
    - What percent of the offspring will be albino?

Procedure (cont.)

- What percent of the offspring will have green leaves?
- What environmental conditions also could affect the color of the leaves?

- **<u>Cross #2 (Normal vs. Dwarf height)</u>** Plant must produce the growth hormone, gibberellic acid (GA), in order to grow to normal height. Plants that inherit two mutated copies of the GA gene (genotype = tt) do not produce GA and will have short stems (phenotype = dwarf). Use a Punnett square and probability table to predict the genotype and phenotype of the offspring from a cross between two heterozygous corn plants for the GA trait.
  - What percent of the offspring will be dwarf?
  - What percent of the offspring will be normal height?
  - What environmental conditions also could affect the height of the plants?

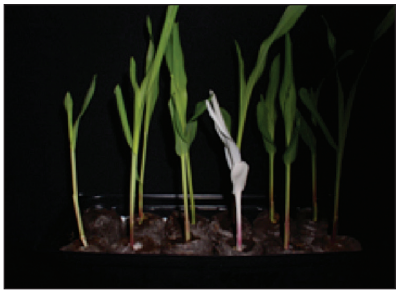
Growing the corn plants (Teacher Demonstration)

1) Add water to two mini-greenhouse 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) and 6 from the Cross #2 (Normal/dwarf height). *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 record plant data in their notebooks.

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 two traits (leaf color and height) were correct.
7) Choose half of the dwarf plants to begin addition of the gibberellic acid paste. Add paste every day for one week. For the plants in the "dark treatment" it is best to limit exposure to light. If available, the gibberellic acid paste should be applied using a dark closet.
8) 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.
6) Students should pair off into six groups depending on their number.
7) Hand out the "Identity Envelopes" and Team Summary.
8) Students should open the envelopes and read through the description of life of the fictitious patient that received.
   - What happened during each period of life?
   - What factors contributed to your patient getting cancer?
   - What was the cause of death?
9) Each group should summarize their results on a Team Summary Sheet and share their results with the rest of the class.

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, addition of growth hormone).

- What affect do genetic factors (genotype) have on plant appearance (phenotype)?
- What two environmental factors (non-genetic) factors were tested in our experiments?
- What affect do environmental factors have on plant appearance?
- Which has more influence traits, genetic or environmental factors?
- What some risk factors which 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.

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.

Follow Up Activities

- Conduct a similar plant experiment comparing the effects 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.

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/a-to-z-guides/genetics-topic-overview**

DNA Forensics

Overview

Problem: How is DNA technology used in forensics?

Students love watching CSI, NCIS, Cold Case Files, Bones, where modern DNA techniques are used to catch criminals and solve crimes. Also, North Carolina has a rich biotechnology industry that has a myriad number of careers involving DNA science to help grow crops, develop new drugs, or conduct DNA testing. This activity introduces students to how DNA fingerprinting can be used to identify suspects using techniques based upon ones used in real molecular biology labs. It also introduces students to other laboratory techniques, notably chromatography, which is used in forensics and other research laboratories around North Carolina.

Acknowledgments

This activity was adapted from the Exploring Electrophoresis and Forensics Kit from the Carolina Biological Supply Company (http://www.carolina.com). Forensic experiments ideas taken from Crime-Solving Science Projects by Kenneth G. Rainis, ©2000 Enslow Publishers, Inc.

NC Essential Standards (Science) and Common Core (Math)

Science Objectives:

7.L.2 Genetics and Heredity
8.L.2 Biotechnology

Math Objectives:

7.RP Ratios, proportions, and percents
7.SP Statistics and Probability

Textbook Resources

Prentice Hall (pp. 582-585)
McDougall Littell (pp. C150-155)
Holt (pp. 444)

Learning Outcomes

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

1) explain how DNA can be used to identify people.
2) conduct scientific inquiry using molecular biology techniques.
3) discuss how biotechnology benefits North Carolina.
4) explore more North Carolina biotechnology careers.

Background

DNA is the code of life – essentially instructions that are the unique recipe for each individual person. Recently, scientists and investigators have been using DNA forensics to identify

Background (cont.)

criminals, victims, and even missing persons. Many students enjoy watching TV shows like CSI (Crime Scene Investigators), Dexter, and NCIS where science is used to investigate crimes and identify suspects. DNA used in forensics can come from a person's blood, saliva, skin cells, hair follicles, semen, mucus, and even sweat. Often only a tiny amount of DNA can be recovered from a crime scene. However, DNA can amplified (amount increased) using the technique called the Polymerase Chain Reaction (PCR), in which tiny bits of DNA can be copied over and over to generate enough for analysis. Next the PCR products ("DNA fingerprints") are separated by gel electrophoresis and compared with control samples (ex. Suspect vs. criminal database, suspect vs. victim, suspect vs. family members, etc).

This activity will let students practice being detectives using various forensic techniques used in crime labs throughout the world. All results will be collected then summarized on a crime scene log to help students identify the culprit who committed this fictitious crime. The crime scene was designed in honor the Museum of Life & Science in Durham, which has provided resources and workshop space for this manual.

Students will use:

- Microscopy to analyze hair, fibers, and soil samples
- Chromatography to analyze ink pen samples
- DNA electrophoresis to analyze DNA samples (from Carolina Biological)

Materials

- *Exploring Electrophoresis and Forensics Kit* from the Carolina Biological Supply Company (http://www.carolina.com). Kit includes pipettes, ready-to-use agarose gels, electrophoresis buffer and gel apparatus.
- 9-volt batteries for gel apparatus
- *CSI forensics poster* (Carolina Biological Supply Company)
- Crime Scene kit
- Fake Blood - mix 2/3 cup water with 2/3 cup of corn syrup -> take 3T of mixture and add red or green food coloring to get dark red/reddish brown color
- scotch tape for collecting samples
- wig hair
- clothing fibers
- three different types of black ink pens – (ball point, sharpie, expo marker)

Materials (cont.)

- Whatman filter paper
- Clear plastic cups
- Acetone or isopropanol
- crime scene tape
- police crime scene log
- sand and dirt
- doll house furniture
- Microscope
- Magnifying glasses
- Beaker
- Internet access

Preparation

- Set up crime scene (doll house furniture, fake blood, fibers, crime scene tape, sand and dirt soil samples, note in black ink, CSI poster).
- Set up the following stations:
  - Microscopy analysis (blood, fibers, fingerprints)
  - Chromatography (pen ink analysis)
  - Soil Analysis (magnifying glass, beakers)
  - DNA Electrophoresis
  - Computer: Forensics and Biotechnology in North Carolina

Procedure

Warm Up

How is DNA science used to solve crimes?

- Show a clip from CSI and have students make a 2-column table linking each test shown in clip and the type of information it revealed about the crime. Make a class list of other TV shows and movies that use DNA forensics.

Crime Scene Data Collection and Analysis

- Students should read through the crime scenario and highlight relevant information and evidence. Students should then sketch the crime scene, view the evidence, conduct the necessary forensic tests, and record their observations and analyses on the crime scene log.
- **Hair, Fiber, Fingerprints Station:** Use microscope or magnifying glass to examine hair, fibers, and fingerprints. Fingerprints can be dusted with charcoal dust then transferred with scotch tape to a microscope slide. Students should compare the materials left behind with those of the suspects.

Procedure (cont.)

- **Soil Analysis Station**: Soil can be viewed using a magnifying glass and/or microscope. Students can place the soil in a beaker of water to further see differences in components. Students should compare shoe soil samples from the suspects with that left at the crime scene.

- **Chromatography Station**: Using the black pens collected from the suspects, mark the Whatman paper, 1 pen/paper. Place Whatman filter paper strips in clear plastic cup with either acetone or isopropanol. Make sure that the solvent touches the Whatman paper but not the pen mark. Cover the cups with plastic wrap to contain smells and prevent excess evaporation. Monitor ink migration and compare to ink migration of the note left at the crime scene. Below shows a chromatography analysis comparing three different types of black ink pens (B=ballpoint, E=expo marker, S=Sharpie) and three common household solvents (al=isopropanol alcohol, a=acetone, w=water). The chromatography took approximately 20 minutes to show clear differences in separation of the ink from the three pens. Alcohol and acetone both caused distinct ink separation patterns between the ballpoint (Bal =ballpoint in alcohol, Ba=ballpoint in acetone) and Sharpie (Sal=Sharpie in alcohol, Sa=Sharpie in acetone) pens. The acetone migration was quicker resulting in wider ink separation suggesting that acetone would likely be useful in differentiating between pens of a similar types (ex. black ballpoint pens from different makers). Water separated the ink but as expected wasn't a good solvent hence you very faint ink separation patterns. Water was tested because it is often used in middle school forensic simulations. However, acetone and alcohol are cheap and relatively safe alternatives that more realistically show how chromatography is done is a real laboratory and yields clear results.

Procedure (cont.)

- **DNA (blood) Analysis:** Follow the protocols described in the *Exploring Electrophoresis and Forensics Kit* from the Carolina Biological Supply Company (http://www.carolina.com). Kit includes pipettes, ready-to-use agarose gels, electrophoresis buffer and gel apparatus. Gels must be prepared the day before but can be run during a class period.

- **Computer: Forensics and Biotechnology Station:** If available set up one or more computers or Internet accessible devices to let students explore more about forensics and similar biotechnologies used in North Carolina. **http://www.ncbiotech.org/** is a good starting point for this type of webquest.

Reflection

Using their notebooks, ask students to write about how what they did in the lab relates to what they have seen on TV or in movies about crime scene analysis. Also have students reflect on the possible careers that relate to studying DNA.

Assessment

Students can be quizzed on the science inquiry techniques and data analysis used to solve the crime. They can also be assessed on the characteristics of DNA that make it an ideal piece of evidence for identifying suspects.

Tips

- This lab will generate a lot of good questions. Teachers may wish to create a poster where students can write their questions on post-it notes. If you have students who routinely finish early and/or need different assignments, these students can look up and post the answers to the questions.

Follow Up Activities

- **Math Extension.**
- **DNA Fingerprinting controversy.** Ask students to find out more about the how law enforcement is using DNA analysis and tracking around the world.

Related Careers

- Forensics Investigator http://www.genome.gov/GenomicCareers/career.cfm?id=16&fv=128
- Biotechnology Careers Brochure http://www.ncbiotech.org/sites/default/files/CareerPathways%5D.pdf

Resources

- **http://www.ncbiotech.org**
- **http://www.dnaforensics.com**
- **http://geneed.nlm.nih.gov/topic_subtopic.php?tid=37**

Case of the Missing Black Widow

Crime

Sometime on the night of Sunday July 22, 2012 or early Monday morning, a genetically enhanced female black widow spider was removed from a locked area of the Museum of Life and Sciences in Durham, NC. The spider was stored inside a secret research lab hidden in the wooded area inside the Ellerbe Creek railway – near where kids often spot Rudolph during Christmastime. There were no signs of breaking and entering into the locked laboratory itself, however, the spider's glass case had been knocked over and glass shards were strewn throughout the lab. Droplets of blood were found leading back out of the lab. Hair and clothing fibers along with some dirt were also were found near the broken spider case. Partial fingerprints were recovered from the spider's glass case. Also found was a note with the combination to the lab written in blue ink. Two museum employees were found in deep sleep in the Science Education Resource Center (SERC) across the street from the museum's main building.

Background

Unknown to local residents, the museum started genetically breeding a GLO-spider that contained the jellyfish green-fluorescent protein (GFP) would cause the deadly spider to glow bright green even under any form of ultraviolet light. The museum's intent was to teach museum patrons about genetic research often use GFP in their work and also to create an easy-to-see version of the poisonous spider. Unfortunately, the museum chose to keep the GLO-spider research secret as the introduction of the GFP caused the spider's bite to result in instant narcolepsy lasting up to 5 days.

Suspects

Because the theft happened in a secret, locked lab – the police believe that this crime was an inside job. The following people are suspects

Shawntel – (Senior Director) O+ blood, brown hair, wore green and blue shirt, nothing on shoes. Found asleep in SERC

Barry – (Museum President) A+ blood, brown hair, wore white shirt and brown khakis, dirt and sand on bottom of shoes

Nancy – (Science Education Coordinator) A+ blood, black hair, wore white shirt and blue jeans, green towel found in backpack, dirt and sand on bottom of shoes. Found asleep in SERC

Jeff – (SERC staff) AB+ blood, dyed black hair, work bluish-green shirt with white shorts, dirt on bottom of shoes

Taneka – (Public Relations) A+ blood, black hair, wore white shirt and blue shorts, sand in pockets of shorts.

George (molecular biologist) A+ blood, salt and pepper hair, wore white shirt and blue pants, dirt under fingernails

Crime Scene Log

Collected by:_____

Collected by:	**Date:**	**Time:**	**Location:**
Crime Scene Sketch			

Specimen	**Location**	**Description**	**Analysis**
Note			
Soil			
Hair fibers			
Clothing fibers			
Blood			
Fingerprints			

Summary of Evidence and Conclusions: _____

_____

_____

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 inherited 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 effector 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 Activities

Heredity & Genetics Scavenger Hunt

Overview

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

NC Common Core

Math Standards

- **6.RP.1** Understand the concept of a ratio and use ratio language
- **6.RP.3** Use ratio and rate reasoning to solve real-world and mathematical problems
- **7.RP.2** Recognize and represent proportional relationships between quantities.
- **7.SP.6** Approximate the probability of a chance event
- **7.SP.2** Use data from a random sample to draw inferences about a population

NC Standard Course of Study (former curriculum)

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

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/newspaper 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 board with an additional column for the words found as follows:
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 students the benefits of displaying data on a circle graph as opposed to the frequency table or a bar graph.

	Words	Tally	Frequency
TV Shows			
Movies			
Books			
Newspaper			

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 Human Traits survey

Overview

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

- Challenge #1: Is it possible to us a class survey of character traits to make calculated and accurate predictions?
- 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 analyses, it helps students to work with data and to represent real life situations mathematically.

NC Common Core

Math Standards:

7.RP.2 Recognize and represent proportional relationships between quantities.

7.RP.3 Use proportional relationships to solve multistep ratio and percent problems.

7.SP.1 Understand that statistics can be used to gain information about a population by examining a sample of the population.

7.SP.2 Use data from a random sample to draw inferences about a population.

NC Standard Course of Study (former curriculum)

Math Objectives:

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

1.03 Develop flexibility in solving problems

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

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.

Learning Outcomes (cont.)

3. Calculate the probability of events.
4. Use the mathematical date to reason various real life situations.

Prerequisites

- 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 what the meaning of Histogram, tally, and frequency.
- Students need to be able to calculate experimental probability [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

Team the class up in pairs, (I suggest that each group is of equal strength). Explain to your students that today they are going to use mathematics to display scientific data, analyze and make predictions, and discover how unique each individual is although we are 99.9% similar.

Hand out the Math Activity 1 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) 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 all your working out).

_____

_____

_____

_____

_____

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.

_____

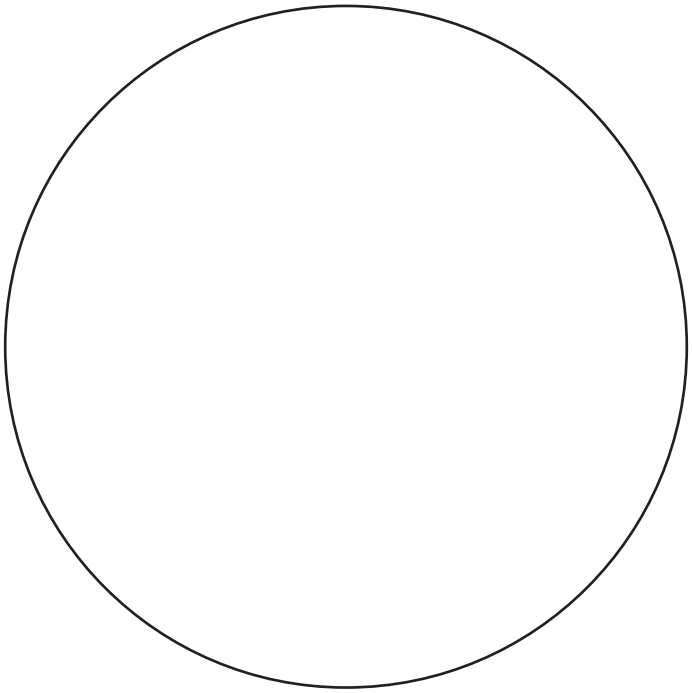
_____

_____

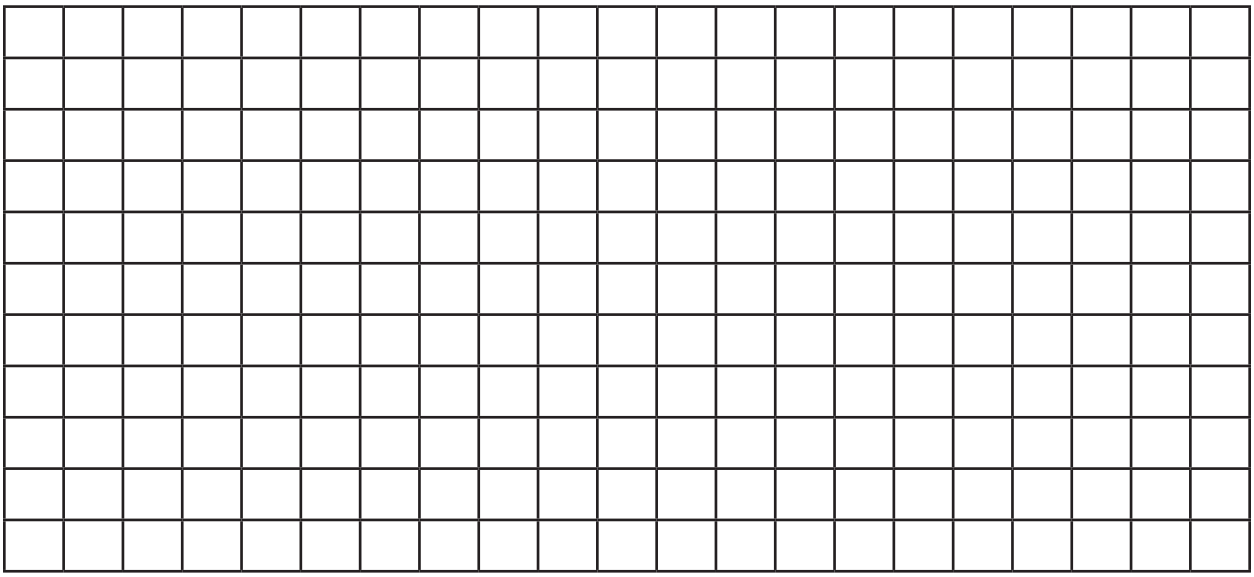
_____

_____

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.



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?

_____

_____

_____

_____

_____

10.3 Rewrite this probability as a percent and a decimal.

_____

_____

_____

_____

_____

11. Rewrite 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.

_____

_____

_____

_____

_____

Analyzing theoretical and experimental probability

Overview

- Problem 1. Does theoretical probability accurately predict actual (experimental) results?
- Problem 2. How can Scientists use theoretical probability as a guideline for measuring actual results?

NC Common Core

Math Standards:

6.RP.1 Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.

6.RP.3 Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.

7.RP.2 Recognize and represent proportional relationships between quantities.

7.RP.3 Use proportional relationships to solve multistep ratio and percent problems.

7.NS.3 Solve real-world and mathematical problems involving the four operations with rational numbers.

7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically. Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate; and assess the reasonableness of answers using mental computation and estimation strategies.

7.SP Use random sampling to draw inferences about a population.

NC Standard Course of Study (former curriculum)

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.

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.

NC Standard Course of Study (former curriculum) (cont.)

6th grade

4.01 Develop fluency with counting strategies to determine the sample space for an event. Includes lists, tree diagrams, frequency distribution tables, permutations, combinations, and the Fundamental County 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.

7th grade

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

Learning Outcomes

Students will be able to:

1. Compare and contrast theoretical and experimental probability.
2. Make predictions from theoretical probability and see how many times an experiment needs to take place before the two events become more similar.
3. Represent the theoretical probability as sample spacing.
4. Use various forms of data (Tree diagrams) to determine probability.

Prerequisites

- fractions (students need to be able to multiply fractions)
- multiplying fractions

Materials

(students working in pairs or groups of 4)

- Probability package for each group (brown bag with 20 tokens of which 15 are the same color and the other a different color.)
- Math Activity sheet for each group.

Vocabulary

Theoretical probability: *The mathematical likelihood of an event occurring written as a fraction or percent.*

Experimental probability: *The actual results in fraction or percent form.*

Sample spacing: *A visual representation of all the possible outcomes.*

Tree diagram: *A diagram showing the sample spacing.*

Independent events: *If two events\are not influenced by each other such as rolling a number cube then spinning a spinner.*

Dependent events: *If the outcome of the first event effects the outcome of the second event, such as not replacing the first item drawn and finding the probability of the second event.*

Procedure

Warm up

- Number each student from 1 to however many students you have in your class. In a container have the same numbers on pieces of paper. Ask a student to draw their numbers. Tell them that they can predict mathematically how many attempts it should take to draw their own number. Have a debate to determine whether this is an accurate prediction.
- Review the vocabulary and pose the problems mentioned in the overview.
- Hand out the probability packet and tokens, and worksheet to each student.
- Allow 30 - 35 minutes for this activity.
- Collect student work and discuss their results. Ask probing questions for students to see that experimental results are often different to theoretical ones. Refer back to the warm up by asking if the prediction is the same as the outcome.

Name_____ Date_____

1. What do you think is the main difference between experimental and theoretical probability?

_____

_____

_____

_____

2. Look at\the tokens in your bag. Represent each color as a percent of the total tokens. Write each percent as a fraction in simplest form. (These mathematical representations are also known as the theoretical probability).

_____

_____

_____

_____

3. Predict which color you would most likely draw first. Why did you choose this color? Now conduct the experiment. Was your prediction correct?

_____

_____

_____

_____

4. Shake your bag, draw a token, record its color, return it into the bag and repeat this experiment three more times. Write each result as a ratio.

Result 1. _____

Result 2. _____

Result 3. _____

Result 4. _____

5. Shake your bag, draw 4 tokens at the same time and record your results. After replacing the tokens, repeat this experiment another three times. Write each result as a ratio.

Result 1. _____

Result 2. _____

Result 3. _____

Result 4. _____

6. Are your results similar for questions 4 and 5? Which experiment demonstrates dependent and which experiment demonstrates independent events?

_____

_____

_____

7. Represent your total amount of each color as a percent of the whole for the experiments in number 5&6.

_____

_____

_____

8. Represent the sample spacing in the form of a tree diagram for 4 tokens of which 3 have the same color.

9. Below is a summary of two Mendel's experiments. Look at his resulting ratios. Are any of these ratios similar to your own? Why do think they are? How are your results similar to the results you would expect to see in a Punnet Square? How could your results from the experiment you have conducted be more similar to his ratio? (Hint: look how many plants he examined!)

Expt. 3: *Color of the seed-coats. Among 929 plants, 705 bore violet-red flowers and gray-brown seed-coats; 224 had white flowers and white seed-coats, giving the proportions 3.15:1.*

Expt.4: *Form of pods. Of 1181 plants, 882 had them simply inflated , and in 299 they were constricted. Resulting ration, 2.95:1.*

How Punnett Squares May Be Used As A Mathematical Tool

Overview

Problem: Can Punnett squares predict mathematical outcomes from sampling? What is the significance of the outcomes and how can the findings be used to make inferences and conclusions about trends.

NC Common Core

Math Standards:

- **6.RP** Understand ratio concepts and use ratio reasoning to solve problems.
- **7.RP.2** Recognize and represent proportional relationships between quantities.
- **7.RP.3** Use proportional relationships to solve multistep ratio and percent problems.
- **7.EE.3** Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically.
- **7.SP.6** Approximate the probability of a chance event by collecting data on the chance process that produces it and observing its long-run relative frequency, and predict the approximate relative frequency given the probability.
- **7.SP.8** Find probabilities of compound events using organized lists, tables, tree diagrams, and simulation.

NC Standard Course of Study (former curriculum)

Math Objectives:

6th grade

- **1.02** Develop meaning for percent.

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.
- **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.

NC Standard Course of Study (former curriculum) (cont.)

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.

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 Punnett squares to make sound mathematical predictions.

Prerequisites

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

Vocabulary and Mathematical Background

Ratios: *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.*

Proportions: *fractions that are equal form proportions*

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]*

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

Before starting this activity, be sure that students know how to draw up and complete a Punnett square and correctly identify the dominant trait for each of th4e four squares. As this works with the Science activity , students should know how to complete Punnett squares but may not see the Mathematical connection yet.

Procedure

Warm up activity

- On the overhead (or on the board), have a blank Punnett square and ask the students to copy it out and complete it. Place the following Genotype in your Punnett square. Ask them for the phenotype for each genotype. (ex. TT = tall plant, tt = short plant). 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 or if the class responds well to group work allow them to work in pairs.

Name_____ Date_____

1.

AA	Aa
Aa	aa

The Punnett 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. https://sites.google.com/a/mail.cashton.k12.wi.us/amanda-albinism/inheritance

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 this 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 Punnett square in question 1 may also be represented as a ratio of 1:2:1 (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 Punnett 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?

_____

Using Math and Science to Solve Real World Problems on Breeding Animals

Overview

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

NC Common Core

Math Standards:

- **7.RP** Analyze proportional relationships and use them to solve real-world and mathematical problems.
- **8F** Use functions to model relationships between quantities.
- **8.SP** Investigate patterns of association in bivariate data.

NC Standard Course of Study (former curriculum)

Math Objectives:

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.
- **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.

8th grade

- **5.02** Develop an understanding of function.
- **5.03** Solve problems using linear equations and inequalities, justify symbolically and graphically.

Prerequisites

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 dependent and independent variables;
2. interpret properties of linear functions;
3. solve problems involving linear functions.

Vocabulary

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.*

Dependent and Independent Variables: *x is the independent variable as y relies on it (dependent variable) for the input.*

Co-ordinate Points: *the point identified by (x,y).*

Quadrants: *labeled I to IV anticlockwise from the top right quadrant.*

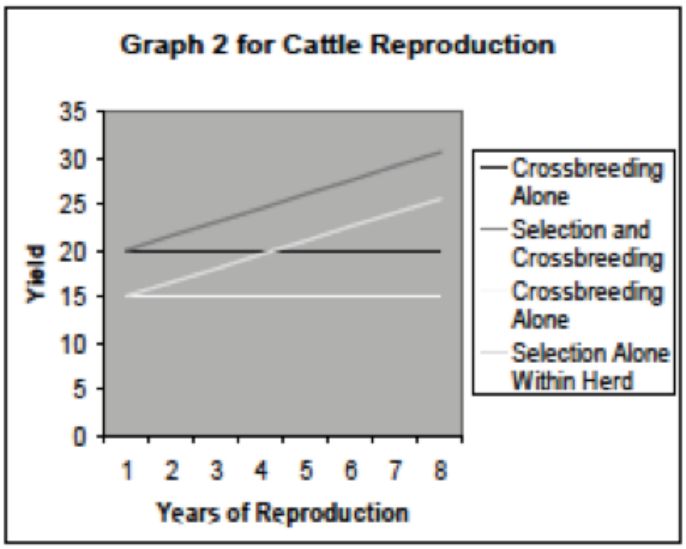
Procedure

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 crossbred? Let them know that today they will investigate crossbreeding in cattle.

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?

_____

_____

2.2 Why would it be harmful to production, if the farmer allows random mating within a herd?

_____

_____

2.3 Why do you think crossbreeding alone does not show increased production?

_____

_____

3.1 Although the data above appears to be accurate, what is it lacking to give us accurate evidence? Would you consider this graph to be misleading? Justify your answers.

_____

_____

_____

_____

_____

Background experience in the laboratory

Overview

Problem: many students have no 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 in conjunctions with the DNA extraction science activity.

NC Common Core

Math Standards:

7.G.1 Solve problems involving scale drawings of geometric figures, including computing actual lengths and areas from a scale drawing and reproducing a scale drawing at a different scale.

7.G.2 Draw (freehand, with ruler and protractor, and with technology) geometric shapes with given conditions.

7.G.3 Describe the two-dimensional figures that result from slicing three dimensional figures, as in plane sections of right rectangular prisms and right rectangular pyramids.

7.G.4 Know the formulas for the area and circumference of a circle and use them to solve problems; give an informal derivation of the relationship between the circumference and area of a circle.

7.G.6 Solve real-world and mathematical problems involving area, volume and surface area of two and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.

8.EE.4 Perform operations with numbers expressed in scientific notation, including problems where both decimal and scientific notation are used. Use scientific notation and choose units of appropriate size for measurements of very large or very small quantities (e.g., use millimeters per year for seafloor spreading). Interpret scientific notation that has been generated by technology.

8.G.3 Describe the effect of dilations, translations, rotations, and reflections on two-dimensional figures using coordinates.

NC Common Core (cont.)

8.G.4 Understand that a two dimensional figure is similar to another if the second can be obtained from the first by a sequence of rotations, reflections, translations, and dilations; given two similar two dimensional figures, describe a sequence that exhibits the similarity between them.

8.G.9 Know the formulas for the volumes of cones, cylinders, and spheres and use them to solve real world and mathematical problems.

NC Standard Course of Study (former curriculum)

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.

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.

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; graph the co-ordinates for these points; conclude a result given the evidence of the graph and the pattern of the table; determine the slope of the given line, predict the weight of an unknown container.

Vocabulary/ Prerequisite Skills

Metric system: *the units to measure in science (works in powers of 10).*

Function table: *a table displaying the relationship between quantities.*

Plot points: *draw points for the co-ordinates.*

Co-linear: *in a straight line, points/co-ordinates which line up.*

Procedure

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 Svcie4nce 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					
50ml	100ml	150ml	300ml	400ml	500ml

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					
50ml	100ml	150ml	300ml	400ml	500ml

2.2 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 the same 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, what is the mass of 1000ml container? Which graph did you use? Why did you use that graph?

3.2 What is the mass of one metric ton? How many grams is one metric ton? Write the scientific notation.

Identifying Various Views of an Object

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 dimensional 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 5 (Genetic Bugs) to accompany the worksheet that is included in this Activity.

NC Common Core

Math Standards:

- **7.G** Draw, construct, and describe geometrical figures and describe the relationships between them.
- **8.G** Understand congruence and similarity using physical models, transparencies, or geometry software.

NC Standard Course of Study (former curriculum)

6th grade

- **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.
- **3.01** Identify and describe the intersection of figures in a plane.
- **3.04** Solving problems involving geometric figures.

7th grade

- **2.02** Solve problems involving volume and surface area of cylinders, prisms, and composite shapes.
- **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. Materials/ Equipment

Materials/ Equipment

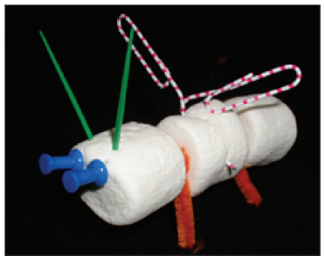
- DNA model
- Overhead projector
- Transparencies
- Worksheet

Preparation

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

Procedure

Warm Up



- Place a picture or actual model of the "genetic bug" from science activity 5 in the front of the class, overhead, or LCD projector. If a digital image is available, it's helpful to change it to black & white so students are just looking at the shapes and not being distracted by colors. Alternatively, you can use an image of DNA.

  Examples of DNA may be viewed at **http://www.sciencemag.org/content/332/6027/342.figures-only**
- Allow students 10 minutes to sketch the "genetic bug" from three different views:
  - Top view (cylindrical body segments should look like rectangles, antennae will appear as diagonal lines)
  - Front view (cylindrical head should look like a circle)
  - Side view (cylindrical body segments should look like rectangles, only see one antenna as a line straight up)
- Share student sketches and discuss differences in the three views.
- *Real Life Problem:* Ask students "How they would be able to identify various cell structures under a microscope?" Ask if we always see the top 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, architects, builders, and even pilots.

Name_____ Date_____

1. Choose the correct word from the list to label each object:
   https://miss-wrights-wiki.wikispaces.com/Yr+7+Chemistry

   List: **Funnel**

   Test tube

   Beaker

   Flask

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

3. What are the formulas for the volume and surface area of a cylinder? Notice that the test tube and beaker are not perfect cylinders. However, how could these formulas be used to estimate the surface area and volume of the test tube and beaker?

_____

_____

_____

BONUS

4. What is formula for calculating the volume of a rectangular prism? If a rectangle prism shaped fish tank with dimensions 1m, 2, 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?

_____

_____

_____

BONUS

5. If two buckets are filled every three hours, how long will it take before the container is empty?

_____

Data Analysis To Further Scientific Reasoning

Recommended - Taught Same Time as the Science Activity 8

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 Common Core

Math Standards:

- **7.NS.3** Solve real-world and mathematical problems involving the four operations with rational numbers.
- **7.EE** Solve real-life and mathematical problems using numerical and algebraic expressions and equations.
- **7.SP** Use random sampling to draw inferences about a population.
- **8.EE** Work with radicals and integer exponents. Understand the connections between proportional relationships, lines, and linear equations.

NC Standard Course of Study (former curriculum)

Math Objectives:

- **4.01** Collect, organize, analyze and display data to solve problems.
- **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.

Learning Outcomes

Students will be able to:

1. plot points
2. identify co-ordinates

Vocabulary

(same as previous activities)

Slope

Rate of change

Linear

Relationship

Materials/ Equipment

- Calculator
- Graphing paper
- Worksheets

Procedure

Warm up:

- Diagram of 3 linear functions 2 of which are parallel.
- Review work required with quick checkpoint quiz (on overhead or board).
    1. Which line is steeper?
    2. What is the slope pf each line?
    3. Why does the one seem to be parallel to the other, what does that mean?

Math Activity 8

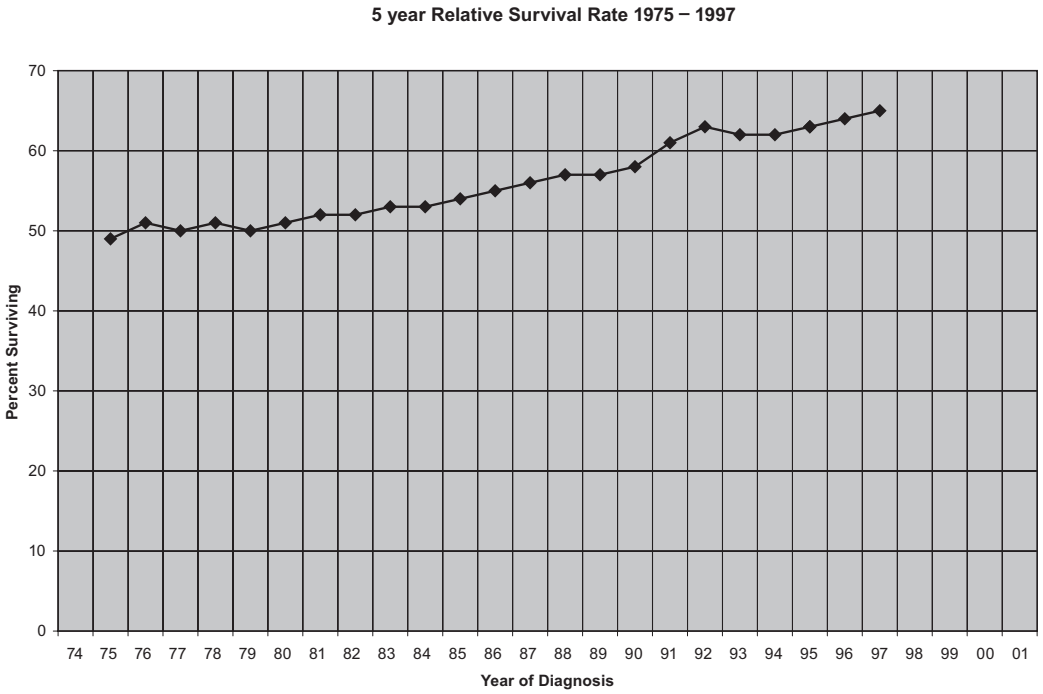
- Hand out the worksheet packet with the 4 graphs.
- After 10 - 12 minutes for each graph, discuss each of the 4 solutions.

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? (meaning what do they say about the populations)
    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. Compare the changes in percent survival between 1975 – 1979 and 1983 - 1987. What might account for the differences?

_____

_____

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 coordinates (1974, 50) (1997, 65). What does the slope represent?

_____

_____

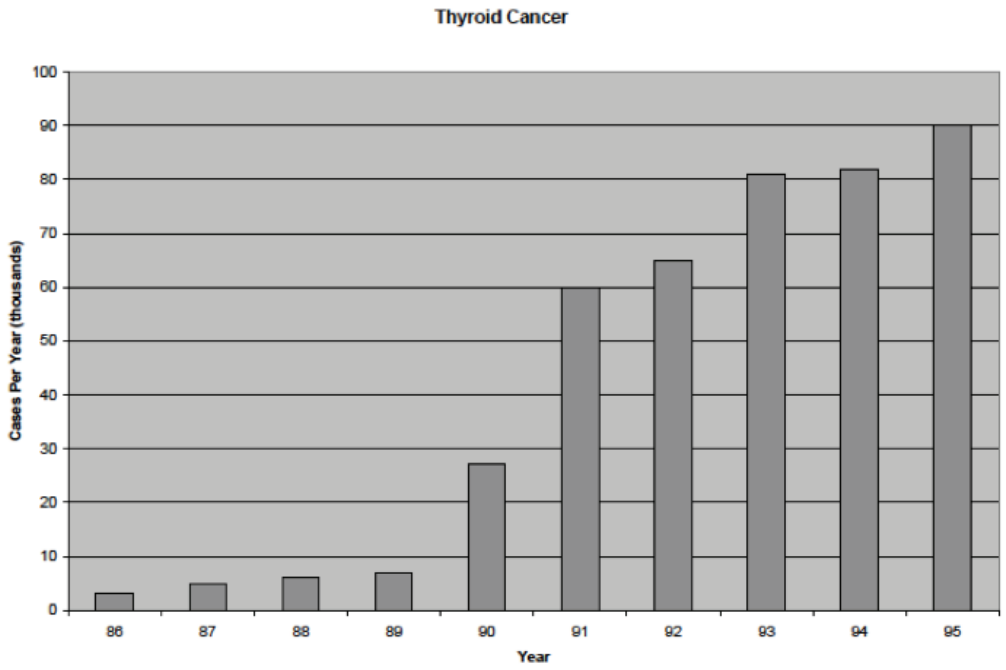
7. Is it possible to determine a function rule for this graph if you were only given the coordinates from question 6? What would this rule be?

_____

_____

_____

_____



1. What is this graph indicating is happening with thyroid cancer?

_____

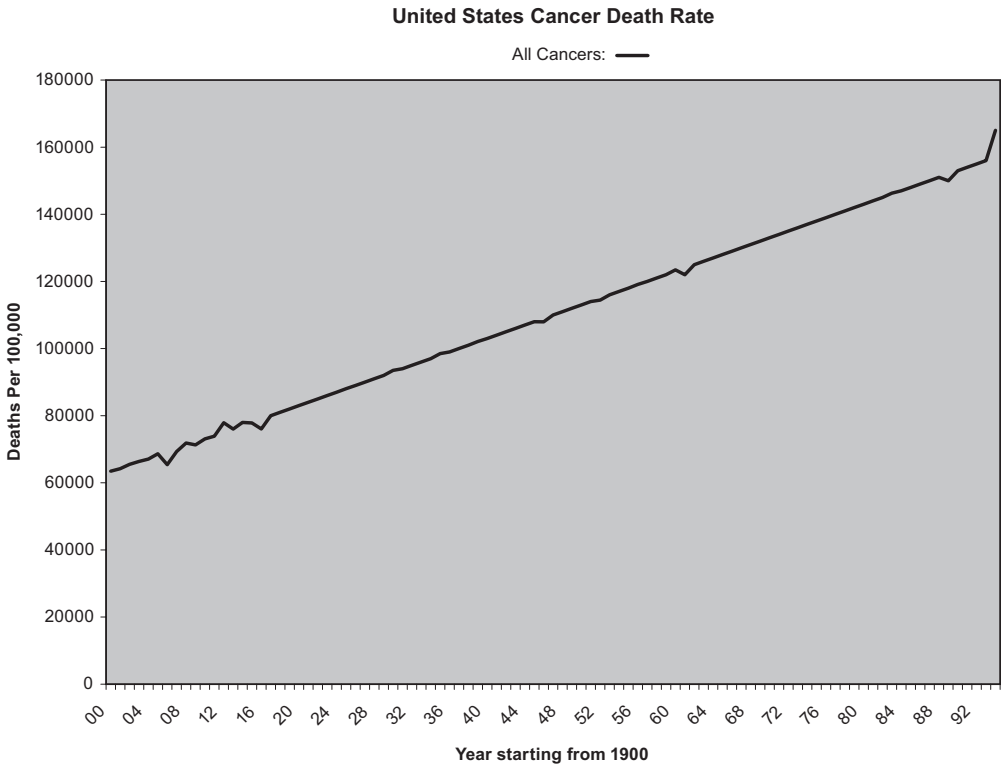
_____

2. Based on this graph how many thyroid cancer cases would you predict in 2000?

_____

_____

3. Why do you think there appears to be such a huge increase from 1989 - 1991? Use the Internet to check your hypothesis.

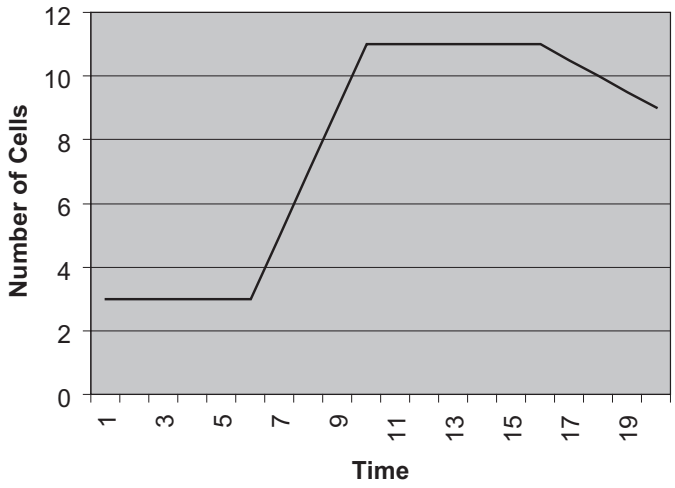


1. If this data showed a linear pattern, it would be represented by the following approximate equation: **y= 0.97x + 62** where 0.97 is the estimated slope and 62 (shortened from 62,000 for ease of calculation) is the estimated y-intercept. Complete a function table below. *Remember 1920 is represented as 20 for x and you will need multiple your calculated y by 1000.*

1920	1940	1960	1982	1990		

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

Phases of Cell Growth



1. Break this graph up into 4 stages and describe the cell growth in each stage.

_____

_____

_____

_____

2. Which stage has a positive slope? What is happening to the cells during this stage?

_____

_____

3. Which stage has negative slopes? What is happening to the cells during this stage?

_____

_____

4. Describe some possible reasons for the death stage (negative slope).

_____

_____

5. The slope is flat during the 1st and 3rd stages. What does a 0 slope mean biologically?

_____

_____

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. 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

NC Common Core

Math Standards:

7.RP Analyze proportional relationships and use them to solve real-world and mathematical problems.

7.NS.3 Solve real-world and mathematical problems involving the four operations with rational numbers.

7.EE.3 Solve multi-step real-life and mathematical problems posed with positive and negative rational numbers in any form (whole numbers, fractions, and decimals), using tools strategically

NC Standard Course of Study (former curriculum)

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.

Materials

Use the following articles:

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://archive.wired.com/wired/archive/11.03/start.html?pg=2l**

Materials (cont.)

3. Puberty and Genetic Susceptibility to Breast Cancer in a case-control study in twins **http://www.nejm.org/doi/full/10.1056/NEJMoa021293**
4. Nature Vs Nurture Revisited **http://www.pbs.org/wgbh/nova/body/nature-versus-nurture-revisited.html**
5. Sibling Rivalry **http://stevenpinker.com/publications/sibling-rivalry-why-naturenurture-debate-wont-go-away**

Procedure

Warm up:

- Give each student a copy of the first article mentioned. Allow them 10 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?

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 and 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. Students might wish to make the following table to help them organize their evidence.

Article	Nature Support	Nurture Support

Allow the class 45-60 minutes to work in pairs or individually. Once the class completes this, allow 3-5 minutes for each presentation (can be done on a subsequent day).

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 (ex. smoking, working with asbestos, exposure to carcinogens, 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.

Math Vocabulary

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

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.

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 frequency 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 straight 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 coordinates.

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.

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