Mathematics, Science, and Technology Education Partnership

IRG Section VII

Professional Development Activities at Brookhaven National Laboratory

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Including Brookhaven National Laboratory in the project has provided an opportunity for the teachers to experience a world class research facility and gain insights on the relevance of science and mathematics' academic content. BNL supported all the populations of the Math Science Technology Project (MSTP) through a series of student programs, teacher workshops and retreats, and parent meetings. The goal was to provide an avenue for all the participants to meet the grant's objective. Our resources, both research and educational, are reflected in the content and quality of these efforts.

The teacher's professional development workshops were developed to integrate current science research with middle school science, math and technology blended activities. Relationships were forged that will continue to benefit these participants and their districts.

BNL modified existing programs to increase the inclusion of mathematics in science. In addition to the MSTP students, all students that experience the Science Learning Center programs now benefit from the increased integration of math and technology. The DNA labs, developed specifically for MSTP, are giving each student and their teachers a chance to experience a full lab activity. These labs, developed in support of this NSF grant, have been sustained through partnerships with BOCES and local school districts. Several thousand students a year now take advantage of this program.

Several facilities at Brookhaven lend themselves to large meetings. The added advantage is the opportunity to have world class research staff available to speak to the groups. The Science Learning Center has been the destination for the teachers, parents and their children during these gatherings. The Science Educators have provided science inquiry programs in a museum setting on several occasions.

MSTP Review

Activities:

- DNA Extraction lab, (lesson plan & PP included)
  Program featuring a one hour DNA Extraction Lab given to an entire grade level, one class at a time. This program includes a teacher workshop in the district prior to the student's lab. Parent demos are also available.
- Science Learning Center programs:
  - Provided hands on Discovery in Science program at Hofstra University for the children of parents attending a Parent Leadership Institute meeting.

- Bus reimbursement for student visits to the Science Learning Center - up to $400 per year.
- Lessons that were math enhanced to accommodate the MSTP students:
  - Mars
  - MagLev
  - Relativistic Heavy Ion Collider (RHIC),

Teacher workshops:

- DNA Lab Professional Development Workshop
  Using BNL's advanced research facilities and equipment, MSTP Fellows participated in a 1-day Science Learning Center "hands-on" DNA workshop that introduces key math concepts in genetics, genetic engineering, and genome analysis. Teachers performed experiments that illustrate the relationship between phenotype and genotype, principles of DNA forensics, modern applications of gene transfer, and genome analysis. These experiments have been specifically designed for ease of replication in middle school and to incorporate state/national sciences standards. (5 hours)
- Adding Math to Science Inquiry Workshop
  Science Learning Center programs and exhibits (3 hours)
- MSTP Workshop 1: includes programs on MagLev trains, planet Mars, and a web based DNA activity. Exhibit exploration time, refreshments and giveaways are included. (2.5 hours)
- MSTP Workshop 2: Includes everything in Workshop 1plus Spectroscopy demo by BNL physicist Lisa Miller and a visit to the National Weather Service (4 hours)

Meetings hosted at Brookhaven National Lab:

- Kick Off Retreat (11/22/03)
  A project overview included the teacher's roles on the team and an examination of the 8th grade assessment. (7.5 hours)
- 1st and 2nd Wave Teachers Retreat (9/24/05)
  This meeting for teachers and parents included a keynote address by BNL's Dr. Stephen Dewey, panel discussions, team building activities (including parents), sharing of activities and poster session, and lesson plan development workshops. (6 hours)
- Hosted a Parent Leadership Institute meeting (9/06). Provided interactive science programs for the participant's children in BNL's Science Learning Center. (6 hours)

Upcoming Events:

- Family Math Project Kick Off Workshop (9/20/08)
  The participants of this Parent Leadership Institute meeting will include15 CSTEP interns, 25 parents plus children, 6 middle school faculty, and 4 SBU/Hofstra faculty/staff and 3 BNL staff. Will provide interactive science activities for participant's children in the Science Learning Center.
  (3 hours)

The MSTP Teacher Workshop

hosted by Brookhaven National Laboratory Science Museum

July 26, 2004

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Brookhaven National Laboratory

Science Museum

MSTP Program — Teacher Workshops

Brookhaven Lab's Science Museum is offering a choice of two workshops to middle school math, science, and technology teachers whose districts are participating in the MSTP grant. This is a way to transition the team member's experiences to their colleagues and to help fulfill the grant's expectations. The objective of these visits is to promote the use of math in the areas of science and technology by using the programs and exhibits in the Museum. There will be extra time to have a discussion of the benefits from this experience.

Each district may choose to attend one of the following:

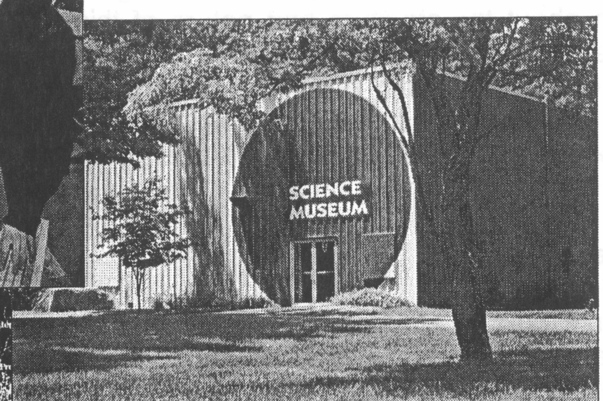
— Workshop 1 —

This 2.5-hour Museum visit includes programs on MagLev trains, planet Mars, and a web-based DNA activity. Exhibit exploration time, refreshments, and giveaways are included.

— Workshop 2 —

This 4-hour offering includes everything in Workshop 1, spectroscopy demo by Brookhaven physicist Lisa Miller, plus a visit to the National Weather Service, which is located on the Lab site.

For reservations,
call Cindi Biancarosa, 631-344-4495.



For more information, contact:

Gail Donoghue
Museum Manager
631-344-2838
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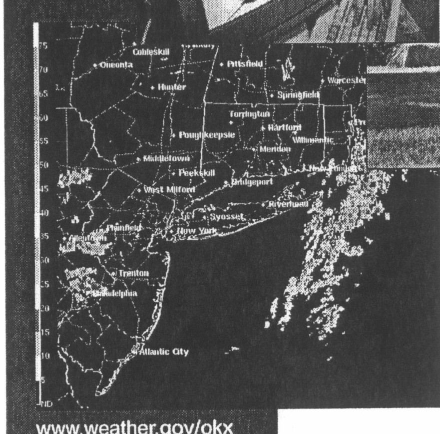

The Science Museum is open year round.

Bus transportation is available from your school.

Visit the Museum's website at www.bnl.gov/scied.

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Science Learning Center Offerings to MSTP Schools

- **DNA Professional Development Workshop**

MSTP Fellows will participate in a 1-day Science Learning Center "hands-on" DNA workshop that introduces key math concepts in genetics, genetic engineering, and genome analysis. Teachers will perform experiments and learn about the 19th century monk Gregor Mendel and his critical observations of how physical traits are passed down to the next generation. Today these rules of heredity are simply known as Mendel's Laws. Participants will apply Mendel's Laws to determine the genotype (gene type) and phenotype (physical trait type) of unknown "parents" using a kernel color trait from an ear of corn. Teachers will then learn about the British geneticist, Reginald Punnett, and the tool he developed to predict genotype and phenotype percentages of offspring. Using this mathematical tool, called the "Punnett Square", participants can predict offspring genotypes and phenotypes from several crosses of corn. Time will be spent studying personal inherited traits that follow Mendel's Laws and developing math activities.
These experiments have been specifically designed for ease of replication in middle school and incorporate state/national sciences standards.

Duration: 5 hours

- **DNA Extraction, an Outreach Program for MSTP Middle School Teachers and Students**

DNA is the molecule that carries the genetic blueprint of all living cells. All life is related through this molecule: humans, whales, plants, and even single-celled organisms like *E. coli*. Students will learn about the structure and nature of this "elegant" molecule by extracting it from cells. Students are introduced to the importance of proper measurement and following a scientific protocol. Students collect the DNA by a technique called "DNA Spooling". Visually observing real DNA enables students to better grasp the basic concepts of molecules and their own genetic code.

Duration: 50 minutes per class

BNL's Office of Education Programs will provide a professional development experience for the grade level teachers as a group to introduce them to the material and the experiments. The DNA extraction program will then be given to the entire grade level of students. These experiments have been specifically designed for ease of replication in middle school and to incorporate state/national sciences standards. The students will actively participate in this lab. All materials will be provided.

Please call 631-344-4495 for more information

Science Learning Center
BROOKHAVEN NATIONAL LABORATORY

Mendel's Law of Heredity: A Corny Experience – lesson plan

Middle school
50 minutes

Summary

Using Punnett Squares and corn, students will explore the laws of basic heredity and use their knowledge to predict the genetics of gummy bears.

Objectives:

The students will utilize Punnett Squares to understand the basics of Mendelian genetics. They will calculate the ratio for possible genotypic and phenotypic outcomes of corn. Students will complete experimental crosses utilizing gummy bears as the experimental organisms.

Vocabulary

Allele – form of a gene, one factor needed to express a trait
homozygous – having two of the same alleles for a genetic trait
heterozygous – having two different alleles for a genetic trait
phenotype – the physical appearance of an organism, how the gene is expressed
genotype – the genetic makeup of an organism
domniant – If two different alleles are inherited in a simple dominant-recessive trait, the one that is expressed is said to be dominant to the other. Some genes are co-dominant in which the phenotype is a blended version of the two (i.e. hair texture will be wavy is a straight and a curly allele are inherited)
recessive – The recessive allele is "hidden" by the dominant allele, not appearing in the phenotype. (i.e. Mendel's pea plants contained the genes for tall or short stems. When one allele for each was inherited the pea plants were tall.)

Materials:

Students will be working in pairs.
Each pair of students will need:

- One ear of corn
- Worksheet
- Pencil
- Gummy Bears kit w/ genetic rules

Procedure

1. Introduction. Explain that we will be working on a very interesting lab, but first we need to build our background knowledge.
2. Briefly discuss genes and traits, asking questions to guide students through the information: Genes are a piece of the DNA sequence that codes for a trait. A trait is a physical characteristic of an organism. Identify some traits of people.
3. Where do you get your genes and traits from? Your parents provide you with your genes. One set from mom, and one set from dad. Each copy of the gene is called an allele. Do other organisms also inherit their genes from their parents?
4. Long before scientists discovered DNA and genetics, Native Americans had a general understanding of basic genetics. Discuss the cultivation of corn into an edible plant. Highlight the use of different colored kernels for different meals and

ceremonies in the Native American culture. They knew each color had to be grown in a separate field to prevent cross pollination of the plants.

5. The first scientist to study genetics was Gregor Mendel. Provide students with a brief background of Mendel and his work with plants in the monastery garden, and the traits he observed in pea plants. Highlight stem height as the one we will focus on.
6. Mendel had purebred tall plants and purebred short plants. This means that the tall plants contained two identical alleles for tallness. Scientists call this homozygous tall; homo meaning same. The short plants also contained two identical alleles for shortness and are considered homozygous short. Demonstrate how we write this out: TT & tt.
7. Mendel took the homozygous tall and crossed them with the homozygous short. This can be illustrated using a Punnett Square, which is similar to a multiplication table. Demonstrate how to write this, with students following along on their paper. All of the resulting offspring have the genotype, or alleles Tt. What will the plant look like? Introduce the term phenotype. Mendel thought they would be a blended form, having medium sized stems but all the plants were tall. This is because one of the alleles is dominant and one is recessive. So there are two ways to be tall (TT & Tt) and one way to be short (tt).
8. Now let's cross two plants from the F1 generation, Tt X Tt. Allow students time to complete Punnett Square, and then walk through results with them. Record the genotypes and the phenotypes of the plants and demonstrate how to put these into a percentage, ratio, or a fraction.
9. Now let's go back to the corn. On this ear of corn we have hundreds of seeds, each one being the offspring of the parent plants. Each one can grow into a "baby" corn plant. What two phenotypes do you observe in the kernels? Which is the recessive? How could we write the possible genotypes for the two phenotypes we observe? If Mendel saw these "babies" he would be able to predict the genotypes of the parents. If time permits allow students to try.
10. Let's see how the corn compares to the results of Mendel's pea plant experiment. Count out a section of 100 kernels and record how many of these are purple and how many are yellow. Each group will record their results on the board. Find the class total for purple and yellow. Then find the total percentage of purple vs. yellow by dividing the part by the whole and multiplying by 100. How close do we come to Mendel's 75-25?
11. We are going to try some more Punnett Squares, but this time you have a challenge. You will receive a bag of baby bears, along with the rules for their genes (dominant, recessive, etc). You will also be provided with several bags of parents. Use the Punnett Squares to help the babies find their parents.
12. For an added challenge students can try a dihybrid cross using the bags of gummies with different colors and sizes. In this challenge, the parents are provided with the genetic rules. Use the Punnett Squares to predict the genotypes and phenotypes of the babies. This can also be done as a whole class activity depending on timing.
13. Point out to student's that some traits are not governed by the laws of simple heredity. Genes can "jump," causing mutations to occur. Some traits are also the outcome of several genes working together, for example eye color. If educator desires, he/she can share the human traits checklist with the students.
14. Wrap up with a brief discussion about Barbara McClintock, Ben Burr, and BNL.

Background information

Corn

Native Americans had an understanding of general genetics well before any scientists "discovered" genetics. They grew many varieties of corn in various different colors. Each color had significance to the different tribes. The Native Americans understood that the different colors had to be grown in separate fields to prevent the crossing of two colors.

Colors:

- In Hopi culture: White corn- prayer offerings & hominy stew at ceremonies; Blue corn- ground up for cornmeal & used as ceremonial offering for children; Red corn- parched & baked in skillet with special prayers to corn spirit (general consumption); Yellow corn (sweet)- baked or roasted outside in big pit (general consumption)
- Cherokees: white corn w/ purple spots, considered Sacred Eagle corn, story passed along the Cherokees states that when the white settlers came the Eagle flew away leaving white kernels behind.

History: The corn was cultivated from a wild grass. The Native American tribes in the south were the first to grow edible corn, collecting and cultivating the plants that were suitable for human consumption. The first corn plants produced small ears of corn which only contained 8-10 rows of kernels. By cross breeding plants that produced more than the average amount of kernels, Native Americans established a line of plants that produced ears of corn we are familiar with today.

As the cultivation and use of corn spread, Native American tribes farther north began growing corn. The corn crops up until this point would only produce corn cobs on the top portion of the stalk, requiring a very lengthy growing season. The tribes in the north bred plants that would produce corn on the bottom of the stalks, which required less time to grow. Through this they cultivated a crop of plants that were suitable for the shorter growing season.

Mendel

He observed many traits in pea plants that occurred in two forms (tall/short stems, white/purple flowers, yellow/green seeds, etc). He established pure breeding lines (all short (tt) & all tall (TT)). He cross bred one plant from each pure breed: one tall (TT) & one short (tt). The resulting F1 generation included all tall plants. There was no blending of the traits, medium plants, as he expected. He then crossed two plants from the F1 generation, producing offspring with a tall-short ratio of 3:1. The F1 genotype for all plants was Tt, producing the possible results of 25% TT, 50% Tt, & 25% tt.

Medel's Basic Laws of Inheritance:

1) Traits are passed on through factors (now called genes).
2) Everyone has 2 copies of the factor, 1 from each parent.
3) Even if a factor does not show in an individual, it can still be passed onto offspring.

General

In Eukaryotic cells DNA is stored as chromosomes in the nucleus. Each gene on the strand of DNA codes for a specific trait. Typically an organism has two copies or alleles of each gene, one from each parent. These alleles may be identical or different, and can result in numerous phenotypes, or physical expressions of the genes.

BNL

Barbara McClintock, a biologist that worked for Cold Spring Harbor, won the Noble Prize in 1983 for her work with corn plants, which she grew at BNL. She discovered that pieces of DNA, now called transposons, can "jump" from one area of a chromosome to another. This can sometimes lead to mutations, or variations in the inheritance of certain genes.

Ben Burr, a geneticist at BNL, worked on sequencing the corn genome, as well as the rice genome. He worked on discovering the placement and function of each gene on the chromosomes of corn by creating mutations in the corn, and viewing the effects in the offspring. Dr. Burr also worked to make stronger and longer cotton fibers produced by corn through deliberating mutating certain genes in the plant's DNA.

Standards:

Content Standard A – Science as Inquiry

Abilities necessary to do scientific inquiry

- Use appropriate tools and techniques to gather, analyze, and interpret data.
- Develop descriptions, explanations, predictions, and models using evidence.
- Think critically and logically to make the relationships between evidence and explanations.
- Recognize and analyze alternative explanations and predictions.
- Communicate scientific procedures and explanations.
- Use mathematics in all aspects of scientific inquiry.

Understandings about scientific inquiry

- Different kinds of questions suggest different kinds of scientific investigations.
- Current scientific knowledge and understanding guide scientific investigations. Different scientific domains employ different methods, core theories, and standards to advance scientific knowledge and understanding.
- Mathematics is important in all aspects of scientific inquiry.
- Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances.
- Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data. All of these results can lead to new investigations.

Content Standard C – Life Sciences

Structure and function in living systems

- Living systems at all levels of organization demonstrate the complementary nature of structure and function. Important levels of organization for structure and function include cells, organs, tissues, organ systems, whole organisms, and ecosystems.
- All organisms are composed of cells--the fundamental unit of life. Most organisms are single cells; other organisms, including humans, are multicellular.
- Cells carry on the many functions needed to sustain life. They grow and divide, thereby producing more cells. This requires that they take in nutrients, which they use to provide energy for the work that cells do and to make the materials that a cell or an organism needs.

Reproduction and heredity

- Reproduction is a characteristic of all living systems; because no individual organism lives forever, reproduction is essential to the continuation of every species. Some organisms reproduce asexually. Other organisms reproduce sexually.
- In many species, including humans, females produce eggs and males produce sperm. Plants also reproduce sexually--the egg and sperm are produced in the flowers of flowering plants. An egg and sperm unite to begin development of a new individual. That new individual receives genetic information from its mother (via the egg) and its father (via the sperm). Sexually produced offspring never are identical to either of their parents.
- Every organism requires a set of instructions for specifying its traits. Heredity is the passage of these instructions from one generation to another.
- Hereditary information is contained in genes, located in the chromosomes of each cell. Each gene carries a single unit of information. An inherited trait of an individual can be determined by one or by many genes, and a single gene can influence more than one trait. A human cell contains many thousands of different genes.
- The characteristics of an organism can be described in terms of a combination of traits. Some traits are inherited and others result from interactions with the environment.

Content Standard F - Science in Personal and Social perspectives

Science and technology in society

- Science and technology have advanced through contributions of many different people, in different cultures, at different times in history. Science and technology have contributed enormously to economic growth and productivity among societies and groups within societies.
- Scientists and engineers work in many different settings, including colleges and universities, businesses and industries, specific research institutes, and government agencies.
- Science cannot answer all questions and technology cannot solve all human problems or meet all human needs. Students should understand the difference between scientific and other questions. They should appreciate what science and technology can reasonably contribute to society and what they cannot do. For example, new technologies often will decrease some risks and increase others.

Content Standard G – History and Nature of Science

Science as a human endeavor

- Women and men of various social and ethnic backgrounds--and with diverse interests, talents, qualities, and motivations--engage in the activities of science, engineering, and related fields such as the health professions. Some scientists work in teams, and some work alone, but all communicate extensively with others.
- Science requires different abilities, depending on such factors as the field of study and type of inquiry. Science is very much a human endeavor, and the work of science relies on basic human qualities, such as reasoning, insight, energy, skill, and creativity--as well as on scientific habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.

Nature of science

- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations.

History of Science

- Many individuals have contributed to the traditions of science. Studying some of these individuals provides further understanding of scientific inquiry, science as a human endeavor, the nature of science, and the relationships between science and society.

Mendel's
Law of Heredity Lab

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t		
t		

Possible Genotypes	Possible Phenotypes

Possible Genotypes	Possible Phenotypes

Use the punnett squares to help you identify the parents of the baby bears.

The parents can be...