Mendelian Inheritance

Overview
This 90 minute lesson (two class periods of 45 minutes) is an introduction to Mendel's Laws of Inheritance for students in grades 5 through 8. By studying inherited traits in humans such as tasting PTC paper and inherited traits in plants such as maize, we can understand how traits are passed down through generations. A discussion of dominant and recessive traits in humans will encourage students to further explore their inheritance as well as their family inheritance.

Learning Outcomes
Students will be able to:
- discuss the contributions of Gregor Mendel and his experiments with the garden pea.
- review the structure of DNA and chromosomes.
- compare a dominant trait to a recessive trait.
- compare a homozygous trait to a heterozygous trait.
- identify traits in themselves that are either dominant or recessive.
- use maize as a model organism to study Mendelian inheritance.
- demonstrate Mendel's Law of Dominance and Law of Segregation by using a Punnett Square.

Prerequisite Knowledge & Skills
Students should:
- know the double helical structure of DNA and that chromosomes are packages of DNA found in the nucleus of cells.
- know that DNA contains genetic information for all living things.
- know that alleles are alternate forms of a gene and are found on the same location on homologous chromosomes
- have a basic understanding of cell division in body cells as well as in gamete formation.
- have an understanding of why sexual reproduction leads to variety of offspring.
- know that flowering plants reproduce sexually.

Misconceptions
- Students may believe that dominant traits are "better than" or "more common than" recessive traits.
- Students may believe that in hybrids, the recessive gene disappears.
- Students may not realize that an allele is a gene

Materials and Equipment
- Student lab note book
- Sentence strips
- PTC paper strips: 1 per student-Carolina Biological
- 3:1 ratio hybrid ears of corn-Carolina Biological
- Computer with internet access

Lesson Structure

Pre-lab (45 minutes) – Day 1
Teacher Prep

- Become familiar with Lab Center http://www.dnalc.org/labcenter/mendeliangenetics/mendeliangenetics_d.html
- Print and copy **Background Reading** from the **Student Lab Notebook** on the Lab center.
- Print and copy **Student Pre-lab Worksheets** from the **Student Lab Notebook** on the Lab center.
- Cut paper strips for Sentence Strips activity.
- Make sure computers with Internet access are available.

Before class
Students will receive the background reading to read for homework the night before starting lab. They will write 2 to 3 questions they have about the background information. They will also highlight any unfamiliar terms.

During Class:
Think – Pair – Share
Using the questions they developed from the homework assignment, each group comes to consensus on one question that they find most interesting. Each group records this question on a sentence strip to be collected by the teacher and posted in the classroom. The teacher will also post one or two of his/her own questions.

Mini lesson
Major lab concepts will be taught using information and resources from the Lab Center at:
http://www.dnalc.org/labcenter/mendeliangenetics/mendeliangenetics_d.html

1. Begin the mini-lesson with a class brainstorm: Why is Gregor Mendel considered the "Father of Genetics?" Write down all student responses on chart paper. Accept all responses.
2. Show class the spoken introduction to the "Mendelian Inheritance" activity from the Lab Center.
3. Explain that for the next few days they will be applying the basic laws of inheritance proposed by Mendel to other model systems. Today, they will get a background on Mendel and how he discovered the basic laws of inheritance.
4. Depending on the availability of resources in your school and the needs of your students, there are several approaches to exploring the website:

a. Student pre-lab worksheets are available in the **Student Lab Notebook**. You can assign students to work individually or in pairs to explore the different activities and answer all of the questions.
b. Use an LCD and/or Smartboard to explore the website with the entire class, and answer the questions.

Lab Activity: Day 2
Description of Activity

Teacher Prep

- Make copies of the **Human Traits Checklist**, the **Human Traits Wheel**, and the **Traits Chart** from the **Student Lab Notebook.**
- Gather PTC paper strips and 3:1 hybrid corn

Inheritance in Maize

- Introduce the use of Punnett squares to predict the inheritance of traits in living things. You can use the "Genetic Inheritance" animation on the Lab Center to introduce their use.
- Corn (Zea mays) is a plant that has been used in genetic research for the last century and selectively bred by Native Americans for even longer!
- Students will carefully observe and collect data on pigmentation in corn kernels.
- Use Punnett squares to visually represent the mathematical probability of various traits being passed from one generation to the next to give additional support for Mendel's great work.

Procedure

- Hand out an ear of corn to each pair of students.
- With a partner, students need to determine the genotypes of the parent corn plants that have produced these offspring.
- To do this, students will count the number of purple (pigmented) and yellow kernels in a small population of kernels.
- Count 100 kernels from a cob that has some purple and some yellow. To do this:
    - Partner #1 will mark the beginning of a row of kernels with a fingertip, and leave the fingertip in place until activity is completed.
    - Partner #2 will start counting the kernels from the fingertip and continue counting complete rows until he/she reaches the 100th kernel.
    - Partner #1 will use a second index finger to mark the 100th kernel. Between Partner #1's fingers there are now 100 kernels.
    - Partner #2 will count how many of the 100 kernels are yellow. Once this is done, fingers can be moved from the corn.
- To find the number of purple kernels, simply subtract the number of yellows counted from 100.
- When students have data, they can add it to a collective chart on the board. They should also copy the collective data chart into their lab notebooks.
- When all lab pairs have contributed data, find the average number of yellow and the average number of purple kernels. Record this in the lab notebook.
- Compare the ratio of purple to yellow kernels.
- Can you infer from this data which trait is dominant and which is recessive?
- With this information how could this generation of corn have inherited pigmentation in this way? What do the genotypes of the parent generation have to be?

    Make a key

    Let P = the gene for purple

    Let p = the gene for yellow

Human Population Study

- Studying human traits by conducting a mini-population study in the classroom provides further insight.
- Use Punnett square to visually represent the mathematical probability of various traits being passed from one generation to the next.

Procedure

- Distribute Human Traits Checklist.
- With a partner, students can use the **Human Traits Checklist** and **Traits Chart** to collect classroom data on a few common genetic traits in humans.
- For each trait listed, students circle whether they have the dominant trait or recessive trait. If they don't have a mirror, partners must help. Provide PTC paper for taste testing.
- Once the data is collected, students will add their own data to a collective data table on the board for everybody in the class, and copy the collective data table into their lab notebooks.
- Tally the total number of students with each trait. Take note of the number of people with dominant traits as opposed to recessive traits.
- Make a final average of the total number of dominant and recessive traits for the whole class.

- Finally, use the **Human Traits Wheel** to identify your "number." This number corresponds to your combination of traits.

Post Lab

- Post-lab worksheets can be done in class together, or assigned for homework, so that students can reflect on what was studied.

Applications

- Read the "**Gregor Mendel Biography**" animation on the website to discuss all three of Mendel's laws that he was able to formulate from his studies with the pea plants.
- Use the "**The Rules of Inheritance**" animation on the Lab Center to discuss how Reginald Punnett was able to work further on Mendel's Laws of Inheritance. Use the **Punnett Squares Worksheet** in the **Student Lab Notebook** to study inheritance patterns in other organisms.
- Watch the "**Color Vision**" animation of Matt Ridley discussing the inheritance of the sex chromosomes and how color vision is inherited more commonly in males than females.
- Have each student travel through the **"How Unique Are You?"** animation and enter all of their physical traits to see how their combination of traits is unique, but may be shared by other people in the world.
- Use the **"Making a Pedigree"** and the "**Mendelian Laws and Humans"** animations to study the construction of pedigrees and how they can be used to trace human inheritance.

Further Exploration

- Have students research a genetic disorder, including: pattern of inheritance, the major signs and symptoms of the disorder, and any possible testing options can be discussed. Students can use the website www.ygyh.org to research, which also has links to other websites with relevant information.
- Research the field of genetic counseling. Genetic counselors work with patients to predict the possibility of inheriting certain disorders. They also test and screen parents and children for the disorders. If someone needed counseling, how could they locate a counselor? What kind of training does one need to become a genetic counselor?
- Learn how society viewed inheritance of certain traits back in the 20th century during the Eugenics Movement using the website: www.eugenicsmovement.org.

Resources

Websites

www.dnalc.org/labcenter
A Dolan DNA Learning Center site which has all background materials, protocols, etc.

www.ygyh.org
A Dolan DNA Learning Center Internet site.
Use this site to learn more about specific diseases

http://www.dnaftb.org
A Dolan DNA Learning Center Internet site.
Use this to explore various genetics concepts from inheritance to genetic engineering.

http://www.dnai.org
A Dolan DNA Learning Center Internet site.
Use this site to learn about the past, present and future of DNA science. This site also has wonderful animations.

www.eugenicsarchive.org
A Dolan DNA Learning Center Internet site.
Use this site to learn about the eugenics movement during the 20th century.

Films
"The Secret of the Code"
3-2-1 Contact, Children's Television Workshop, 1991

"Cracking the Code of Life"
NOVA, WGBH.org (PBS)

"Anastasia, Dead or Alive"
NOVA, WGBH.org (PBS)

Books
Balkwill, F.R. & Rolph,M (2002) *Enjoy Your Cells*
Woodbury, New York: Cold Spring Harbor Press
Balkwill,F.R. & Rolph, M (2002*) Have a Nice DNA*
Woodbury, New York: Cold Spring Harbor Press

New York State
NYS Standard 4: Science
The Living Environment

- Living things are both similar to and different from each other and nonliving things.
- Organisms inherit genetic information in a variety of ways that result in continuity of structure and function between parents and offspring.

- Individual organisms and species change over time.
- Human decisions and activities have a profound impact on the physical and living environment.

National Science Standards
Content Standard C: Life Sciences
Reproduction and Heredity

- 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.

AAAS Benchmarks
Chapter 5: The Living Environment
Standard B: Heredity

- Some new gene combinations make little difference, some can produce organisms with new and perhaps enhanced capabilities, and some can be deleterious.
- Genes are segments of DNA molecules. Inserting, deleting, or substituting DNA segments can alter genes. An altered gene may be passed on to every living cell that develops from it. The resulting features may help, harm, or have little or no effect on the offspring's success in its environment.
- In some kinds of organisms, all the genes come from a single parent, whereas in organisms that have sexes, typically half of the genes come from each parent.

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