HISTORIC GERMANTOWN SCIENCE *Sleuths*

Section 3 : STENTON

LESSON OBJECTIVE

To learn how organisms reproduce and pass down their traits to their offspring (children), and why there is so much variation in offspring.

The barn at Stenton

Key Terms

Natural Selection

a process in which natural factors decide whether a species can survive and reproduce based on the characteristics of its individuals. Natural selection is caused by random factors in the environment, such as heating or freezing, lack or abundance of predators, lack or abundance of food.

Artificial Selection

a process in which humans consciously select for or against particular features in organisms. For example, by choosing which individuals to save seeds from or breed from one generation to the next. People have been artificially selecting plants and animals for thousands of years. Species can evolve dramatically through selective breeding.

Test your knowledge

Multiple choice

1. These things have genes:

a) a maple tree
b) raccoon
c) cockroach
d) all of the above

2. The way a plant looks is called its:

a) biome
b) phenotype
c) DNA
d) genotype

3. This is an example of a trait:

a) a pug's short nose
b) the number of seeds a tree makes
c) how much money a person makes
d) a car's paint color

4. How a child looks compared to its parents is determined by

a) the mother's genes
b) the father's genes
c) chance
d) all of the above

Match the term with its definition

Genotype ○	○ a system in which all organisms are similar
Trait ○	○ the way an organism looks or functions, controlled by genes
Heredity ○	○ the genetic make-up of an organism
Biome ○	○ passing down traits from one generation to the next
Monoculture ○	○ an area with a specific climate, animals, and plants

Site History

Stenton was home to six generations of the Logan family from 1730-1860. James Logan (1674-1751) was an influential figure in colonial Pennsylvania: secretary to founder William Penn, Mayor of Philadelphia, Lieutenant Governor of Pennsylvania, and a chief justice on the supreme court. He founded the Loganian Library with the nearly 3000 books he collected in his lifetime. This library is now part of the Library Company of Philadelphia, founded by his young friend, Benjamin Franklin. Like Franklin, Logan was very interested in science and mathematics. Logan conducted his own backyard experiments on maize (corn) in the early 18th century which led to the identification of male and female reproductive organs in the plants. One of Logan's primary responsibilities in early Pennsylvania was negotiating with the local Native Americans, the Lenape of eastern Pennsylvania and the Haudenosaunee of New York. Archaeological evidence has shown that the Lenape lived in this area for 13,000 years. Through a deceptive agreement known as the Walking Purchase, James Logan and William Penn's sons forcibly removed the Lenape from 1,876 acres of their lands in Bucks County Pennsylvania in September, 1737.

Did you know?

The name Lenape translates to "original people." They lived mostly in the Delaware Valley, but were a nomadic people who traveled up into what is now southern New York, New Jersey, and northern Delaware which collectively they called Lenapehoking or "Land of the Lenape."

James Logan (1674-1751)
Unknown artist
Probably 19th century
NSCDA/PA at Stenton
Gift of William Logan Fox, 1965

Stenton embankment, 1870s

What to know before you go *(continued)*

Key Terms

Cross Breeding

in artificial selection, deliberately mating two different variations of the same organism to create a new offspring. This is used for breeding crops, dogs, and flowers, for example.

Gene (Genetic)

an element of heredity or a molecule called DNA that all living organisms have inside every cell of the organism. Genes are the building blocks of organisms, and determine how they are structured, what they look like, and how they function. An error in gene copying can lead to a mutation, which can have a bad effect (birth defect, death of organism) or good effect (better eyes, stronger sense of smell).

James Logan purchased 511 acres, six miles from the port City of Philadelphia and near the German Township, later known as Germantown. Situated between the Germantown Road and the York Road (Broad Street today), Stenton was accessible to travelers and trade goods going in and out of Philadelphia. Construction of the brick, Georgian-style house began in 1723 with enslaved laborers digging the cellar. Carpenters and plasterers completed the interior seven years later. James Logan named Stenton after the town in Scotland where his father was born. Today, Stenton is one of the best preserved colonial houses in the Philadelphia area and presents an impressive collection of Logan family artifacts stewarded by The National Society of The Colonial Dames of America.

Corn growing at Stenton

The Logan family lands in 1777 overlaid onto a contemporary map illustrates that William Logan added to his father's land-holdings. *Created by James M. Duffin.*

Gregor Johann Mendel

Gregor Johann Mendal (1822-1884) was an Austrian-Czech biologist, meteorologist and mathematician who was also a monk in St. Thomas's Abbey in Brno (now in the Czech Republic). Mendel came from a family of farmers and became a monk partly because it allowed him to have a free education. He is famous for his experiments with pea plants conducted between 1856 and 1863 that established the laws of inheritance before anyone knew anything about DNA or how traits were passed from parent to offspring. On a plot of about 5 acres at the monastery, he studied seven different traits of pea plants: plant height, pod shape and color, seed shape and color, and flower position and color. By ***cross-breeding*** plants of different types, he became able to predict what the offspring would look like.

He noted that when he crossed a true-breeding green pea with a true-breeding yellow pea, their offspring were always yellow. But when he further crossed the resulting offspring, the result was 1 green pea to every 3 yellow peas. He applied the term "dominant" to refer to genes that overpowered other traits, and "recessive" to refer to genes that hid their traits when crossed with a dominant one.

LEFT: Plate of Gregor Mendel from Volume 1, Issue 1 of *The American Breeders Magazine*, 1910

Key Terms

Sexual Reproduction

when two organisms combine half of their different genetic material to produce genetically diverse offspring that are different from their parents. Examples of this are: most plants and almost all animals. Disadvantages: you have to find a mate, growth is slower, and offspring might have a trait that is unwelcome. Advantages: the diversity of sexually produced offspring gives species a better chance of surviving in an unpredictable or changing environment.

Asexual Reproduction

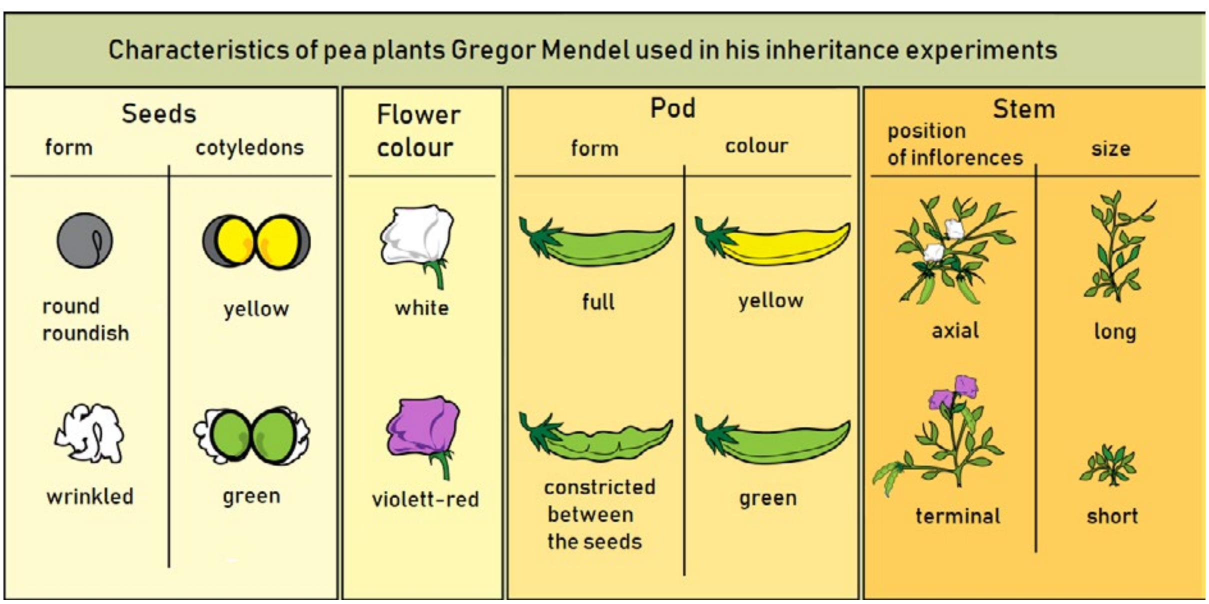
a form of reproduction where offspring are produced by a single parent without the fusion of gametes, resulting in genetically identical individuals or clones. This process is common in unicellular organisms like bacteria or amoebae, as well as in some multicellular organisms such as plants and certain animals (some female frogs will have asexually created offspring if there are no male frogs around).

Key Terms

Chromosome

stringlike package of genetic material (DNA) that is tightly coiled. Chromosomes occur in pairs in organisms: humans have 23 distinct pairs of chromosomes (46 total)–22 pairs of body chromosomes and 1 pair of sex chromosomes (X or Y). Other organisms may have fewer (a yellow fever mosquito has 6) or more (a black mulberry bush has 308). A potato plant has 48, 2 more than humans!

Mendel came up with his laws of inheritance based on years of painstakingly breeding pea plants: the Law of Dominance, Law of Segregation and the Law of Independent Assortment, which are now considered keystones in the science of genetics. When he gave a paper on his work at the Natural Historical Society of Brno in 1865, he was largely ignored. After he was promoted to abbot in 1868, his experimental work ended as he was caught up in the bureaucracy of the Abbey and tax disputes with the local government. Mendel died in 1884 from kidney disease. The next abbot burned all the papers in Mendel's collection in an effort to end the tax disputes. He was not recognized for his genius until the 1930s, when his work was connected to that of Charles Darwin, thus creating the modern science of evolutionary biology. At that time in the Soviet Union and China, Mendelian genetics was rejected, leading to the imprisonment and even execution of geneticists in those countries.



The Three Sisters Crop

Modern farming practices favor crops grown in monocultures, that is, huge areas of all the same plant. In indigenous cultures, something called *companion planting* was and is still practiced instead. Here in Pennsylvania, the Lenape people that used to live on this land practiced companion planting of three crops: maize (corn), beans, and squash. The corn and beans are planted together in mounds formed around the base of the plants; squash is planted between the mounds. The bean vines climb up the cornstalks, and the squash leaves shade the roots of the corn and beans from direct sun, keeping the ground moist. This method also increases soil temperature in the mound and improves drainage, actions which support the maize when newly planted in spring. The name "three sisters" comes from an indigenous legend common across many peoples that once farmed the continent of North America, including the Lenape.

Keya Wakpala Garden, a community garden on the Rosebud Indian Reservation in south central South Dakota, incorporates the Three Sisters method. Signs in the Lakota language identify plants. *Photo by USDA NRCS South Dakota. License.*

Did you know?

The Three Sisters legend starts: *"Very long ago, there were three sisters who lived in a field. The youngest was so small she could not yet walk; she crawled along the ground, dressed in green [squash]. The middle sister wore a bright yellow dress and darted back and forth across the field [beans]. The eldest sister stood tall and straight, and her body bent with the wind. She had long yellow hair and wore a green shawl [corn]. The three sisters loved one another very much and could not imagine living without the others."* The legend goes on to tell how the sisters met with an indigenous boy whom they befriend and then help by providing nourishment all winter long.

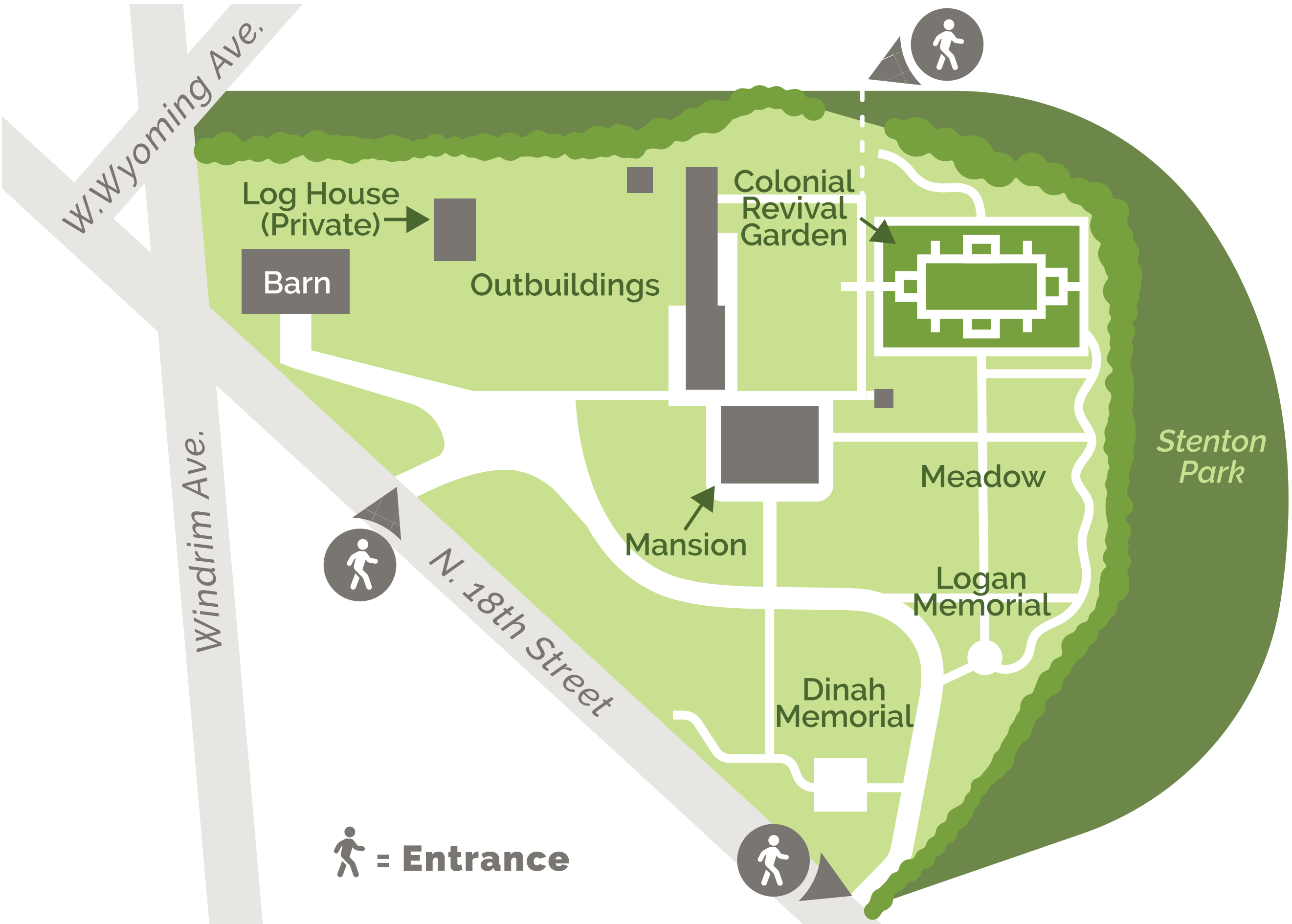
Supplemental Vocabulary

Allele	a variant of a sequence of nucleotides on a specific section of a gene (DNA molecule). In other words, the allele a sex cell (gamete) receives from one gene (say for hair color) does not influence an allele received for another gene (say for height).
Biodiversity (Biological Diversity)	the variability and variety of life on earth. It can be measured in genetic variability, species diversity, and ecological diversity. Biodiversity is greatest in the tropics, because of the warm, moist climate.
Biome	a distinct geographical region with specific climate, vegetation, and animal life. It consists of a biological community that has formed in response to its physical environment and regional climate. Biomes may span more than one continent. A biome may have multiple ecosystems within it. A microbiome is a tiny ecosystem; for example a yard or even a puddle.
Dominant (Dominance)	when one allele hides or overrides the effect of the corresponding allele on the other half of the chromosome pair. Examples of dominant alleles are the ones for dark hair, for normal blood cells, and for long noses in dogs.
DNA (deoxy-ribonucleic axid)	a complex molecule that carries genetic information necessary for the development, functioning, growth, and reproduction of all known organisms. It consists of two strands that coil around each other to form a twisted ladder (double helix), with each strand made up of nucleotides containing a sugar, phosphate group, and one of four nitrogen bases: adenine, thymine, guanine, or cytosine.
Gamete	reproductive cell having half the number of chromosomes of its parent, often called a sperm cell or egg cell.
Genotype	the complete genetic makeup of an organism. An organism's genotype is not always obvious just from observing the individual; you have to observe it at a microscopic level in order to see the genotype.
Heterozygous	if alleles on two matching chromosomes of an organism are different, the organism is called heterozygous
Homozygous	if alleles on two matching chromosomes of an organism are the same, the organism is called homozygous
Law of Independent Assortment	different genes are inherited independently of one another. In other words, the allele a sex cell [gamete] receives for one gene does not influence the allele received for another gene.
Law of Segregation	when an organism makes sex cells [gametes], each sex cell receives just one gene copy, which is selected randomly

Supplemental Vocabulary *(continued)*

Monoculture	the cultivation of a single crop on a farm or in a region or country. Examples of monocultures are soybean fields (almost any crop field), lawns, Christmas tree farms, and factory chicken farms
Mutation	a change in the DNA sequence of an organism. Mutations can be the result of errors in DNA replication during cell division, exposure to toxins, radiation, or a viral infection. Mutations that occur in eggs and sperm can be passed on to offspring, while mutations that occur in body cells are not passed on. Mutations by definition are neither good nor bad, but may have good, bad or neutral effects on the offspring that inherit them. So calling someone a "mutant" could actually be a compliment.
Phenotype	the set of observable characteristics or traits of an organism. Basically, what it looks like, how big it is, what it sounds like, and so on.
Punnett square	a diagram used to predict the probability of certain genotypes in a cross breeding experiment. It was invented by British geneticist Reginald Punnett in 1905. It is used for one trait only.
Recessive	when one allele's effect is hidden or overridden by the corresponding allele on the other half of the chromosome pair. Examples of recessive alleles are the ones for blond hair, for sickle-shaped blood cells, and for short noses in dogs.
Solution	a liquid mixture of two or more substances that are equally mixed throughout. Salt water is an example of a solution; cake batter is not.
Test cross	a test to figure out the genetic makeup of an organism whose genetic makeup is unknown. In this test, a plant (or animal) with a dominant phenotype (the unknown) is bred with a plant or animal with the recessive phenotype. If all offspring have the dominant phenotype, it means that the unknown organism is homozygous dominant. If the offspring are varied, it means that the unknown organism is heterozygous.
Trait	a characteristic of an organism that can be observed outwardly (phenotype). Examples of traits are eye color, height, number of leaves coming off one stem, egg shape.

Can't wait to see you at **STENTON!**



www.stenton.org

What have you learned?

Multiple choice

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Match the term with its definition

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Monoculture ○	○ an area with a specific climate, animals, and plants

Did you know?

It is possible, either naturally or through artificial insemination, to create hybrid breeds across species, leading to such creatures as the liger (cross between female tiger and male lion). This can happen only when the two species are genetically very close. For instance, both lions and tigers have 38 chromosomes and have many similar genes. This offspring is called a first-generation hybrid. If ligers went on to mate, their offspring would be second-generation hybrids. Some animals, such as mules (created from a cross between a male donkey and a female horse), are sterile, because the horse has 64 chromosomes and a donkey has 62. The mule has 63 chromosomes, an uneven number, so it can't have offspring.

Data Analysis

1. Think back to the Punnett squares you discussed during your visit to Stenton. Now decide on one human trait that you wish to study, such as the ability to roll your tongue, whether cilantro tastes like soap, free hanging vs attached earlobes, hair color, etc. Then make a record of how many students in your class have either one trait or the other. Based on the statistics, can you tell which is dominant? Now ask each student to find out whether their biological parents have this trait or not. Based on what you think, can you deduce which is the dominant allele? Make a Punnett Square to show this.

2. Find two different microbiomes near your school or your home. Make lists of flora (plants) and fauna (animals) you observe in these places over the course of a week. Visit several times a day, so you can get the diurnal (daytime) animals, nocturnal (nighttime) animals, and crepuscular (coming out at dawn and dusk) animals. Is either of these microbiomes a monoculture? Make tables of your data and rank the biodiversity of each microbiome.

Photograph of a liger

Links to Useful Sites

[Southside Permaculture Park: Three Sisters]

[Wikipedia: List of Organisms by Chromosome Count]

[Oneida Indian Nation: Legend of the Three Sisters]

[Khan academy - Introduction to Heredity]

[Lenape: The First Agricultural Innovators]

[UC Davis: How to Cross Pollinate Beans (YouTube)]

[Hand Pollination in Common Beans (YouTube)]

[MSU: Crossing Dry Bean]

Site Lesson Extensions

Get two bags of pinto beans, one black and one red, then grow your own plants. Clearly label the pots. When they are sexually mature (have flowers), cross them to fertilize the plant. This will involve taking the pollen from the red bean plants and dusting it on the black bean plants' stigmas (or vice versa, depending on which blooms first). Label the blossoms that you have cross-pollinated with a paper tag, gently pinch them closed, or use a piece of tape to close them, and remove any blossoms near them so there will be no accidental self-pollination. When a beanpod develops from the pollinated blossom, see what color the beans are. Determine which color is dominant or recessive from the phenotypes of the offspring. The new beans should all have one dominant color. If you cross a second generation, you should have a more or less 3:1 ratio for dominant to recessive traits, though this will not always be perfect, since you won't be able to tell from the phenotypes of the first-generation offspring which beans are homozygous dominant and which are heterozygous dominant.

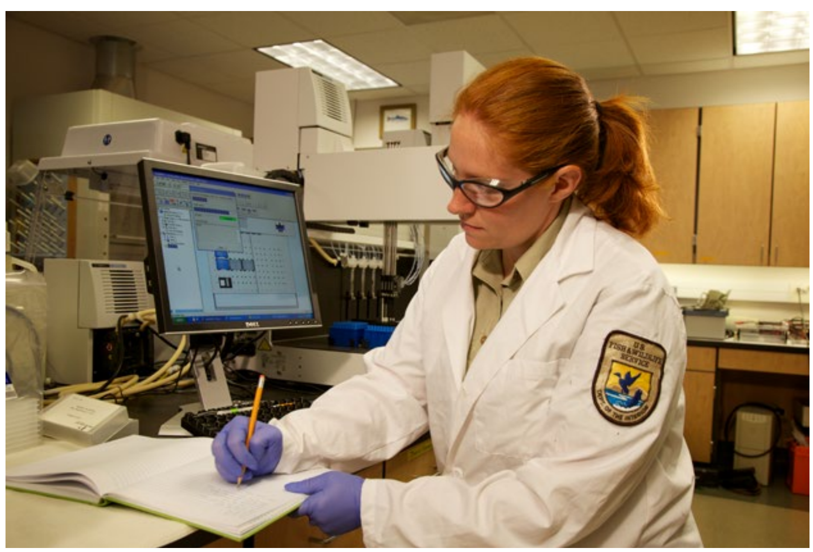
Writing Prompt

Why do you think sexual reproduction is the most common way for plants and animals to create offspring? What are its advantages? Why is being able to pass down a trait to your offspring usually a good thing? When would there be an advantage of the offspring not being exactly identical to its parent? Give at least two examples of this.

Geneticist

A geneticist is a biologist or doctor who studies the science of genes, heredity, and variation in organisms. There are many subfields of genetics, such as agriculture, animal breeding, genetic counseling, gene therapy, biotechnology, forensic DNA analysis, and genomics (gene mapping).

Some geneticists perform experiments in model organisms such as fruit flies, rats, or humans and analyze data to interpret the inheritance of biological traits. A medical geneticist is a doctor who evaluates, diagnoses, and cares for patients with hereditary conditions such as diabetes or congenital defects such as Down's syndrome. They may inject modified genes into a patient in hopes of curing a rare genetic disease. They may provide counseling and analysis of genetic defects for pregnant women. Some may work to breed more resilient or more fertile crops or cows that produce more milk. A forensic genetic pathologist is a scientist who analyzes crime scene DNA to figure out who committed the crime.



Geneticist Jennifer Von Bargen recording data in the Conservation Genetics Lab. *Credit Ryan Hagerty/USFWS.* [License.]

Did you know?

The first genetically engineered plants to be produced for human consumption were introduced in the mid-1990s. Today, approximately 90 percent of the corn, soybeans, and sugar beets on the market are GMOs.

Genetically Modified Organisms

A genetically modified organism (GMO) is an animal, plant, or microbe whose DNA has been altered using genetic engineering techniques. For thousands of years, humans have cross-bred plants and animals to create certain desired traits (tougher skin, longer ears, prettier color, larger size). Recently, though, modern advances in biotechnology have allowed scientists to directly modify the DNA of microorganisms, crops, and animals. The old methods of modifying plants and animals—selective breeding and crossbreeding—can take a long time and can sometimes produce mixed results, with unwanted traits appearing alongside desired traits. By targeting certain alleles on chromosomes when modifying DNA, scientists can avoid this problem and change the genetic makeup of an organism without creating any unwanted traits.

Blues and purples do not occur naturally in roses, so scientists used genetic modification to create this lavendar colored rose, a variety called "Applause".

Did you know?

Most crops in the U.S. are grown as a monoculture, which means each plant is practically genetically identical. Farmers do this because monocultures are more efficient, easier to plant and harvest, and because certain agricultural equipment is specially designed to harvest and process one crop. However, there are many downsides to crop monocultures. Growing food in this way can deplete soil nutrients, cause erosion, and requires more pesticide and water use than other methods of farming.

Genetically engineered crops produce higher yields, have a longer shelf life, and are resistant to diseases and pests. Genetically modified organisms can be a source of concern, however. Genetic engineering changes an organism in a way that would not occur naturally. It is even common for scientists to insert genes into an organism from an entirely different organism. While inserting a gene from a frog into tomatoes to make them more resistant to frost (frogs have a sort of antifreeze in their blood) may make them harvestable after the weather gets cold, the effects of humans consuming frog antifreeze aren't known. Other concerns include the possibility of the genetically engineered DNA spreading to non-GMO plants and animals. A modern-day geneticist can help create beneficial organisms but must also be aware that changing an organism's genetic makeup at the level of DNA may have consequences that are unexpected or harmful.

2014 "March Against Monsanto" *Credit: Rob Kall. License.*

Acknowledgements

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Cover images include a solar microscope, bone slide with mosquito specimen, and meteorological tablets from the collection of the Wyck Association; Isaac Norris' Thirty Year Pocket Almanac from 1677 from the Stenton Collection on deposit at The Library Company of Philadelphia; and Hexamer General Survey of Wingohocking Hosiery Mills, Shoemaker Lane and Wingohocking Creek, Germantown, Philadelphia, Philadelphia County, Pennsylvania. vol.10 Plate 943, from the Free Library of Philadelphia.

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STENTON

Awbury Arboretum

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