Mendelian Genetics

Activity

Part I: Introduction

Some of your traits are inherited and cannot be changed, while others can be influenced by the environment around you. There has been ongoing research in the causes of cancer. Most of the time, cancer can be influenced greatly by nature. The food you eat, the amount of radiation you are exposed to, or even your weight can affect your chances of developing cancer. However, with the discovery of BRCA1, or the "breast cancer gene," scientists insist that the causes of cancer may lie more with nature than previously thought.

Instructions

Below is a list of traits that an individual may possess. For each of the listed traits, write an "X" either under the "Nature" column if the trait is inherited, or in the "Nurture" column the trait is learned or influenced by the environment. Place an "X" in both columns if it is a combination of the two.

Trait	Nature	Nurture
Brown Eyes		
Athletic		
Short in Height		
Red Hair		
High IQ		
Overweight		
Smoking		
Mental Illness		
Addiction		
Cancer		

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Activity, continued

Part II: Gregor Mendel

Have you ever looked at your sibling and wondered why he may be tall like your father, whereas you may be short like your mother? Or maybe why you look more like a grandparent than you do your own parents? Maybe the trait of having a larger nose skipped a generation. All of this can be explained using genetics and inheritance patterns.

Gregor Mendel (1822–1884), considered the father of genetics, studied pea plants by crossing them and noting the resulting traits in the offspring. Through his studies with pea plants, Mendel developed three principles or “laws” of inheritance:

1.The law of segregation: during reproduction, alleles are randomly separated into gametes during the process of meiosis.

2.The law of independent assortment: genes located on the same chromosome will be inherited independently of each other. Therefore, even though a plant has a long stem, it doesn’t mean that it will also have purple flowers.

3.The law of dominance: a dominant allele will completely mask a recessive allele. A homozygous dominant and heterozygous genotype will produce the same phenotype.

Mendel was able to predict the outcomes of crossing plants with dominant traits and those with recessive traits. Mendelian crosses are used to predict the possible genotypic and phenotypic outcomes of offspring. That’s what you’ll do soon, but you don’t have to grow the plants!

As you have learned in previous lessons, the DNA sequence or the information contained in the gene, can be used to create proteins that specify a particular trait such as eye color. The information carried on the gene is the genotype, and the way that information is expressed, such as blue or brown eyes, is the phenotype.

Remember that an organism’s genes are carried on the chromosomes in the nucleus of the cell. During meiosis, gametes or reproductive cells are formed. When an egg and sperm from two individuals unite, the offspring inherits one set of chromosomes from the mother’s egg and one set of chromosomes from the father’s sperm. This creates a unique set of chromosomes for each offspring.

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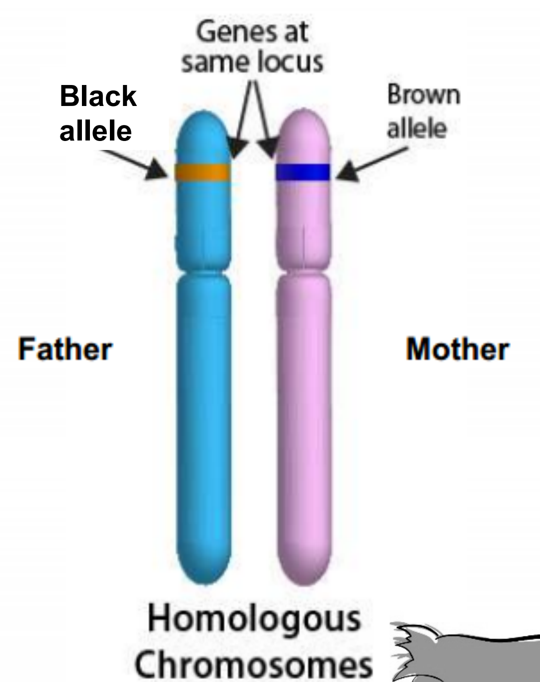
Activity, continued

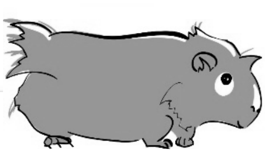
Part II: Gregor Mendel, continued

The maternal and paternal chromosomes in a chromosome pair will carry the same gene for a specific trait but often a slightly different version. A different version of the same gene is called an allele. The combination of alleles, one from the father and one from the mother, results in a unique genetic combination. This unique combination of alleles in each individual helps create diversity within species.

Below you will see two chromosomes from the offspring of true-breeding parent guinea pigs. We call the parents the P Generation and their offspring the F1 Generation. True-breeding means that each parent has two matching alleles for a trait, in this case fur color. If the allele for white fur color is represented by **B**, the true-breeding genotype must be **BB** (one from each chromosome), and the phenotype will always be white fur. On the other hand, if the allele for black fur color is represented by b, the true-breeding genotype has to be **bb**, and the phenotype will always be black fur. Let's walk through this step by step.

In our diagram below, the F1 offspring has inherited one chromosome from the father (shown in blue) and one from the mother (shown in pink). On these two chromosomes, you can see the specific locus for the gene for fur color. It is this specific location on the chromosome that contains the gene for fur color. You can see, however, that each allele of the gene expresses a different trait or phenotype. The offspring has inherited the black allele (**b**) from the father and the white allele (**B**) from the mother. Genetics tells us this particular offspring will have either brown or white fur. How can you predict that outcome?





1. Which parent is considered to be homozygous dominant and what is the genotype?

____

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2. Which parent is considered to be homozygous recessive and what is the genotype?

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3. How would the genotype of this offspring be represented?

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4. Using what you have read, color in the guinea pig below with his resulting color, based on his genotype. The resulting color would be considered the phenotype.

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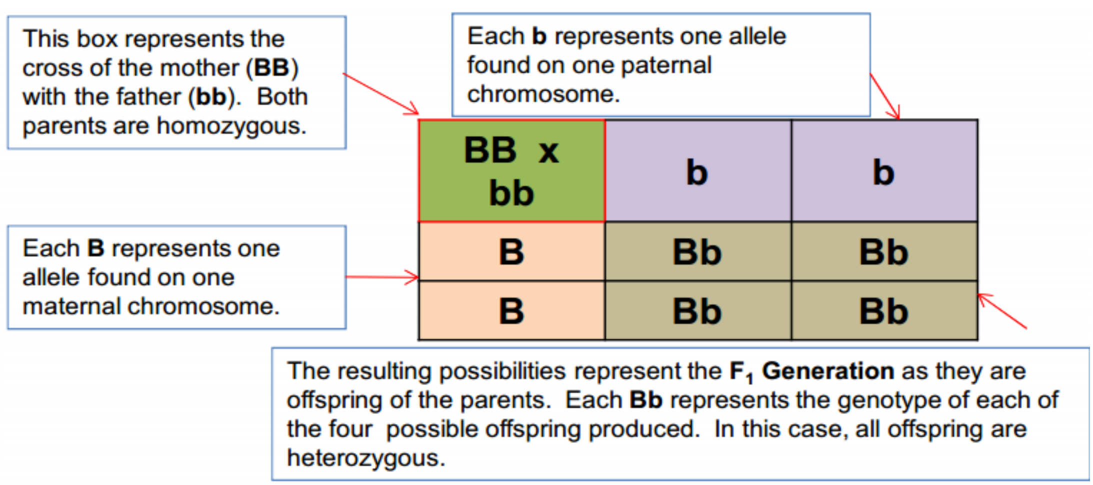
Activity, continued

Part III: Predicting Genetic Outcomes

Fur Color Trait Example

Each genotype for a trait may have dominant and/or recessive alleles. The dominant allele is represented by an uppercase letter (**B**)**,** while the recessive allele is represented by a lowercase letter (**b**). In our example, both parents are homozygous for fur color, which means that each carries two of the same allele, one allele from each parent. Therefore, the genotype of one parent is **BB** (homozygous for brown fur), and the genotype of the other parent is **bb** (homozygous for black fur). Homozygous individuals always express the phenotype that matches their alleles. If the parents had a genotype that was heterozygous, that would mean they would carry one of each allele for that trait, or **Bb**. Heterozygous individuals express the phenotype of the dominant allele, which in this case is brown fur.

Our cross between a parent with homozygous dominant fur color **BB** and a parent with homozygous recessive fur color **bb** is shown in the Punnett square (named after Professor Reginald Punnet,1875–1967) below. You can see that all of the possible combinations result in a dominant **B** and a recessive **b**, which means they are all heterozygous. The dominant trait will be expressed in this phenotype, so all of the offspring will have brown fur.



The results of Punnett Square analyses are expressed as ratios for both genotypes and phenotypes. In our first example on the previous page, all four of the offspring genotypes are **Bb**, with no other combinations, so the genotypic ratio would be 4:0. The only phenotype expressed in the offspring will be brown fur, with no other choices, so the phenotypic ratio would be 4:0 (or 100% brown).

If the results of another cross were **BB** = 1, **Bb** = 2, and **bb** = 1, the genotypic ratio would be 1:2:1. The expression of the phenotype would be three offspring with brown fur and one with black fur, so the phenotypic ratio would be 3:1.

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Activity, continued

Part III: Predicting Genetic Outcomes, continued

Tongue-Rolling Trait Examples, Scenario One

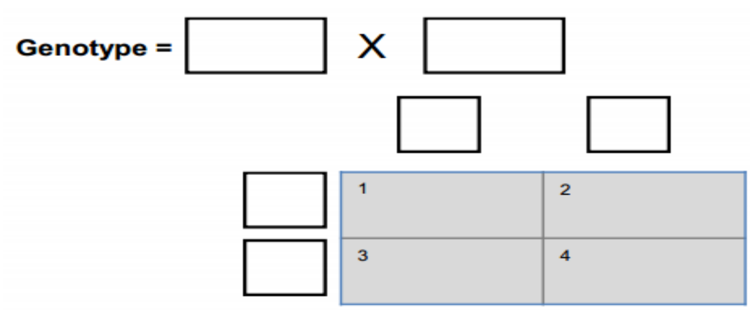
A man has a genotype of **Rr**, with **R** being dominant for the ability to roll the tongue and **r** being recessive for not being able to roll the tongue. This means that he is able to roll his tongue. A woman also has a genotype of **Rr** and therefore has the ability to roll her tongue.

Tongue-Rolling Trait

Phenotype	Allele
Ability to roll tongue	R (dominant)
Inability to roll tongue	r (recessive)

The pair decides to have offspring. The genotype cross is **Rr x Rr**. This means it is a cross between two parents who are able to roll their tongue.

1.Complete the Punnett square for a cross between the two heterozygous parents.



2.Use the information from the Punnett square to fill in the chart below.

Offspring Box Number	Genotype	Phenotype	Homozygous or Heterozygous?
1			
2			
3			
4			

F1 Genotypic Ratio: ________________ F1 Phenotypic Ratio: _________________

3.State the difference between a genotype and phenotype, and then state how you would identify each. That is, where would you look for a genotype or a phenotype?

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Mendelian Genetics

Activity, continued

Part III: Predicting Genetic Outcomes, continued

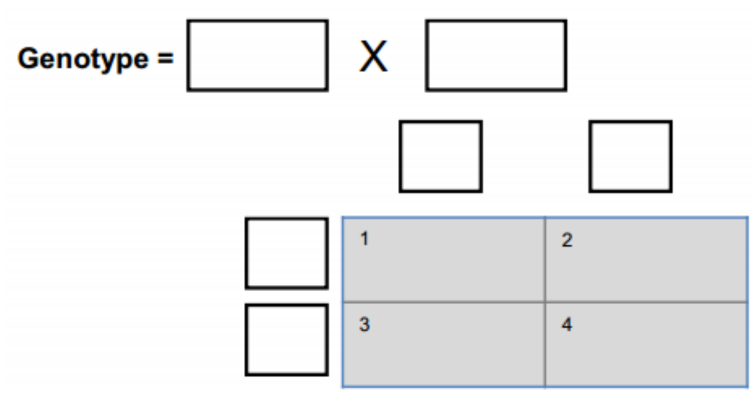
Tongue-Rolling Trait Examples, Scenario Two

A man has a genotype of **Rr**, which means he has the ability to roll his tongue. A woman has a genotype of **rr**, which means she cannot roll her tongue. They also decide to have offspring. This is a cross between a parent who is heterozygous for tongue rolling with a parent who is homozygous recessive.

Tongue-Rolling Trait

Phenotype	Allele
Ability to roll tongue	R (dominant)
Inability to roll tongue	r (recessive)

1.Complete the Punnett square for a cross between these two parents.



2.Use the information from the Punnett square to fill in the chart below.

Offspring Box Number	Genotype	Phenotype	Homozygous or Heterozygous?
1			
2			
3			
4			

F1 Genotypic Ratio: ____________________ F1 Phenotypic Ratio: ____________________

3.In your own words, explain why the offspring of a homozygous dominant parent for any trait would all express the dominant trait in their phenotype.

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Mendelian Genetics

Activity, continued

Part III: Predicting Genetic Outcomes, continued

Tongue-Rolling Trait Examples, Scenario Three

A man and woman have eight children. All eight children have the ability to roll their tongue; however, it was determined that half of them were carriers for passing on the allele for not being able to roll their tongue.

Tongue-Rolling Trait

Phenotype	Allele
Ability to roll tongue	R (dominant)
Inability to roll tongue	r (recessive)

1.What does it mean to be a "carrier" for a trait? What would be the genotype of someone who is a carrier for passing on the trait of not being able to roll the tongue?

____
____
____
____

2.Using the information from the scenario, what would the genotypes of the parents be?

_________ and __________.