Is Albinism a Dominant or Recessive Trait in Corn Plants?

Purpose
Students will understand the relationship between alleles, genotype, and phenotype and make predictions about genetic outcomes. Create a hydroponic system that tests Mendelian genetics. Make predictions about expected outcomes and assess the lab experimental design for improvements.

Outcome
Create Punnett Squares, determine expected genetic outcomes, and analyze lab results.

Introduction
Inside the cells of every living organism are the instructions that control everything that happens genetically to the organism. The instructions are located on chromosomes inside the cell's nucleus and are known individually as genes. Each gene dictates the kind of protein that will be manufactured. These proteins, alone or in groups, result in the formation of characteristics or traits in all living organisms. However, not all genes control a particular trait. Some may instead function as the switch to turn other genes on or off.

In most sexually reproducing plants and animals, offspring inherit two genes for a particular trait. One gene for a trait comes from the male parent and the other comes from the female parent. In corn plants, the trait for the green pigment, chlorophyll, is inherited in this manner.

A seedling exhibits a particular appearance or phenotype, based on the traits inherited from both parents. The seedling's genetic make-up is known as its genotype. This can be homozygous, with both genes being the same, or heterozygous with one gene being dominant and one gene being recessive. A dominant gene blocks the expression of a recessive trait. If a seedling is heterozygous for a trait, the recessive trait is hidden. It is only when the heterozygous plant passes the recessive trait on to its offspring that it may be expressed.

The possible outcomes of theoretical crossings between plants possessing different traits can be predicted by using a Punnett square. A Punnett square is a diagram in which the possible genotypes of the parental gametes (ova and pollen) are placed next to the rows and columns. The resulting combinations are then entered in the chart. The ratios of expected genotypes and phenotypes can be determined by tallying similar squares. The Punnett square shown in below demonstrates a cross between two corn plants, which are heterozygous for yellow kernels.
Hydroponics
Hydroponics is the growing of plants without soil. Instead, plant roots are supplied with a solution that contains all essential nutrients necessary for plant growth and development. Because these plants spend less energy seeking out nutrients, they grow and develop much more rapidly than plants grown in soil.

Contrary to popular belief, hydroponics is not a new technology. It is believed that the hanging gardens of Babylon may have been the first hydroponic gardens used for food production and that the Aztecs grew crops on floating reed rafts in shallow lakes. Today, in Mexico City, rafts float in park lakes bearing beautiful flowers.

In the late 17th century, John Woodward, an English physician, discovered that plants grown in water did not grow as well as plants grown in a solution containing essential plant nutrients. In 1860, the German researchers Sachs and Knop developed nutrient solution formulas and solution cultures for research on essential plant requirements. In 1929, a plant physiologist by the name of William Gericke used these nutrient solution formulas to grow crops and called the process “aquaculture”. However, that term was being used for another process, so Gericke instead coined the word “hydroponics”.

During World War II, hydroponics was used to supply U.S. troops with fresh food. Vegetables were grown hydroponically on rock islands in the Pacific, as well as on submarines. With the invention of plastic during the 1950s, hydroponics started to become more mainstream and was no longer limited to just the military or the lab.

Recent widespread destruction of the environment in many areas has resulted in the use of hydroponics as an alternative means of growing food in places where it would be difficult to grow healthy crops. Hydroponic greenhouses have been built throughout the world and currently supply fresh produce to local markets year-round. Some areas that use hydroponics extensively include South Africa, the Middle East, Israel, and the Netherlands, to name a few. Hydroponics is also used to grow crops in all fifty U.S. states, thus providing food to a rapidly growing population.
In addition, hydroponics is playing an important role in the exploration of Earth and space. The scientists at the Antarctica Research Station utilize hydroponics to grow fresh food during the dark, gloomy Antarctic winters. NASA scientists have been experimenting with the practicality of hydroponics in space, not only as a means of providing fresh food for space travelers, but as a means of recycling water in space ships and space stations. Perhaps hydroponics will be used to provide fresh foods on future intergalactic journeys.

A simple hydroponic system is comprised of a planting container, planting medium, a reservoir, a wick, air space, and a light source. The planting container holds the planting media where the plant or seed is grown. The planting medium is an inert material such as perlite, vermiculite, rock wool, clay pellets, or other commercially available substances. It may also be a mixture of media. The wick is usually a narrow strip of felt used to transport and disperse the nutrient solution from the reservoir to the roots of the plant. The air space is located between the top of the nutrient solution in the lower container and the bottom of the planting container. This space allows the plant’s roots to receive needed oxygen for healthy growth. The light source can be natural or artificially provided. It supplies the plant with the necessary energy to carry out photosynthesis.

All plants manufacture their own food through a process called photosynthesis. Certain elements are needed by plants in order to carry out this amazing process. Carbon, hydrogen, and oxygen are obtained from air and water, but all other elements must be provided. With hydroponics, the nutrient solution provides elements usually supplied as salts by the soil. Although certain plants have different nutrient requirements, all plants require macronutrients and micronutrients. Macronutrients include nitrogen, phosphorous, potassium, magnesium, sulfur, and calcium. Micronutrients include iron, manganese, boron, zinc, copper, and molybdenum.

**Pre-lab Questions**

1. Genes are located in what specific molecule?

2. The information in genes is stored in the sequence of what component of the nucleotide?

3. Genes contain the information to synthesize what type of macromolecule?

4. Explain the Rule of Dominance.
Data

Container Number: ______________ 

Date Seeds Planted: ____________ 

Group Members: _____________________________________________________________ 

__________________________________________________________________________ 

Hypothesis

Predict what will happen in this experiment (hydroponic containers from all classes). Include “if” and “then” in your hypothesis. Use the following terms: albinism, dominant or recessive and make a prediction of the resulting phenotypic ratio (e.g., 5:1).

__________________________________________________________________________ 

__________________________________________________________________________ 

Table 1 – Results of Germination of Group Hydroponic Container

<table>
<thead>
<tr>
<th>Number of Seeds Germinated</th>
<th>Number of Green Seedlings</th>
<th>Number of Albino Seedlings</th>
<th>Observations</th>
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Table 2 – Results of Germination of All Hydroponic Containers

<table>
<thead>
<tr>
<th>Number of Seeds Planted</th>
<th>Period 1</th>
<th>Period 2</th>
<th>Period 3</th>
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Total Number of Seeds Planted by all periods: ____________
Number of Seeds Germinated

Total Number of Seeds Germinated by all periods: ________

Number of Green Seedlings

Total Number of Green Seedlings for all periods: ________

Number of Albino Seedlings

Total Number of Albino Seedlings for all periods: ________

Questions

Answers the following questions referring to the class results. Use complete sentences and show all of your calculations.

1. What is the ratio of seeds that germinate to seeds planted?

2. What is the percentage of seeds germinated?

3. What percentage of seeds that germinated successfully was able to produce green pigment?

4. What percentage of seeds that germinated successfully was albino (not able to produce green pigment)? What is the ratio of green plants to albino plants?
5. Summarize the major differences between the growth of seedlings with pigment and without pigment.

6. According to your observations, describe what effect the inability to produce pigment has on developing seedlings? **Explain** why this happens.

7. Complete the following Punnett squares and determine the probable genotypes and phenotypes of these offspring seeds below. Determine the ratio of green to albino plants (e.g., 3:2 or 100% albino). Assume that the ability to produce chlorophyll is “A” and albinism is “a”. Label the alleles (A or a) on each row and column of the square.

A. **AA x AA (Both Parents Homozygous Dominant)**

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**Genotype:**

**Phenotype:**

**Ratio:**
B. Aa x Aa (Both Parents Heterozygous)

   | Genotype: |
---|-----------|
   | Phenotype:|
   | Ratio:    |

C. aa x aa (Both Parents Homozygous Recessive)

   | Genotype: |
---|-----------|
   | Phenotype:|
   | Ratio:    |

D. Aa x aa (Heterozygous Crossed with Homozygous Recessive)

   | Genotype: |
---|-----------|
   | Phenotype:|
   | Ratio:    |

E. AA x aa (Cross Homozygous Dominant with Homozygous Recessive)

   | Genotype: |
---|-----------|
   | Phenotype:|
   | Ratio:    |
8. What do the results from question 7 show your genotypes of the parental generation in this experiment should be? **Explain** your answer using ratios from your results (question 4) and question 7.

9. What were the probable phenotypes of the parental generation in this experiment? **Explain** your answer.

10. Based on your data in this experiment, is albinism a dominant or recessive trait? How do you know?

11. Refer back to your original hypothesis. Was your hypothesis supported?

12. Explain how it was or was not supported. Use your results (**quantitative data**) from this experiment.
13. Based on the results of this experiment, if you were to repeat it, what would be your revised hypothesis? Be sure to use an “If…then…..” statement, a ratio, and the vocabulary from your original hypothesis. If your original hypothesis was correct, please restate it here.

14. If you were to do this experiment over, how would you improve it? Create a new experiment with a new design. You must develop an idea on how to improve it.

15. Summarize what you learned from this experiment.