BC Agriculture in the Classroom Foundation

Healthy Hybrids:
An Investigation of Genetic Crosses & Punnett Squares

Students will learn about basic genetic principles - crosses through patterns of inheritance - and will be able to predict genotypes of organisms using Punnett Squares.

Subject Levels/ Suggested Grade

Science 9-10

Life Science 11

Science for Citizens 11

Environmental Science 11

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Grade & Subject	Curricular Competencies	Content Connections
Science 10	• Consider the changes in knowledge over time as tools and technologies have developed • Connect scientific explorations to careers in science • Consider social, ethical, and environmental implications of scientific findings from their own and others' investigations • Transfer and apply learning to new situations • Consider the role of scientists in innovation	• DNA structure and function ▪ genes and chromosomes ▪ gene expression ▪ interactions of genes and the environment • patterns of inheritance ▪ Mendelian genetics, Punnett squares, complete dominance, co-dominance, incomplete dominance, sex-linked inheritance, human genetics • mechanisms for the diversity of life: • applied genetics and ethical considerations ▪ genomics, GMOs, gene therapy, cloning, stem cells, reproductive technology, species, population and ecosystems, forensics, genetic engineering
Science 9	• Apply First Peoples perspectives and knowledge, other **ways of knowing**, and local knowledge as sources of information • Seek and analyze patterns, trends, and connections in data, including describing relationships between variables (dependent and independent) and identifying inconsistencies • Construct, analyze and interpret graphs (including interpolation and extrapolation), models and/or diagrams	• asexual reproduction: ▪ mitosis ▪ different forms • sexual reproduction: ▪ meiosis • First Peoples knowledge of interconnectedness and sustainability
Life Sciences 11	• Apply First Peoples perspectives and knowledge, other ways of knowing, and local knowledge as sources of information • Seek and analyze patterns, trends, and connections in data, including describing relationships between variables, performing calculations, and identifying inconsistencies • Construct, analyze, and interpret graphs, models, and/or diagrams	• First Peoples understandings of interrelationships between organisms • microevolution: ▪ adaptation to changing environments • changes in DNA ▪ natural selection • macroevolution: ▪ speciation ▪ processes of macroevolution • evidence for macroevolution

Grade & Subject	Curricular Competencies	Content Connections
Science for Citizens 11	• Consider the changes in knowledge over time as tools and technologies have developed • Connect scientific explorations to careers in science	• beneficial scientific innovations • food security (e.g., production, distribution) • actions and decisions • ethical, cultural, social, economic, environmental, and political implications • waste recycling and disposal including limitations of recycling • agriculture/aquaculture practices and processes (e.g., hydroponics, food crops, feed crops, fuel crops, animal husbandry, fish farms, new technologies, use of chemicals, environmental impacts) • energy generation, use, and efficiency (e.g., production, economics, environmental impacts) • sustainability of resources (e.g., impacts of personal choices, product life cycles)
Environmental Science 11	• Make observations aimed at identifying their own questions, including increasingly abstract ones, about the natural world • Formulate multiple hypotheses and predict multiple outcomes • Experience and interpret the local environment • Apply First Peoples perspectives and knowledge, other ways of knowing, and local knowledge as sources of information • Consider the changes in knowledge over time as tools and technologies have developed • Consider social, ethical, and environmental implications of the findings from their own and others' investigations	• ecosystem complexity • First Peoples knowledge and other traditional ecological knowledge: agriculture, ethnobotany, harvesting cycles • benefits of ecosystem services such as in food production, waste management • human actions (harvesting, resource extraction and consumption, population growth) • First Peoples ways of knowing and doing • human actions and their impact on ecosystem integrity • resource stewardship

Teacher Background

Since the beginning of agriculture, over 10,000 years ago, people have selected their strongest, most productive animals to breed, and have chosen crop varieties with the most desirable traits to reproduce. For example, agriculture farmers may select organisms that have larger fruit size, smaller seeds, sweeter-tasting fruit, or increased resistance to pests for cultivating. In animals, favorable traits that may be selected for include decreased levels of aggression, high percentage of lean meat, and/or increased fertility.

Farmers in today's market need a strong understanding of genetics in order to compete with other producers. Whether they chose to focus on purebred animals or on crossing different types of fruit, they use the most up to-date scientific genetic information to improve the production of their commodities.

In this activity, students will learn about simple genetics, including mono-hybrid and dihybrid crosses. Students will then have the opportunity to use Punnett Squares to predict the genotypes and phenotypes of possible offspring.

Materials

- *Powerpoint*: Healthy Hybrids: A Closer Look at Genetics in Agriculture
- Video: How to Draw Punnett Squares https://www.youtube.com/watch?v=prkHKjfUmMs
- *Student Handout*: Genetic Terminology Worksheet
- *Student Handout*: Practicing Punnett Squares
- *Student Handout*: BC Genetics Worksheet

Procedure

1) Begin by asking students to identify a list of traits they believed they received from either their mother or father. If you wish, request students to share one or two responses with the class. Ask students if there are there any physical traits that they have, that neither of their parents display?
2) Next, review with students the difference between inheritable traits vs. acquired traits and determine if all of the traits mentioned in Step 1 were genetic rather than acquired.
3) View the PowerPoint: Healthy Hybrids with the class asking students to complete their *Genetic Terminology Worksheet* during the presentation.
4) Have students watch the video: How to Draw Punnett Squares.
5) Students can then complete the *Practicing Punnett Squares Worksheet* and *BC Genetics Worksheet* demonstrating their understanding of mono and dihybrid crosses.

Extension Activities

- Have students develop flashcards using the genetics terminology (paper or online-Quizlet).
- Invite a plant or animal breeder to do a presentation on their product(s) in your live or virtual classroom.
- Connect this activity to one of our other resources available to order at www.bcaitc.ca.

Genetic Terminology Worksheet

Name: _____ Date: _____

DIRECTIONS: Use the boxes to fill in the definitions for Genetics terminology below.

HYBRIDS	
GENETICS	
HEREDITY	
CHROMOSOMES	
GENES	
ALLELES	
GENOTYPE	
PHENOTYPE	
LAW OF DOMINANCE	
LAW OF SEGREGATION	
LAW OF INDEPENDENT ASSORTMENT	
DOMINANT ALLELE	
RECESSIVE ALLELE	
CO-DOMINANCE	
INCOMPLETE DOMINANCE	
PUNNETT SQUARE	

Practicing Punnett Squares Worksheet

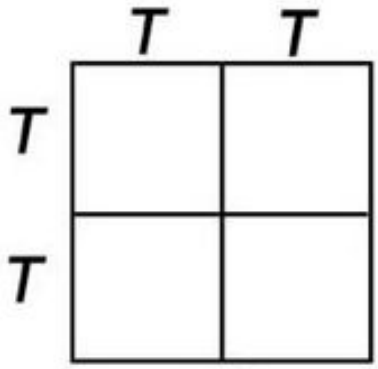
Name: _____ Date: _____

These show the 2 alleles of each parent plant crossed with each other and the resulting 4 possible offspring with T = tall, t = short.

TT = dominant tall, tt = recessive short, Tt = mixed hybrid

TT = dominant tall (genotype tall, phenotype tall)
Tt = mixed hybrid (genotype hybrid, phenotype tall)
tt = recessive short (genotype short, phenotype short)

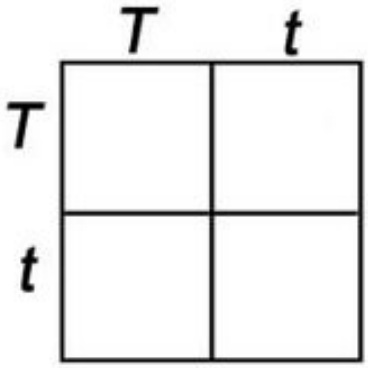
Using the Punnett's Squares below, name the offspring of all possible parent combinations.



Both parents are dominant tall, name the 4 possible offspring.

1. _____ 2. _____

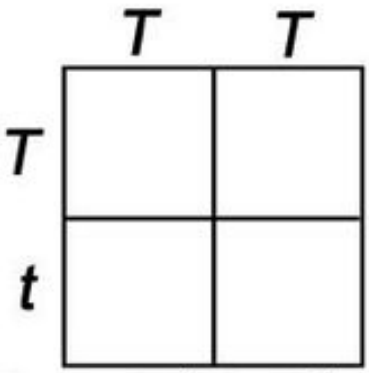
3. _____ 4. _____



Both parents are mixed hybrids, name the 4 possible offspring and the expected ratio.

1. _____ 2. _____

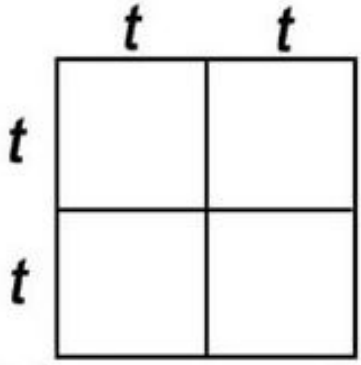
3. _____ 4. _____



One parents is dominant tall, one is mixed hybrid, name the 4 possible offspring.

1. _____ 2. _____

3. _____ 4. _____



Both parents are recessive short, name the 4 possible offspring.

1. _____ 2. _____

3. _____ 4. _____

BC Genetics - Practice Worksheet

Name: _____ Date: _____

1. Salish™ apples are a new trademarked, late-season variety that was developed in Summerland, British Columbia, and released to market until 2012. It underwent a long and vigorous process beginning with cross-pollination, and its parents are the splendor and gala apple. Named after the language spoken by the native Canadian First Nation tribe that lived in the Okanagan area in British Columbia, Salish™ apples were bred for both the consumer and grower with an appealing appearance, rich flavor, long shelf life, late harvest date, and high yields.

   Let's assume Splendor apple has a genotype of SS and the Gala apple has a genotype of GG. The genotype SG would create the Salish apple. Draw the Punnett square to demonstrate this cross and the resulting offspring.

2. There are over 10,000 varieties of tomato plants in the world, and each one produces its own unique fruit – from giant-sized slicing tomatoes to tomatoes so tiny you could fit 10 on a spoon! BC greenhouses produce mini tomatoes with names that hint at their size, shape, and taste including the Grape, Cherry, and Gem. These bite-size fruits are bursting with flavor. They are full of nutrients and vitamins that help keep us healthy.

   In tomatoes, red fruit (R) is dominant over yellow fruit (r). If a homozygous red fruit (RR) is crossed with a yellow fruit (rr) what will be the appearance of the offspring?

3. Beef cattle are cattle that are raised for their meat. It takes from 18 to 30 months for a beef animal to reach market weight. Most of the ranching in the province takes place in the interior regions of BC, where there are large areas of rangeland for grazing available.

   In cattle, horns (h) are recessive over hornlessness (H). If two homozygous cattle, one hornless and the other horned, are crossed, what are the genotypes and phenotypes of the first generation?

4. There are more than 3 million commercial laying chickens in BC, with about 80% of those are located in the Fraser Valley. The eggshell color depends on the breed of the hen. Generally speaking, white shell eggs come from hens with white feathers, while brown shell eggs are from hens with brown feathers. Brown birds are homozygous for the B allele and white birds are homozygous for the W allele. Their alleles are said to be codominant. What do you think happens when a black rooster is crossed with a white hen? What will the color of their offspring be? What do you predict will be the color of the eggs they lay?

5. Name an organism that you think would have been a good candidate for Mendel to study the genetics of inheritance? Why did Mendel choose to study pea plants rather than animals or, humans?