Norman Borlaug- Hunger Fighter
Grades 9-12
Math, Science

Objectives
Through classroom experiences, students will solve math word problems related to the reading. They will conduct an experiment to isolate DNA in wheat germ. They will also describe Norman Borlaug's influence in beginning the Green Revolution and apply concepts to current local and world events.

"Civilization as it is known today could not have evolved, nor can it survive, without an adequate food supply."
- Norman Borlaug

Vocabulary
crop failure—reduction in crop yield to a level that there is no marketable surplus or the nutritional needs of the community cannot be met
developing nation—a nation with a low level of material well-being
dwarf—an animal or plant much below normal size
gene—a part of DNA or RNA that is usually located on a chromosome and that contains chemical information needed to make a particular protein controlling or influencing an inherited bodily trait or activity or that influences or controls the activity of another gene or genes
plant breeder—someone who propagates plants sexually under controlled conditions
resistant—capable of withstanding the force or effect of a disease
stalk—a plant stem especially of a plant that is not woody

Background
Norman Borlaug was a **plant breeder**. He used high-yield agriculture techniques to help people get more food from their land. For 50 years he worked in **developing nations** like Mexico, India, and Pakistan. Before he began his work, mass starvation had been predicted in many parts of the world. Since then, food production has expanded faster than human population in all parts of the world except sub-Saharan Africa. Borlaug received the Nobel Peace Prize in 1970, mostly for his work reversing food shortages in India and Pakistan during the 1960s.

Norman Borlaug was born in Cresco, Iowa, in 1914. When he was a young man, the Dust Bowl hit the Midwestern US. Some people blamed modern farming methods, but Borlaug believed just the opposite was true. He noticed that the effects of the Dust Bowl were not as bad in Iowa and other places where high-yield agriculture techniques were being tried. He decided that his life's work would be to help people grow more food in places where **crop failures** were regular facts of life.

Borlaug helped found the International Maize and Wheat improvement Center (CIMMYT) in Mexico. There he helped develop high-yielding semi- **dwarf** wheat varieties. Today this wheat feeds a large portion of the world's population.

Borlaug's leading research achievement was the development of dwarf spring wheat. He found many benefits to growing plants with shorter **stalks**. Nature favors **genes** for tall stalks because in nature, plants must compete for sunlight. Borlaug found that plants with stalks that were short and of equal length would receive equal amounts of sunlight when they did not have to compete with taller-stalked plants. In addition, dwarf wheat used more energy growing valuable grain rather than using its energy to grow tall stalks with no food value. Stout, short stalks also support wheat kernels better. Tall-stalked wheat may bend over at maturity, making it more difficult to harvest.

Borlaug also developed cereal grains that were day neutral (insensitive to the number of hours of light in a day) and could, therefore, be grown in many climates. He particularly favored growing wheat in countries where starvation was a concern because wheat grows in nearly all environments and is **resistant** to insects.

Additional Reading

Bartoletti, Susan Campbell, *Black Potatoes: The Story of the Great Irish Famine, 1845-1850,* Houghton-Mifflin, 2001.

Hesser, Leon, *The Man Who Fed the World: Nobel Prize Laureate Norman Borlaug and His Battle to End World Hunger*, Righters Mill Press LLC, 2019.

Mann, Charles C., *The Wizard and the Prophet, Penguin Random House, 2018*

Smith, David J., *If the World Were a Village*, Kids Can, 2002

Vietmeyer, Noel, *Our Daily Bread; The Essential Norman Borlaug,* Bracing Books, 2012

Websites

https://www.worldfoodprize.org/en/dr_norman_e_borlaug/about_norman_borlaug/

https://allianceforscience.cornell.edu/blog/2020/04/norman-borlaug-legacy-documentary/

https://www.purdue.edu/discoverypark/food/programs/borlaug-fellows/norman-borlaug.php

REV 9/2020

Activity 1: Cross Breeding Probabilities, (Science, Math, Plant Science)

1 50 minute class period

Students will experiment with probabilities and statistics.

Oklahoma Academic Standards

Activity 1: Cross Breeding Probabilities (Science, Math, Plant Science)

B.LS3.1	Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
B.LS3.3	Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population
B.LS4.1	Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.
A1.D.2.3	Calculate experimental probabilities by performing simulations or experiments involving a probability model and using relative frequencies
BS.03.03.01.a	Describe the selective plant breeding process.

Materials:

- Red paper (High yielding genes)
- Blue paper (Dwarf genes)
- Scissors
- Cup
- Pencil/pen
- Activity 1 Worksheet 1 **"Cross Breeding Probabilities Experiment**"
- Activity 1 Worksheet 2 "**Generation Results Table"**

Procedures:

1. Pair up students and provide each pair with red and blue paper, scissors, and a cup.
2. Provide the "**Cross Breeding Probabilities Experiment**" worksheet and the "**Generation Results Table**."
3. Monitor students as they complete their investigations.

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Activity 1 Worksheet 1: Cross Breeding Probabilities

Name: ______________________________ Date: ____________________

Dr. Norman Borlaug bred thousands of wheat varieties. High yielding varieties of wheat that produced a large seed head could not hold up under their own weight and would fall over before harvest. Dwarf varieties were shorter and sturdier yet prone to disease and produced less grain. Dr. Borlaug worked to create a new strand of wheat to be high yielding, yet sturdy enough to stand until harvest. Modern crossbred plants are selected from purebred strains with certain traits. You will recreate Dr. Borlaug's cross breeding process.

Materials

- Red paper (High yielding genes)
- Blue paper (Dwarf genes)
- Scissors
- Cup
- Pencil/pen
- **"Cross Breeding Probabilities Experiment**"
- **"Generation Results Table"**

Procedures

Step 1

1. Cut 16 evenly sized pieces of blue paper and 16 evenly sized pieces of red paper. These are the alleles of your parent plants. Each parent will provide one allele to each offspring.
2. Place all 32 pieces of paper into a cup.

Step 2

1. Take turns drawing out one piece of paper out of the cup to form each offspring. Each offspring will have two alleles. There will be sixteen offspring from this first mating.
2. Record the number of High Yielding (HY), Dwarf (D), and Hybrid (H) on **Generation Results Table**. Calculate the ratio HY:D:H.
3. Keep only the Hybrid offspring and place the remaining pieces back in the cup.

Step 3

1. Repeat Step 2 using only the hybrid offspring created by the previous mating.
2. Continue mating hybrids until no hybrids are produced.

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Activity 1 Worksheet 2: Generation Results Table

Name: ______________________________ Date: ______________

Generations Results Table

Generation	Number of Parents	High Yielding (HY) (Red)	Dwarf (D) (Blue)	Hybrid (H) (Red/Blue)	Ratio HY:D:H
1	32				
2					
3					
4					
5					
6					

Questions

1. Which generation produced the greatest ratio of hybrids?

2. Why did the number of hybrids decrease in later generations?

3. How would the number of hybrids be affected if purebred high yielding and purebred dwarf plants were added to the pool of parent plants?

Activity 2: Wheat Germ DNA, (Science, Plant Science) 1 50 minute class period

Students will use the following experiment to isolate the DNA in a wheat germ.

Oklahoma Academic Standards

Activity 2: Wheat Germ DNA (Science, Plant Science)

B.LS3.1	Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
B.LS3.2	Make and defend a claim based on evidence that inheritable genetic variations may result from: (1) new genetic combinations through meiosis, (2) viable errors occurring during replication, and/or (3) mutations caused by environmental factors.
PS.03.01.05.a	Explain the principles behind recombinant DNA technology and the basic steps in the process.

Materials

- Graduated cylinder
- 400 mL or larger beaker
- Raw wheat germ
- Spoon
- Liquid soap
- Baking soda
- Activity 2 Worksheet 1 "**Wheat Germ DNA Experiment"**
- Meat tenderizer
- Eyedropper/Pipette
- Test tube
- Denatured alcohol
- Pencil
- Lab notebook
- Reading Page "**Parts of Wheat Kernel**"

Procedures

1. Hand out copies of the "**Wheat Germ DNA Experiment**". Students will work in groups to complete the experiment.
2. Pour 100 ml of warm water into a cup/beaker.
3. Add one spoonful of raw wheat germ and stir a few times.
4. Add one squirt of liquid soap and stir a few more times but not so hard that you generate bubbles.
5. Add 1 tsp baking soda and 1/8 tsp meat tenderizer. Stir for 5-10 minutes, then let solids settle to the bottom.
6. Draw off some of the clear liquid at the top with an eyedropper. You do not want solids at the bottom.
7. Put into a test tube.
8. Fill the test tube 1/3 full of liquid.
9. Add denatured alcohol slowly with the eyedropper and watch the DNA strands appear at the interface between the wheat germ slurry and the alcohol.
10. Discuss what you saw. Record your observations.

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Activity 2 Worksheet 1: Wheat Germ DNA Experiment

Name: ______________________________ Date: ______________

When farmers are making decisions about what varieties of wheat to plant, they are thinking about DNA. Each kind of wheat has DNA that gives it certain characteristics to help it grow better in a particular region, season, etc. Wheat varieties are genetically changed over time through natural selection. Some varieties grow better in drought conditions while others might be better at resisting certain pests. The varieties best suited to survive in their particular circumstances have a greater chance of passing their traits on to the next generation. Norman Borlaug used knowledge of wheat DNA to breed wheat for the conditions that would grow best in the areas where he was conducting his research. Wheat germ is one part of the wheat kernel. Read the **Parts of a Wheat Kernel** page to learn more about the wheat germ. Use the following experiment to isolate the DNA in wheat germ.

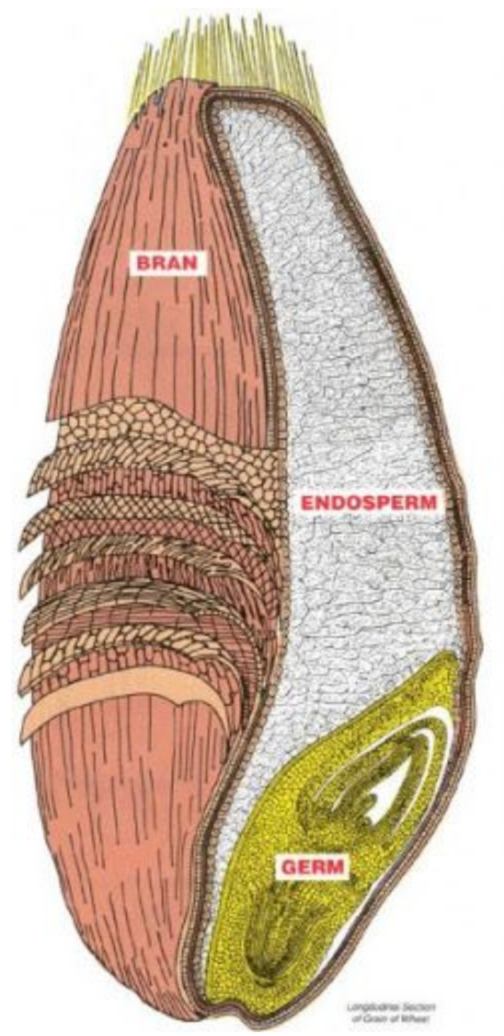
Materials

- Graduated cylinder
- 400 mL or larger beaker
- Raw wheat germ
- Spoon
- Liquid soap
- Baking soda
- Activity 3 Worksheet 1 "**Wheat Germ DNA Experiment**"
- Meat tenderizer
- Eyedropper/Pipette
- Test tube
- Denatured alcohol
- Pencil
- Lab notebook
- Activity 3 Worksheet 2 "**Parts of a Wheat Kernel**"

Procedures

1. Pour 100 ml of warm water into a cup/beaker.
2. Add one spoonful of raw wheat germ and stir a few times.
3. Add one squirt of liquid soap and stir a few more times, but not so hard that you generate bubbles.
4. Add 1 tsp baking soda and 1/8 tsp meat tenderizer. Stir for 5-10 minutes, then let solids settle to the bottom.
5. Draw off some of the clear liquid at the top with an eyedropper. You do not want solids at the bottom.
6. Put into a test tube.
7. Fill the test tube 1/3 full of liquid.
8. Add denatured alcohol slowly with the eyedropper and watch the DNA strands appear at the interface between the wheat germ slurry and the alcohol.
9. Discuss what you saw. Record your observations.

Sometimes called the wheat berry, the kernel is the seed from which wheat plant grows. Each tiny seed contains three distinct parts that are separated during the milling process to produce flour.



Endosperm - Endosperm is the germ's food supply and the source of white flour. In its natural state, the endosperm provides essential energy to the young wheat plant, allowing the plant to send roots down for water and nutrients and shoot sprouts up for sunlight.

Bran - the bran is a multi-layered, hard outer coating of the wheat kernel. Bran is included in whole wheat flour and can be purchased as a stand-along grain.

Germ - the germ is the embryo, or sprouting section of the kernel. The germ is the part of the wheat kernel that will sprout and grow into a new wheat plant. During the milling process, the germ is often separated from flour because the fat content limits the flour's shelf life. In whole wheat flour, it is stabilized and then put back in to keep the flour "whole". Wheat germ is also sold as a health food to be added to other foods.

These three parts are protected by tough outer husk that protects the kernel from potential hazards such as sunlight, pests, water and disease. This protective structure is separated from the grain, along with the straw when wheat is harvested with a combine. Wheat kernels vary in both texture and color, from white to red to sometimes even purple.

Source: Wheat Foods Council