ENGINEER THE PERFECT WHEAT PLANT

Overview

Students will take on the persona of a young Dr. Norman Borlaug and engineer a perfect wheat plant. Students will take into account the environment, potential risks of pests and disease; harvest and storage of the grain produced as well as nutritional values of the food and food safety.

Activity 1: Students will research Norman Borlaug and The Green Revolution using the Internet. They will report back to the class Borlaug's contribution to solving challenges of world hunger.

Activity 2: Students will take on the persona of a young Dr. Norman Borlaug and design a "perfect" wheat plant taking into account the environment, potential risks of pests and disease; harvest and storage of the grain produced as well as nutritional values of the food and food safety. Students will design the "perfect" wheat plant for their environment.

Grade Level
9th-12th

Time Required
9 weeks
Activity 1: 1-45 minute class period
Activity 2: 2-45 minute class periods
Activity 3: 5-45 minute class periods over 9 weeks

Objectives

1. Students will be able to describe research done by Dr. Norman Borlaug.

2. Students will be able to identify what inputs are needed to grow a highly productive food plant in an environmentally responsible way.

3. Students will be able to name best management methods to protect the food plant from pests such as insects, weeds and disease.

4. Students will be able to outline the best way for delivery of a safe nutritional food that helps alleviate world hunger.

5. Students will be able to engineer their version of the "perfect" wheat plant

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Background Information

Once the science of genetics became better understood, plant breeders used what they knew about the genes of a plant to select for specific desirable traits. This type of genetic modification, called **traditional plant breeding**, modifies the genetic composition of plants by making crosses and selecting new superior genotype combinations. Traditional plant breeding has been going on for hundreds of years and is still commonly used today. Plant breeding is an important tool, but has limitations. First, breeding can only be done between two plants that can sexually mate with each other. This limits the new traits that can be added to those that already exist in that species. Second, when plants are mated, (crossed), many traits are transferred along with the trait of interest including traits with undesirable effects on yield potential. Developing new desirable traits is achieved by **genetic engineering**. Genetic engineering physically removes the DNA from one organism and transfers the gene(s) for one or a few traits into another. It involves four steps to complete:

1. **Gene Cloning**: Separation of a desired gene from DNA source and replicating the desired gene thousands of times.

2. **Gene Design**: Placing the desired gene into the DNA of the plant being engineered

3. **Transformation**: The new gene is inserted into the nucleus of some of the cells where it is regenerated into a transgenic plant.

4. **Backcross Breeding** - Using traditional plant breeding methods, transgenic plants are crossed with elite breeding lines to produce a plant that expresses the trait encoded by the new transgene with a yield potential of many hybrids.

For more information:
Information on wheat production from Kansas State:
https://www.bookstore.ksre.ksu.edu/pubs/c529.pdf

KFAC Exploring Kansas Plants, Crops Educator Guide: wheat pp. 42-43; 123-124

Vocabulary

Traditional Plant Breeding: Modification of the genetic composition of plants by making crosses and selecting new superior genotype combinations.

Genetic Engineering: The process of removing the DNA from one organism and transferring the gene(s) for one or a few traits into another. It involves four steps to complete, gene cloning, gene design, transformation, and backcross breeding.

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Activity 1 - Research Norman Borlaug

Who's that Guy? Research Norman Borlaug and come up with a question you would like to ask him about his work in designing the perfect wheat plant. Why did he win the Nobel Peace Prize in 1970? To complete this activity, investigate Borlaug's contributions to solving food insecurity challenges.

Research Norman Borlaug and his work that earned him the Nobel Peace Prize.
https://www.britannica.com/biography/Norman-Borlaug.

Read the book, *The Boy That Changed the World*, By Andy Andrews.

The World Food Prize was started by Norman Borlaug:
https://www.worldfoodprize.org/index.cfm?nodeID=87664&audienceID=1
https://www.nobelprize.org/nobel_prizes/peace/laureates/1970/borlaug-facts.html

Acceptance speech by Norman Borlaug for Nobel Peace Prize:
https://www.nobelprize.org/nobel_prizes/peace/laureates/1970/borlaug-lecture.html

Procedure

Break students into small groups
Give each group a topic based on Borlaug's work

Guiding Questions For Groups

- Who was Norman Borlaug? How did he get involved in plant breeding?
- Describe Triticale.
- What was the Green Revolution?
- What is the World Food Prize?

Ask each group to share what they found after a few minutes of research.

Concluding Questions

These questions can be used for individual assessment or class discussion.

What is the significance of Norman Borlaug's work?

How does his work affect our lives today?

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Activity 2 - Design the Perfect Wheat Plant

Preparation

Students will need to learn background material about wheat production.

See poster provided by K-State Extension: https://www.bookstore.ksre.ksu.edu/pubs/MF3300.pdf

Gather props to be used for construction of a model of the perfect wheat plant. Make sure the students have access to computers to do research and to create their power point presentation. Give them the speech scorecard so they can prepare their speech properly. Give them the power point rubric so they can prepare their power point presentation properly.

Materials

- Access to a device with Internet
- Access to presentation software

Procedures

Create groups of students to work on designing the perfect wheat plant traits. Group work can be divided by cutting rubric into rows and distributing tasks to each group member. Assign each group of students an area in the U.S. or world that grows wheat. They need to design their “perfect” wheat plant for that particular environment. To satisfy the requirements in the rubric, they need to choose pests they are controlling for such as disease, insects and weeds by designing appropriate genetic modifications to combat these conditions.

Their drawings should be scanned into the power point to illustrate the changes in the plant that will help it meet environmental challenges as outlined in the rubric.

Each new variety of wheat should include:

1.Traits that deal with a hostile environment (they decide the challenge)
Examples: Very cold, very hot, very dry, very wet
2. Traits that help with resistance to a common wheat disease of their choice
3. Traits that allow a plant to produce despite pressure from a common weed of their choice
4. Traits that help with resistance to common wheat insect pests of their choice
5. Plants that have traits that show a high yield capacity
6. Plants that have traits that show it is easy to capture the majority of grain at harvest
7. Plants that have traits that lend themselves to high nutrition and food safety (free from allergens or toxins)

Extensions: Teams can also go into more detail on the production environment and management practices that will enhance growth and grain production in their wheat plant. They may also go into more detail on the infrastructure such as roads, transportation, funding of farming, that will help increase the food supply for their local population.

Building A Structure : Engineering the Perfect Wheat Plant

Teacher Name_____ _____

Student Name: _____

CATEGORY	4	3	2	1
This plant has traits that				
The wheat plant has traits that show it is adapted to the challenging environment of your choice. Describe your environment.	This plant has several recognizable traits that show it is adapted to the challenging environment of your choice.	This plant has a few recognizable traits that show it is adapted to the challenging environment of your choice.	This plant has a couple of recognizable traits that show it is adapted to the challenging environment of your choice.	This plant has no recognizable traits that show it adapted to the challenging environment of your choice.
The plant has traits to resist a wheat disease of your choice. Name the disease_____	This plant has several recognizable traits that show it is adapted to resist disease.	This plant has a few recognizable traits that show it is adapted to resist disease.	This plant has a couple of recognizable traits that show it is adapted to resist disease	This plant has no recognizable traits that show it adapted to resist disease.
This plant has traits to compete with a common weed of your choice. Name the weed _____	I can share several traits this plant has that indicates it can compete with ____ (name of common weed)	In can share a few traits in t his plant that indicates it can compete with _____ (name of common weed)	I can share of couple of traits this plant that indicatee it can compete with _____(name of common weed)	I cannot share any traits of this plant that indicated it can compete with _____ (name of common weed)
This plant has traits that indicate it is resistant to an insect pest of your choice. Name your insect_____	This plant has several traits that indicate it is resistant to an insect pest of your choice.	This plant has a few recognizable traits that show it is adapted to resist the insect pest of your choice.	This plant has a couple of recognizable traits that show it is resistant to an insect pest of your choice	This plant has no recognizable traits that show it adapted to resist an insect pest of your choice.
This plant has recognizable traits that show a high yield capacity	This plant has several recognizable traits that show it has a high yield capacity.	This plant has a few recognizable traits that show it has a high yield capacity.	This plant has a couple of recognizable traits that show it has a high yield capacity.	This plant has no recognizable traits that show it has a high yield capacity.
This plant demonstrates traits that show it is easy to harvest and store.	This plant has several recognizable traits that show it is easy to harvest and store.	This plant has a few recognizable traits that show it is easy to harvest and store.	This plant has a couple of recognizable traits that show it is easy to harvest and store.	This plant has no recognizable traits that show it is easy to harvest and store.
This plant has characteristics that provide good nutrition and food safety. Name type of nutrient or health benefit_____	I can share several traits this plant has that indicates in provides good nutrition and/or other health benefits.	I can share a few recognizable traits of this plant that indicate it provides good nutrition and/or other health benefits.	I can share of couple of traits this plant has that indicate it provides good nutrition and/or other health benefits	I am not able to share any traits that indicates it provides good nutrition and/or other health benefits.

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Conclusion

Students can discuss what they liked about each group's new wheat plant and make a list describing the "perfect wheat plant" using different traits from each group.

Take it further by writing a paper on a challenging food problem to qualify for admittance to the Kansas Youth Institute that is connected with the World Food Prize.
Explore the Youth Programs sponsored by the World Food Prize and Kansas State University College of Agriculture:
https://www.worldfoodprize.org/index.cfm?nodeID=87664&audienceID=1.

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Activity 3 - Create a "Living Feekes" Scale

Preparation

Note: Best if lesson is started in early August

Week 1: Order Seeds, Purchase Supplies (See Materials). There may be about a week of wait time for the seeds to be sent to you.

Week 2: Provide Background on wheat from grass to a domesticated grain crop.

See Resources on KFAC's website:
Exploring Plants Kansas Crops Educator's Guide
https://ksagclassroom.org/education-center/educators-guide/
Wheat Germ DNA Extraction Lesson
https://ksagclassroom.org/education-center/lesson-plans/wheat-germ-dna-extraction/
Wheat Growth Stages
https://ksagclassroom.org/education-center/resources/wheat-growth-stages/
Wheat Plant Part Labeling
https://ksagclassroom.org/education-center/resources/wheat-labeling-plant-parts-chart-key/
See K-State Extension Webpage for Resources:
https://www.agronomy.k-state.edu/extension/crop-production/wheat/index.html

Week 3: Assign groups and Plant Seeds

Week 4: Observation

Week 5: Transplant seeds into Milk jugs

Week 6: Observe

Around Week 9 (Early to Mid October): Transplant seedlings into large containers or outdoor plot

Assign students into groups of five or smaller with each group assigned a different type of seed to germinate and plant.

Each group will need to label their cups with their name and the proper name of their seed/plant type and plant their seed in the cup as described.

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Materials

- Clear germination 8 oz. plastic-ware cups one per student.
- Coffee filter
- Potting soil
- Hard Red Winter wheat kernels, obtain from local coop or farmer
- A colored “Solo” cup
- Foil
- Thermometer
- Milk jugs
- One tray
- Popsicle Sticks

For light stand:

- 1 10 foot long PVC Pipes 1 inch diameter. (Have hardware store cut this pipe if you do not have access to a saw)
- 2 tee joints, 1-inch diameter
- 2 elbows,
- 4 end caps
- 2 shop light kits
- 2 warm bulbs
- 2 cool bulbs
- Timer
- Fertilizer - 2 Tablespoons
- Osmocote slow release fertilizer pellets(N (Nitrogen),15-P(Phosphorus),0-K (Potassium),12).
- General purpose fertilizer N-20; P-10; K-10

Each group of five can grow a different type of plant (see types below).

Winter Bread Wheat - (hexaploid) 42 chromosomes - Bread
Einkorn**
Tritcum Monococcum - (diploid) 14 chromosomes
Flat Bread
Aegilops Tauschii (goat grass) - (diploid) 14 chromosomes
Winter Barley - (diploid) 14 chromosomes - member of grass family
Winter Rye - (diploid)14 chromosomes - member of grass family

Note**: When working with the einkorn seeds you will need to take an extra amount of time to peel the glume (outside hard covering) away from the seed to prepare for germinating and planting (Soaking the seeds may help loosen the outside coating.)

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Procedures

PHASE ONE

Day 1

Have students write their name on both the clear and colored cups.
Use a sharp knife or scissors to make several drainage holes in the bottom of the cups.
Moisten a paper towel or ½ of a coffee filter and form around the inside of a clear plastic cup.
Add potting soil to the cup to hold the paper towel or filter in place.
Using a pencil or popsicle stick to place kernels of wheat between the towel and cup wall, so you can still see the seeds. Plant at least 10 seeds per group.
Place the clear cup into a colored plastic cup of the same size.
Form foil around the colored cup to block all sunlight to the roots.

Observe the seeds in the germination cups and log growth of the stems, leaves, and roots; record observations.
Document plant growth changes by taking pictures of the plant and saving to a powerpoint slide labeled with the date of the observation.

Day 4

Students should start to see the emergence of roots by taking the clear cup out every few days and observing germination and root growth for small amounts of time. Be sure to place the clear cup back into the colored cup and foil after recording your observations.

Day 5-6

Students should start to see three roots appear, one primary and two secondary roots.

Day 7

The shoots should start to grow rapidly.

PHASE TWO

After about a week of germination:
Day 8 - Create Light Stand
Create PVC grow light stands and purchase shop light and two kinds of bulbs, one with a warm bulb and one with a cool bulb.
See this video produced by the Department of Communications at Kansas State University:
http://kansashealthyyards.org/component/allvideoshare/video/easy-to-make-a-grow-light?Itemid=101

Position the grow light two feet above the growing plants. Set the grow lights on a timer to supply 16 hours of light a day.

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Procedures Continued

Transplant seedlings into larger containers and document growth of roots and leaves.

Cut off the tops of one gallon milk jugs so that the jug is about 6” tall.
Cut drainage holes into the bottoms of the jugs.
Fill jug with potting soil, make sure to leave 2-3” from the top.
Transplant 3-4 of the sprouted seedlings into a small 2” wide x 4” deep into milk jug.
Put one transplant in each corner of the pot. Plant roots 1 inch deep.
Label the jug with type of plant using a marker and a Popsicle stick.
Add water to the jug so that the soil is moist, not wet
Place labeled and water jugs onto a tray

For optimum growth, wheat likes cooler temperatures. Put the plants in a cooler area of the room with your new light stand, or place outside. Keep the temperature around 40 degrees.

Water the plants every other day, three days a week. Include Pete’s General purpose N-20, P10, K-10 fertilizer dissolved in the water each day. 2 Tablespoons of fertilizer mix per 1 quart of water.

Observe the transplants and log growth of the stems, leaves, and roots. Measure length of plant, document changes.

PHASE THREE

Transplant seedlings to a larger container or to an outdoor plot.

At the end of one month, or when the plants have several tillers or leaves you may transplant the wheat plants into a larger container such as a 2-3 gallon bucket (3 plants per container). Add Osmocote slow release fertilizer pellets(N-15, P-0, K-12) to the top of the soil in the container. Two tablespoons of fertilizer per container. Make sure you keep the soil watered. Water when your finger comes out dry when placed an inch into the soil.

OR

Transplant to outdoor plot:

Place plants at the same depth to soil as they were in the pot. Add slow release fertilizer to the top of the soil around the plant. Osmocote N-15, P-0, K-12. Two tablespoons of fertilizer per 3 plants.

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If you plant outside, make sure you are planting in early October.

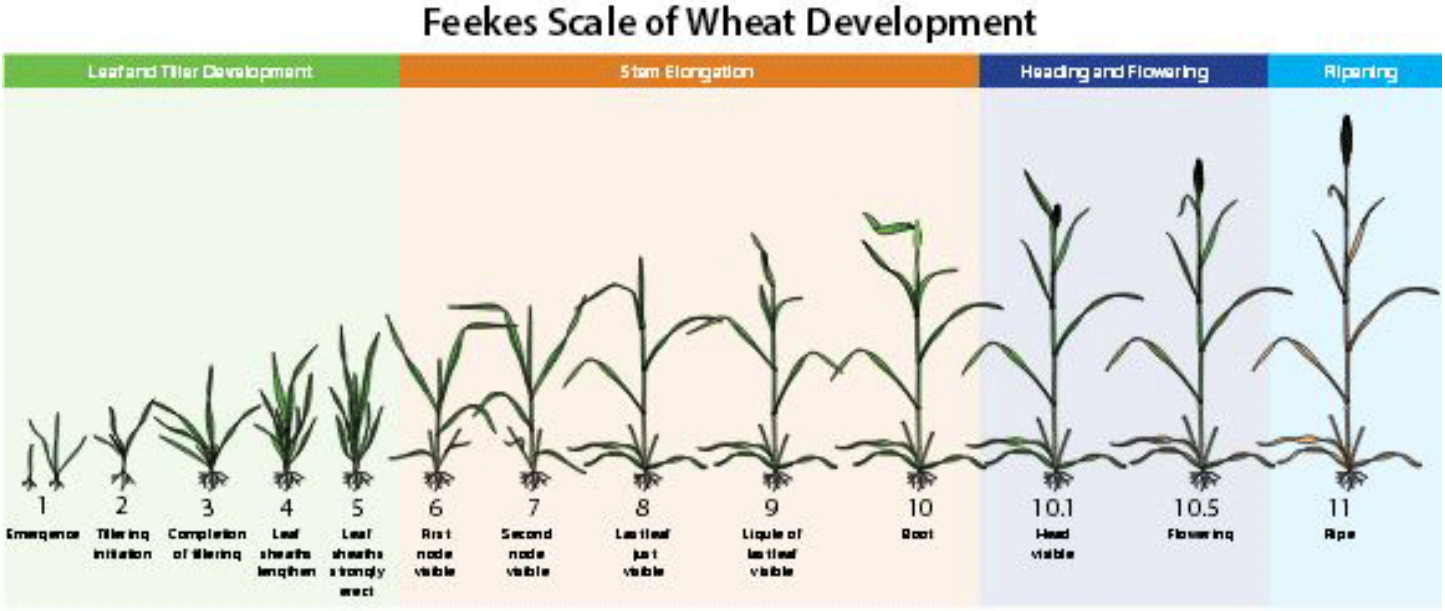
Sacrifice one plant in each grouping every two weeks by pulling it out of the soil to document the shoot, leave, root, and flowering, and head growth. Students document on computer to create their own “real time” Feekes Scale of Wheat Development!

Student Reports
Students should compile a report. Examples being a power point presentation, written essay, or informational video. Including but not limited to: compare and contrast size of seed, germination time, seedling growth, mature plant growth, time of flowering; amount of seed harvested per plant, if seeds are full and plump or shriveled etc, graph of growth rates etc.

K-State Research and Extension publications website:
https://www.bookstore.ksre.ksu.edu/pubs/MF3300.pdf

Students can download and print this poster to use in their learning experience.

Wheat Plant Growth and Development Feekes Scale



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