GOOD in every GRAIN

GRAIN FARMERS OF ONTARIO

Growing for the future
Teacher's guide

Barley | Corn | Oats | Soybeans | Wheat

www.GoodInEveryGrain.ca

Dear Teacher:

Grain Farmers of Ontario would like to thank you for choosing to use the Growing for the Future resource, developed for grades 6 through 8. The six lessons are designed to complement the Science and Technology curriculum, with cross curricular ties to Language.

Each of the activities will encourage students to think critically about topics such as sustainability, Genetically Modified Organisms, and biodiversity. Students will explore information from a variety of sources and apply their knowledge through hands-on activities and engaging projects.

We hope that you enjoy using this resource in your classroom. For more information and activities about agriculture and food, please visit www.GoodinEveryGrain.ca or www.agscape.ca. •


Soybeans


Wheat

More Than Food

Learning goals

- Students will gain a broader understanding of the end uses of commonly grown Ontario grains and oilseeds.
- Students demonstrate an understanding that humans rely on renewable and non-renewable resources.

Materials and resources

- pictures of products listed in Appendix 1A
- pictures or samples of barley, corn, oats, soybeans, and wheat (Appendix 1B)
- copies of Appendix 1A: Grain & oilseed products
- copy of Appendix 1B: Grain & oilseed products answer key
- copy of Appendix 1C: Persuasive writing checklist
- small bins for sorting activity

Grade 6

Curriculum expectations

Science & Technology, Grade 6, Understanding Life Systems: Biodiversity

3. Demonstrate an understanding of biodiversity, its contributions to the stability of natural systems, and its benefits to humans.

3.6 Identify everyday products that come from a diversity of organisms.

Language Arts, Grade 6, Writing

1. Generate, gather, and organize ideas and information to write for an intended purpose and audience.
2. Draft and revise their writing, using a variety of informational, literary, and graphic forms and stylistic elements appropriate for the purpose and audience.
3. Use editing, proofreading, and publishing skills and strategies, and knowledge of language conventions, to correct errors, refine expression, and present their work effectively.
4. Reflect on and identify their strengths as writers, areas for improvement, and the strategies they found most helpful at different stages in the writing process.

Students should be familiar with persuasive writing prior to this lesson.

Hook

Ask students, if you were to take a drive through the country in the summer what would you see growing in the majority of the fields? (barley, corn, oats, soybeans, wheat). Hold up samples or pass around pictures to see if students recognize any of the plants.

Activity

There is a common misconception that farms only provide us with food. In reality, agriculture also provides us with a wide variety of raw materials from which we are able to make cosmetics, medicines, fuel, car parts, and much more. Many of the items we use every day come from resources that are either extracted from the natural world through industries such as mining, or they are grown on farms.

Show students one of the Grain Farmers of Ontario videos on end-uses:
https://youtu.be/Jv3sQ7QxNq0 OR
https://www.youtube.com/watch?v=G7j9IcXLiYI&feature=youtu.be

Hand out Appendix 1A: Grain and oilseed products. Ask students to use five different colours or symbols to mark the products they believe include or are derived from each of the grains or oilseeds.

Alternatively, provide students with a variety of pictures of the products listed in Appendix 1A and have them work in groups to sort them into five piles – barley products, corn products, oat products, soybean products, and wheat products. You could also consider having them sort them further into food products and industrial products.

Or, incorporate the sorting of the products into your daily physical activity by dividing the class into two groups. Provide each group with a set of pictures (1 per student) and have them take turns running and placing their pictures into the appropriate bin (barley, corn, oats, soybeans, wheat). The team that finishes first and has the most correct wins.

Follow the sorting activity with a class discussion about each product. Are there some products that could fit in more than one category? Were the students surprised by any of the products?

As we have seen from the extensive list of products, grains and oilseeds are used for more than just food. Ask students how they feel about this fact? Introduce the idea of resources – nonrenewable, renewable.

Write the word "Resources" on the centre of the board. Discuss what kinds of resources are essential to our everyday lives. We use many resources to provide our basic needs – food, water, shelter, and clothing. Write the word "Nonrenewable" on one side of the board and "Renewable" on the other side. Discuss the definitions of each word.

- Nonrenewable resources are made naturally by the earth but do not renew themselves fast enough for people to count on having the resource for an indefinite period time. Some resources are considered nonrenewable because access to the resource is limited. For example, oil and natural gas are nonrenewable. The elements are found in the structure of the earth's crust, but there is not an infinite amount of these products and we are limited to what we can access through mining.
- Renewable resources are either naturally reproduced at a sustainable rate or they can be produced in agriculture at a rate equivalent to the demand or need. For example, corn can be used for ethanol fuel, and a new crop of corn can be grown and harvested each year.

Ask students to brainstorm examples of each type of resource and list them under the appropriate heading on the board.

Renewable	Nonrenewable
- trees	- coal
- animals	- natural gas
- soybeans	- rocks
- corn	- minerals

For further learning on renewable resources, consider having students watch the following Scholastic Study Jams:

Natural Resources
http://studyjams.scholastic.com/studyjams/jams/science/energy-light-sound/natural-resources.htm

Renewable Fuels
http://studyjams.scholastic.com/studyjams/jams/science/energy-light-sound/renewable-fuels.htm

In terms of being a renewable resource, as a class, consider the benefits and challenges of using a food product (grains and oilseeds) in non-food products.

Follow up / extension activity

Ask students to write a persuasive media piece on the following topic – Grains and oilseeds should be used in non-food products: Yes or No?

Offer students the option to prepare their media piece as a farmer, government trade official, product (oil, plastics, etc.) processor, environmentalist, etc.

Offer students the option to choose how they present their arguments. Possibilities could be:

- poster board
- speech
- story
- play
- video
- essay

Assessment

Assessment for learning – Complete a diagnostic assessment of students familiarity of common grains and oilseeds grown in Ontario and their understanding of renewable and nonrenewable resources during class discussion.
Assessment as learning – Students will assess their success against the checklist for their persuasive media.
Assessment of learning – Evaluate student work using Appendix 1C - Persuasive writing checklist for their ability to demonstrate an understanding of their writing and end-uses of grains and oilseeds. •

Appendix 1A: Grain and oilseed products

cosmetics
adhesives
paper products
soy sauce
milk substitute
ceramics
natto
penicillin
miso
corn syrup
peanut butter
tempeh
shortening
ethanol
glue
salad dressing
waxes
solvents
printing ink
tofu
paper
oil
soft drinks
cookies
cereal
vanilla extract
cornmeal
beer
oatmeal
carpet
sweeteners
bread
candles
crackers
Windex
crayons
pizza dough
toothpaste
dog food
aspirin
gum
flatbreads
margarine
soy nuts
butanol
edamame
soap
whisky
meat substitute
plastics
biodiesel
shampoo
fruit jam
lubricants
hydraulic fluid
fibres & textiles
tires
ice cream
corn starch
explosives
fish food
hand cream
cakes

Appendix 1B: Crops and crop stages

Appendix 1B: Grain and oilseed products answer key

Barley	Corn	Oats	Soybeans	Wheat
beer	asprin	bread	adhesives	bread
cereal	butanol	hand cream	biodiesel	cakes
fish food	ceramics	oatmeal	candles	cereal
	cornmeal		carpet	cookies
	corn syrup		crayons	crackers
	corn starch		edamame	flat breads
	cosmetics		fibres & textiles	paper
	ethanol		hydraulic fluid	pizza dough
	explosives		lubricants	
	fruit jam		margarine	
	glue		meat substitute	
	gum		milk substitute	
	ice cream		miso	
	oil		natto	
	paper products		oil	
	peanut butter		plastics	
	penicillin		printing ink	
	plastics		shortening	
	salad dressing		solvents	
	shampoo		soy nuts	
	soap		soy sauce	
	soft drinks		tempeh	
	sweeteners		tofu	
	tires		waxes	
	toothpaste			
	vanilla extract			
	whisky			
	Windex			

Appendix 1C: Persuasive writing checklist

Key elements	What it looks like	Student thoughts	Teacher thoughts
Reasoning & Organizing Ideas	• The writer's opinion is clearly stated. • The writer maintains his/her opinion throughout the piece. • The author has supported his/her opinion with facts and/or strong arguments. • There is a clear beginning, middle, and end. • The persuasive argument is thoughtfully "wrapped-up". • The ideas are linked and fit together in a way that makes sense.		
Communication	• The writer's "voice" is clear. He/she sounds sincere and committed to his/her opinion. • The words the writer uses set the right tone for his/her purpose and audience. • The sentences vary in length and kind. • There is a variety in sentence beginnings. • The writer has used persuasive techniques, e.g. repetition, asks questions, and places strongest fact/argument toward the end.		
Application of Language Conventions - spelling -grammar -punctuation and capitalization -paragraphs	• The writer has attempted to make sure there are no spelling errors. • The author has made no obvious mistakes in grammar. • Capital letter and end-of-sentence punctuation are correct. • The writer has attempted to use other punctuation correctly.		
Content	• The writer has clearly demonstrated their understanding of society's reliance on resources. • He/she has given consideration to the positive or negative aspects of using a food product (grains and oilseeds) in non-food products.		

Plant Classification

Learning goals

- Students will understand the importance of plant classification.
- Students will learn how to use and create a dichotomous key.
- Students will identify common Ontario grain crops through examining their unique characteristics.

Materials and resources

- Appendix 2A: Growth stages of a plant (corn, soybean, oat, and wheat)
- Appendix 2B: Guiding questions – plant characteristics
- Appendix 2C: Specimen characteristics graphic organizer
- Appendix 2D: Developing a dichotomous key
- Appendix 2E: Specimen characteristics answer key

Grade 6

Curriculum expectations

This lesson is designed to be integrated into the Understanding Life Systems: Biodiversity unit. It specifically addresses plant classification.

Grade 6, Understanding Life Systems: Biodiversity

2. Investigate the characteristics of living things, and classify diverse organisms according to specific characteristics.

2.3 Use scientific inquiry/research skills to compare the characteristics of organisms within the plant or animal kingdoms.

3.1 Identify and describe the distinguishing characteristics of different groups of plants and animals.

3.5 Describe interrelationships within species, between species, and between species and their environment.

Prior to this lesson, students may be required to review basic plant parts (roots, stem, leaves, flowers, seeds). Consider having students spend time watching the plant video clips found here http://studyjams.scholastic.com/studyjams/jams/science/index.htm.

Hook

As a class, use Appendix 2A: Growth stages of a plant and Appendix 2B: Guiding questions – plant characteristics to explore the characteristics of different grains. Have students use Appendix 2C: Specimen characteristics graphic organizer to record their observations.

Activity

Inform students that they are going to investigate the characteristics of common field crops grown in Ontario in order to create their own dichotomous keys.

Explain to students what a dichotomous key is – a tool used for organism identification, whereby the user makes a series of choices between two alternative character descriptions.

Break students into four (or as many as there are specimens provided) groups. Provide each group with the growth stages of a specimen. Tell students they will have three minutes to look at the assigned growth stages and make note of distinguishing characteristics of the plant such as the flower colour, seed size, leaf shape, etc.

Ask them to record their observations on their graphic organizers. Students will rotate through the various plant types. Have students repeat this until they have recorded the characteristics for all of the specimens provided.

Once students have had the chance to record their observations, as a class, go through the steps of creating a dichotomous key using Appendix 2D: Developing a dichotomous key. Draw an example on the board.

Provide students with time to create their keys. Once they have completed their key, have them pair up with another student who has also finished to test and provide feedback on one another's keys.

Assessment

Assessment for learning – Complete a diagnostic assessment of student's prior knowledge of plant parts/characteristics during the class discussion on/observations of the growth stages of grains and oilseeds.

Assessment as learning – Have students provide feedback to one another during the sharing of their dichotomous keys.

Assessment of learning – Evaluate student graphic organizer and dichotomous key for knowledge and understanding of plant characteristics and their application in identifying a variety of organisms.

Enrichment

Supply students with illustrations of the plant characteristics outlined in Appendix 2B: Guiding questions – plant characteristics.

Bring in real samples of the plants or provide vibrant pictures of their specimens at various growth stages for students to use to make their observations.

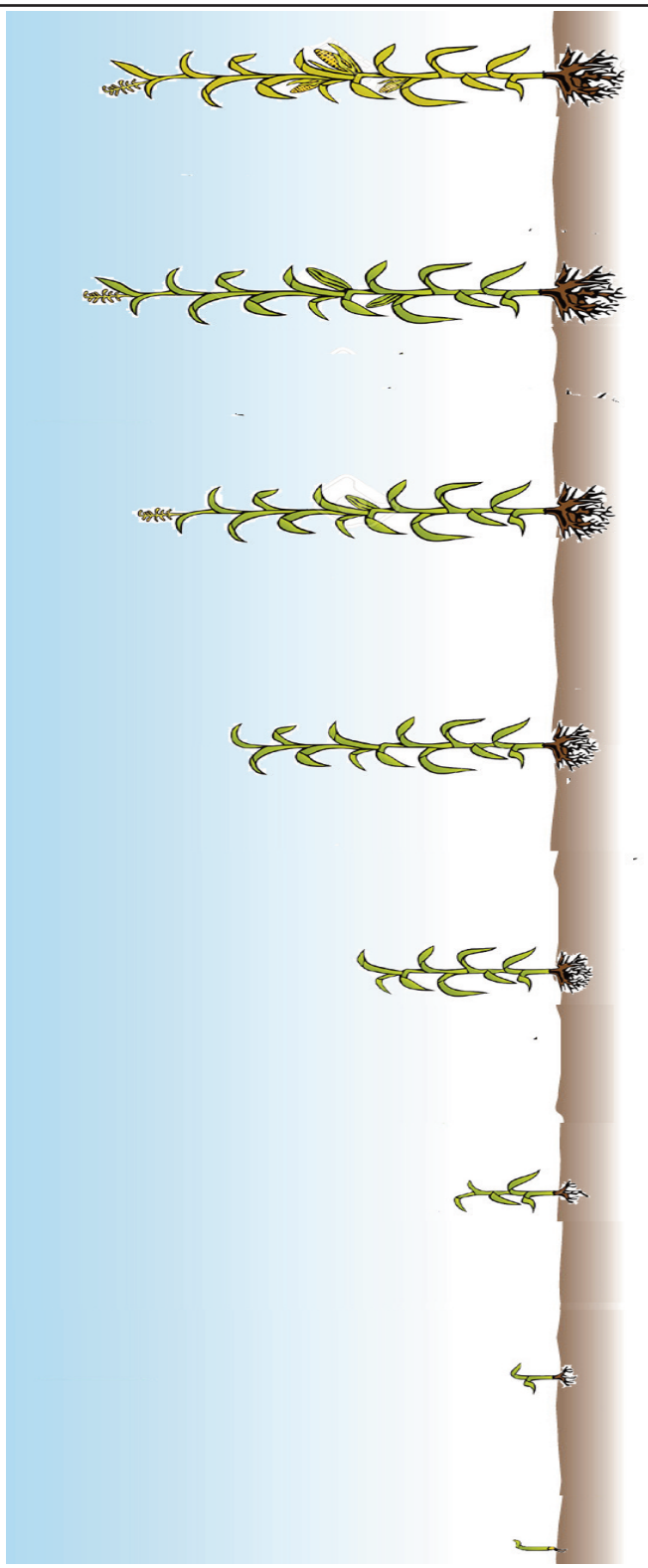
Challenge your students by increasing the number of specimens for the creation of their dichotomous keys. Possible options of crops grown in Ontario include: barley, canola, potatoes, apples, and/or carrots.

Follow-up activity

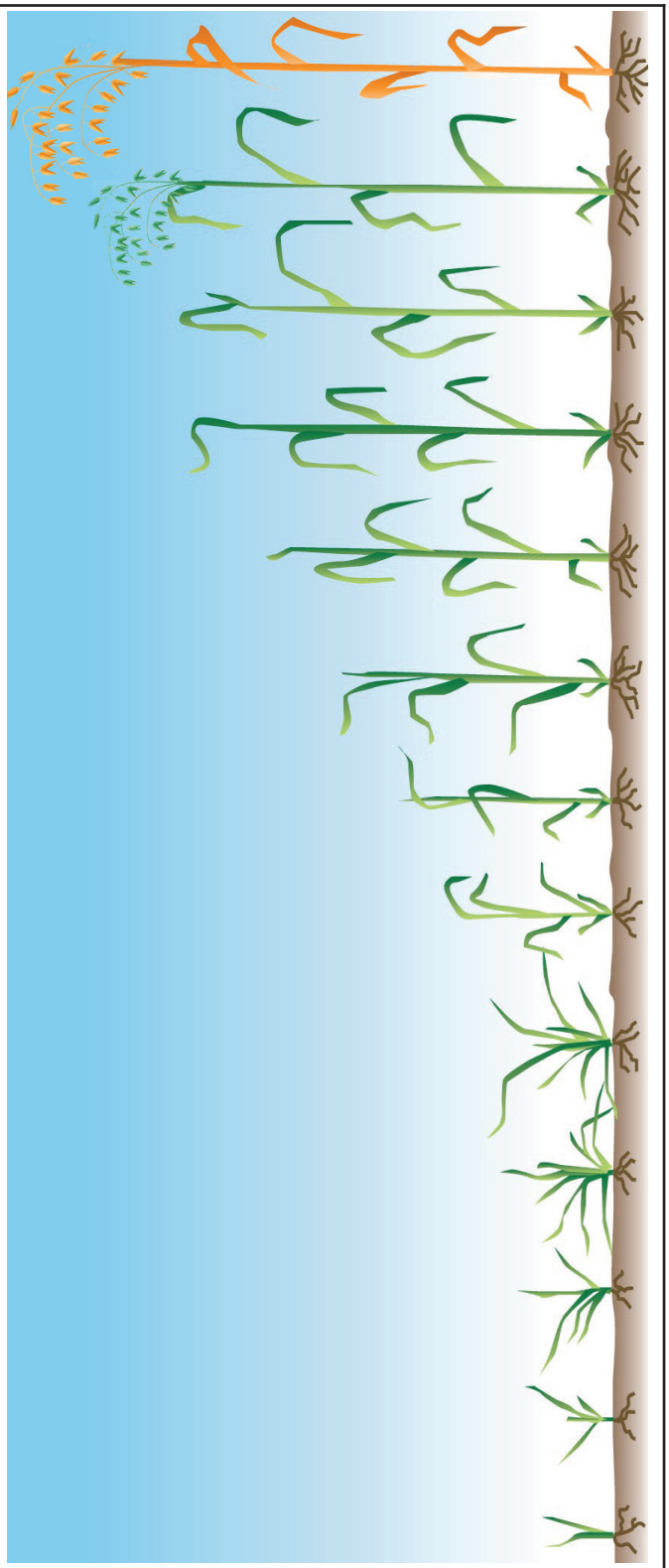
Ask your students to further investigate an Ontario grown crop of their choice and create a poster board that includes the crop's complete taxonomic name, a variety of labeled pictures, how the crop reproduces, and interesting facts. •

Appendix 2A: Growth stages of a plant (corn and oat)

Growth stages of a corn plant

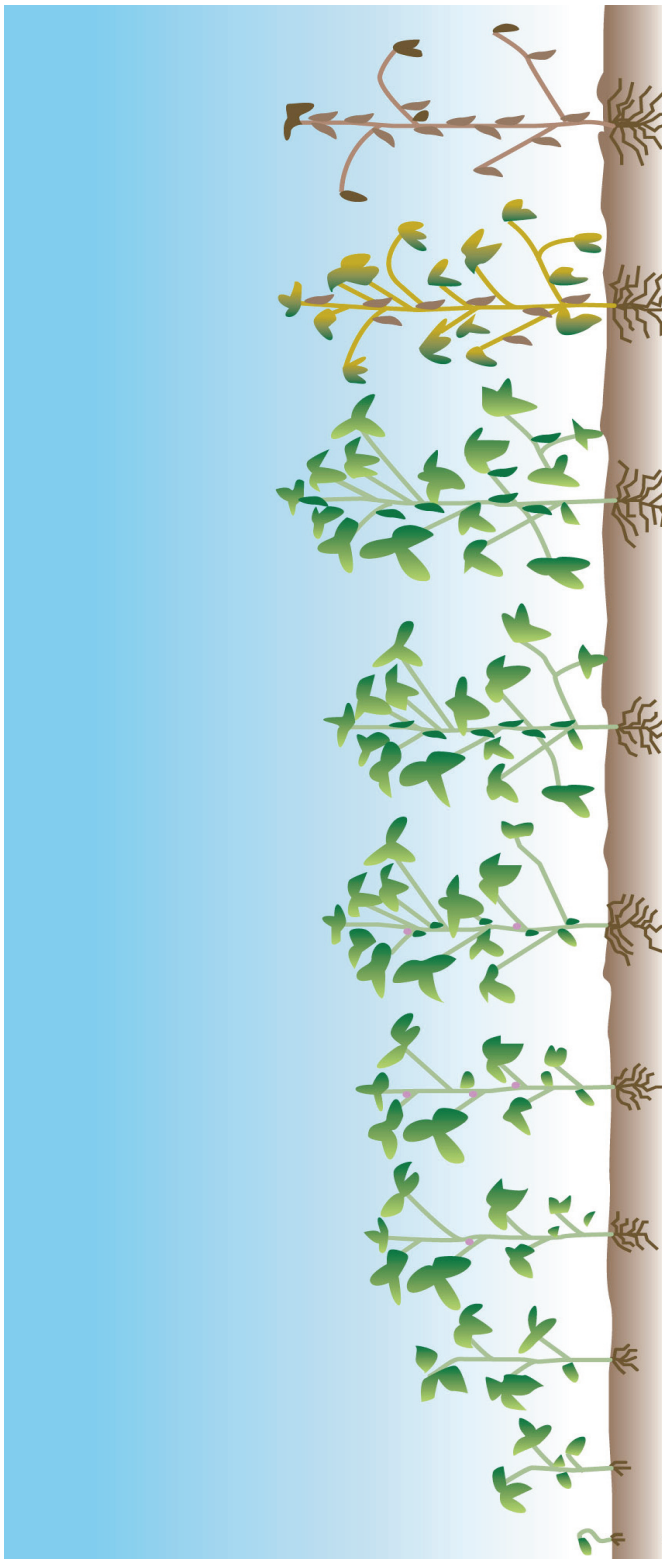


Growth stages of a oat plant

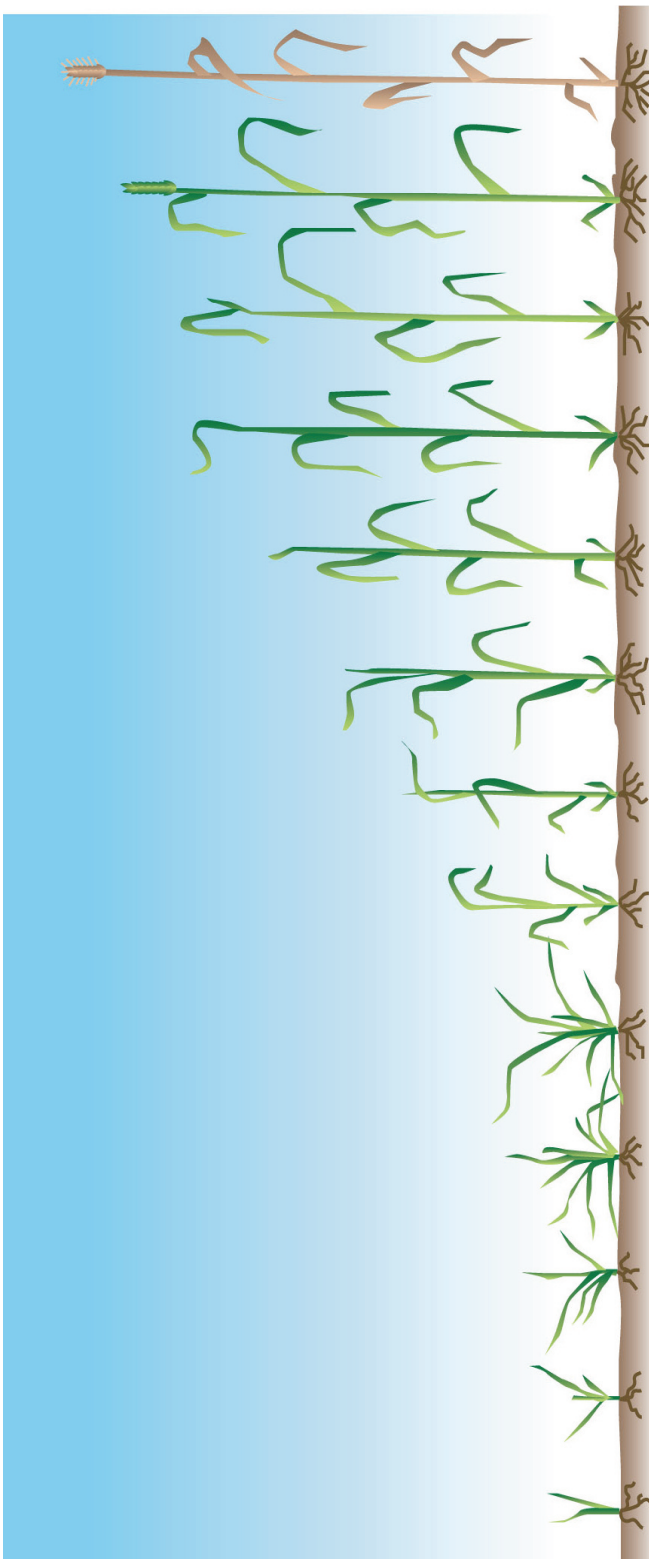


Appendix 2A: Growth stages of a plant (soybean and wheat)

Growth stages of a soybean plant



Growth stages of a wheat plant



Appendix 2B: Guiding questions - plant characteristics

What do the seeds look like?

Are they large or small?
What shape are they?
What colour are they?

What about the leaves?

How are they arranged?

Alternate
- one leaf per node (a joint or point of attachment for leaves and branches)

Opposite
- two leaves per node on opposing sides of the stem

Whorl
- three or more leaves per node are arranged in a circular pattern

Are they simple or compound?

Simple
- have only one definite segment present between the stem and the end of the blade

Compound
- are divided into definite and distinct segments called leaflets

What shape do they have?

Elliptic
- broadest in the middle and narrower at either end

Linear
- long and narrow with the sides being close to parallel to each other

Lanceolate
- are much longer than wide, with the widest point below the middle

Spatulate
- look similar to a spatula, with the tip being rounded and gradually tapering to the base

Ovate
- egg-shaped

Oval
- round to oval and don't have a pointed tip

Cordate
- heart-shaped

Is it a flowering plant? If so, ...

What colour are the flowers?
How are they arranged?
How are they pollinated?

Is the plant a monocot or a dicot?

Monocots (mono = one)
- have a single seed leaf (known as the cotyledon) that emerges from the seed
- have leaf veins that form a parallel pattern
- have floral parts (petals) that are in multiples of three

Dicots (di = two)
- have two seed leaves (or cotyledons) that emerge from the seed
- have leaf veins that form a parallel pattern

What type of root system do they have?

Taproot
- a single, dominant root that penetrates downward to a considerable depth from which smaller more fibrous roots sprout

Fibrous roots
- densely branching roots that are similar in size with growth oriented both outwards and downwards

Rhizomes
- elongated, horizontal, below ground stems that can emerge some distance from the mother plant, giving rise to new plants.

Stolons
- similar to rhizomes except that the elongated, horizontal stems are above ground. Stolons root at the nodes or tips and give rise to a new plant.

This appendix was developed using the following resources:
- *Graham, Linda E., et al. Plant Biology 2nd Edition. Pearson Education, Inc., 2006*
- *Mangold, J and Parkinson, H. Plant Identification Basics. Ag and Natural Resources. Montana State University. September 2013.*

Found online at
http://store.msuextension.org/publications/AgandNaturalResources/MT201304AG.pdf

Appendix 2C: Specimen characteristics graphic organizer

	Corn	Oat	Soybean	Wheat
Scientific Name				
Seed				
Roots				
Stem				
Leaves				
Flowers				
Fruit				
Other				

Appendix 2D: Developing a dichotomous key

A dichotomous key is a useful tool for organism identification. The user makes a series of choices between two alternative character descriptions. By observing similarities and differences in organisms, scientists can classify them and gain further understanding of their characteristics. Scientists use dichotomous keys to organize and classify large amounts of information so it can be easily shared and studied.

A dichotomous key is a guide, sort of like a map of characteristics, that leads the user to the correct identification of an organism. To make a dichotomous key you will choose physical characteristics that can be used to divide a collection into two parts.

Step 1:
Begin by gathering your organisms (or pictures of organisms) to be identified.

For this example we will use a turtle, an iguana, a cow, a horse, and an orangutan.

Step 2:
Decide how to split your group in two parts. Carefully observe your specimens to pick a characteristic which can be used to decide which organism goes into which group. Record the chosen characteristic and the groups formed.

Example:
A turtle, an iguana, a cow, a horse, and an orangutan could be divided by class:

1. A. The organism is a mammal. See #2.
   B. The organism is a reptile. See #3.

Step 3:
After the collection has been divided into two groups, divide the first group into two more groups based on one characteristic. Record your characteristic and groups. When you form a group with only one organism, name it.

Example:

2. A. The mammal has hooves. See #4.
   B. The mammal does not have hooves. The organism is an orangutan.
3. A. The reptile has a shell. The organism is a turtle.
   B. The reptile does not have a shell. The organism is an iguana.

Step 4:
Continue to identify characteristics and divide groups until all of the organisms are named. Be sure to record each division made. When the first group is complete, repeat the steps until all of the organisms in the second group have been named.

Example:

4. A. The organism has cloven hooves. The organism is a cow.
   B. The organism does not have cloven hooves. The organism is a horse.

Your Turn
This above example is somewhat short and simple. The more items you have in your collection, the longer your key will be.

Possible physical characteristics to use include plant size, shape, leaf shape, stem type, colour, and presence of seeds, fruits, or flowers.

Have a friend try out your completed key to see that it leads users to the correct choices and identification.

Appendix 2E: Specimen characteristics answer key

Characteristics listed below found in plant descriptions found on www.plantvillage.org.

	Corn	Oat	Soybean	Wheat
Scientific Name	*Zea mays*	*Avena sativa*	*Glycine max*	*Triticum durum*
Seed	• yellow • tear-drop	• tan • elongated oval	• tan • round	• tan • elongated oval
Roots	• fibrous • prop (grow from stem above ground to help support plant)	• fibrous	• fibrous • nodules	• fibrous
Stem	• large hollow • simple stem of nodes and inter-nodes	• hollow • tillers	• erect bush with woody stems	• hollow • erect smooth stem with tillers
Leaves	• pairs of large long slender leaves extend off of each internode • total 8-21 per plant • linear or lanceolate (lance-like) with an obvious midrib • simple	• long slender • simple	• trifoliate • alternately arranged leaves possess three individual leaflets which are oval or lance-like in shape • compound	• long slender • linear leaves that grow in two rows on either side of the stem with larger 'flag' leaves at the top of the stem • simple
Flowers	• male and female inflorescences positioned separately on the plant • male inflorescence is known as the 'tassel' • female inflorescence is the 'ear' • wind pollinated	• inflorescence consists of a number of branches, or racemes, and spikelets which usually contain three florets • wind pollinated	• compound inflorescence • purple or white • self-pollinating	• spike that is made up on individual spikelets, each possessing 3-9 florets • wind pollinated
Fruit	• modified spike (ear)	• kernels develop within the spikelets	• 3-5 seeds per pod	• kernels develop within the spikelets
Other	• annual • grass	• annual • grass	• annual • legume	• annual • grass

Sustainable Agriculture

Learning goals

- students demonstrate an understanding that humans rely on finite resources and that it is important to protect those resources
- students demonstrate an understanding of sustainable agriculture practices used to mitigate our impact on the environment

Materials and resources

- access to the internet to show YouTube clips and for research purposes
- apple (alternate hook), knife (alternate hook)
- copies of Appendix 3A: Research guide example - crop rotation
- copy of Appendix 3B: Research guide
- copies of Appendix 3C: Helpful websites
- copies of Appendix 3D: Case study (extension activity)
- copies of Appendix 3E: Sustainable agriculture practices: answer keys
- copies of Evaluating Internet Sources: Focus on Agriculture & Food https://magic.piktochart.com/output/7248640-evaluating-internet-sources-focus-on-agriculture-and-food
- Sustainability information: www.gfo.ca/Market-Development/Sustainability-Environment

Grade 6 and 7

Curriculum expectations

Science and Technology, Grade 6, Understanding Life Systems: Biodiversity

1. Assess human impacts on biodiversity, and identify ways of preserving biodiversity

Language, Grade 6, Media Literacy

1. Create a variety of media texts for different purposes and audiences, using appropriate forms, conventions, and techniques

Science and Technology, Grade 7, Understanding Life Systems: Interactions in the Environment

1. Assess the impacts of human activities and technologies on the environment, and evaluate ways of controlling these impacts;
2. Investigate interactions within the environment, and identify factors that affect the balance between different components of an ecosystem;
3. Demonstrate an understanding of interactions between and among biotic and abiotic elements in the environment.

Language, Grade 7, Media Literacy

1. Create a variety of media texts for different purposes and audiences, using appropriate forms, conventions, and techniques

Hook

If technology allows, show students a video clip of "Dust Bowl – a 1950's documentary" on YouTube (https://www.youtube.com/watch?v=CM3ZHMBhP2k&feature=youtu.be). Be sure to watch the first 7 minutes of the film. Follow the clip with a class discussion on what they think caused the environmental disaster. An alternative hook is the "Earth as an Apple" (taken from OAFE Update Number 55, Winter 2007).

Slice the apple into quarters. Set aside three of the quarters. These represent the oceans of the world. The fourth quarter roughly represents the total land area left.

Slice this quarter in half, giving you two 1/8th world pieces. Set aside one of the pieces. This is land inhospitable to people (the polar areas, deserts, swamps, very high or rocky, mountainous areas). The other 1/8th piece is the land area where people live, but not necessarily grow the foods needed for life. Now slice this 1/8th piece into four sections giving you four 1/32nd pieces.

Set aside three of these pieces. These are areas too rocky, too wet, too cold, too steep or with soil too poor to actually produce food. They also include the areas of land that could produce food but are buried under cities, highways, suburban developments, shopping centres, and other structures that people have built.

This leaves us with 1/32nd slice of the earth. Carefully peel this slice. This tiny bit of peeling represents the surface, the very thin skin of the earth's crust upon which humankind depends. Less than 5 feet deep, it is quite a fixed amount of food-producing land. Now you realize that protecting our land resources are important, too.

Advanced agricultural technology and sustainable agriculture practices enable the world to feed many of its people. But, with a fixed land resource base and an ever increasing number of people trying to feed themselves from the fixed base, each person's portion becomes smaller and smaller and more important to the individual person. We must protect the quality of our air, water, and land.

Activity

Write the words sustainable and agriculture on the board. Ask students what they think these words mean.

Introduce the concept of Sustainable Agriculture using the Ontario Ministry of Agriculture, Food and Rural Affairs Fact Sheet – Introduction to Sustainable Agriculture found at http://www.omafra.gov.on.ca/english/busdev/facts/15-023.htm

The majority of today's farmers use a combination of sustainable agriculture practices to reduce erosion, soil nutrient loss, and chemical use. Sustainable agriculture aims to create a farm landscape that resembles as closely as possible a natural ecosystem while growing food for the world's increasing population.

Hand out Appendix 3A: Research guide example – crop rotation.

As a class, using Appendix 3A: Research guide example – crop rotation, discuss the sustainable agriculture practice of crop rotation in order to provide students with an example of your expectations for the group assignment.

Tell the class that the goal of their research is to become the class expert on their sustainable agriculture practice and develop a presentation (slide show, video, poster, fact sheet, etc.). They may choose to develop their presentation for farmers – providing reasons why the farmer should incorporate the student's researched practice into the their operation or for the general public – informing them of what practices farmers are using to reduce their impact on the environment (local biodiversity and/or ecosystem). Presentations must include a visual aid (pictures, labeled drawings, or diagram) to illustrate the practice.

In groups, assign students one of the sustainable agriculture practices listed below.

Sustainable agriculture practices include:

- crop rotation
- growing cover crops
- strip inter-cropping
- no-till or minimal tillage
- planting field borders and windbreaks
- biocontrol agents
- biotechnology

Hand out a copy of Appendix 3B: Research guide and Appendix 3C: Helpful websites to each group. Review Evaluating Internet Sources: Focus on Agriculture & Food with students. Provide students time to research, answer the guiding questions, and develop their presentations.

Summary

The agriculture industry uses and takes care of natural resources such as soil and water in order to grow and produce crops that provide us with the necessities and luxuries we use every day. There are many examples of sustainable agricultural practices designed to decrease soil erosion, maintain water quality, and preserve soil quality.

Sustainable agriculture practices are important to preserve our ability to provide food for a growing population.

If you did not show students a clip of The PBS documentary: "The Dust Bowl" at the beginning of this lesson, consider ending the lesson with this clip.

As a class, discuss what lessons were learned and what still needs to be done to improve the sustainability of agriculture.

Assessment

Assessment for learning – Complete a diagnostic assessment of students' familiarity of sustainable agriculture in the activity introduction.
Assessment as learning – Observe students during the research process and have checkpoint meetings to have them share their self-assessment with the teacher. Adjust classroom instruction and scaffolding according to their ability to investigate their practice and answer the assigned questions accordingly. An answer key has been provided to assist you with assessment of the content.
Assessment of learning – Evaluate student presentations for their ability to demonstrate an understanding of sustainable agriculture practices.

Extensions

- Have students apply the knowledge from this lesson to a "real world" situation using Appendix 3D: Case study.
- Consider searching hashtags such as #cdnag, #ontag #rootsnotiron, #notill, #striptill, etc. on Twitter to see what farmers are doing in real life situations.

Companion Lesson

Celebrate 2016 International Year of Pulses – Lesson 4: Growing Pulses or Food Choices and Sustainability lesson. Both lessons can be found on www.aitc-canada.ca. •

Appendix 3A: Research guide example - crop rotation

1. **Describe your group's sustainable agriculture practice.**
   Crop rotation is the practice of growing different types of crops on the same plot of land in successive growing seasons.

2. **When or why is it used? Are there particular situations it is good for (for example, on a hill or near a road or a body of water)?**
   Crop rotation is used for a variety of reasons.
   - decrease the amount of fertilizer used
   - break pest, disease, and weed life-cycles
   - improve soil structure

3. **What is the major environmental benefit of this practice?**
   Fertilizer
   Different crops use different amounts of nutrients. If the same crop is planted continuously, the soil will become depleted of some nutrients more than others, increasing fertilizer use. For example, some crops use a lot of nitrogen, while others are able to return nitrogen to the soil. Crop rotation can play a major role in decreasing the potential risk of nitrate leaching to surface and groundwater by enhancing soil nitrogen availability and therefore reducing the amount of nitrogen fertilizer that needs to be applied.
   Pests
   Farmers rotate the crops they grow in order to naturally break the life cycle of pests, diseases, and weeds that would increase in population size if the same crop (food source) was planted year after year.
   Soil Structure
   Growing different crops each year can also help improve soil structure and fertility by alternating deep-rooted and shallow-rooted plants. Including a variety of crops in a crop rotation such as wheat, edible beans, and alfalfa greatly improve soil-health by increasing organic matter.

4. **What are some additional benefits of this practice?**
   Farmers often see an increase in yields when crop rotation is practiced on their farms.

5. **How does this agriculture practice directly impact biodiversity?**
   Growing a greater diversity of plants is known to improve soil microbial biodiversity. Higher crop diversity increases the quality and quantity of crop residues that can be incorporated into the soil, which then become available to the microbial communities.

List any new vocabulary associated with the practice.
nitrogen, leaching, organic matter, residues, microbial

List all of the resources you used to answer the questions above.
- Soil Management
  http://www.omafra.gov.on.ca/english/crops/pub811/8building.htm
- Ontario Soil & Crop Improvement Association
  www.ontariosoilcrop.org
- Ontario Grain Farmer magazine
  www.ontariograinfarmer.ca
- Soil Conservation Council of Canada
  http://www.soilcc.ca/resources.htm
- Food and Agricultural Organization of the United Nations: Natural Resources and Environment
  www.fao.org

Appendix 3B: Research guide

1. Describe your group's sustainable agriculture practice.	
2. When or why is it used? Are there particular situations it is good for (for example, on a hill or near a road or a body of water)?	
3. What is the major environmental benefit of this practice?	
4. What are some additional benefits of this practice?	
5. How does this agriculture practice directly impact biodiversity?	
List any new vocabulary associated with the practice.	
List all of the resources you used to answer the questions above.	

Appendix 3C: Helpful websites

A Primer on Ontario Cropping and Tillage Systems
https://tdaynard.com/2014/04/06/a-primer-on-ontario-cropping-and-tillage-systems-2/

Agriculture & Agri-food Canada
http://www.agr.gc.ca/

Biodiversity International
www.bioversityinternational.org

Good in Every Grain
www.goodineverygrain.ca

Grain Farmers of Ontario
www.gfo.ca

Environmental Sustainability of Canadian Agriculture
- Report #1 (2000)
  http://www.agr.gc.ca/resources/prod/doc/policy/environment/pdfs/aei/summary.pdf
- Report #2 (2005)
  http://www.ecomatters.com/NAHARPfull.pdf
- Reports #3 (2010)
  http://publications.gc.ca/collections/collection_2011/agr/A22-201-2010-eng.pdf

Food and Agricultural Organization of the United Nations: Natural Resources and Environment - The Importance of Soil Organic Matter
www.fao.org

Ontario Grain Farmer magazine
www.ontariograinfarmer.ca

Ontario Ministry of Agriculture, Food & Rural Affairs
www.omafra.gov.on.ca

Ontario Soil & Crop Improvement Association
www.ontariosoilcrop.org

Soil Conservation Council of Canada
http://www.soilcc.ca/resources.htm

Soil Management
http://www.omafra.gov.on.ca/english/crops/pub811/8building.htm

Sustainable Agriculture
http://discover.monsanto.com/sustainable-agriculture/

The Good Growth Plan
http://www4.syngenta.com/what-we-do/the-good-growth-plan

The Value of Biodiversity
http://www.naturesask.ca/rsu_docs/faming-and-biodiversity.pdf

Appendix 3D: Case study

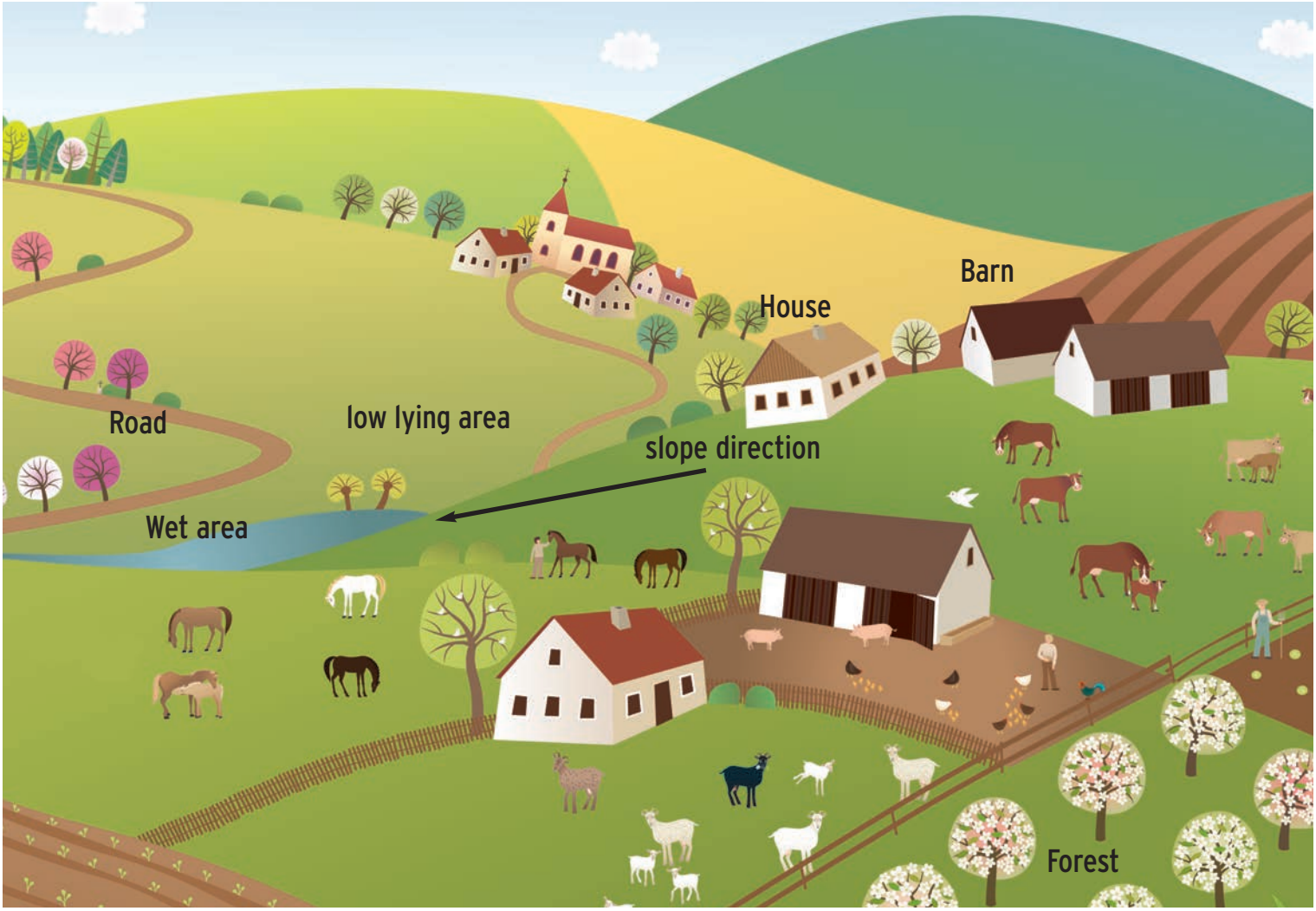
You have just purchased a 40.5 hectare (100 acre) farm. The previous owner has grown corn on the land for the last 3 years. They have used minimal tillage practices in order to break up and incorporate the corn stalks from previous years. There is a farmhouse and a small forest on the property. The farm is located on a small hill with high and low lying areas. The low lying area is often flooded each spring.

In the space below, write a proposal for at least two conservation practices you wish to use on your land.

1. Choose which sustainable agriculture practices you will use.

2. Indicate on the map where you will use those practices.

3. Write a paragraph to justify why you have chosen the practices and their locations. Make sure to discuss the benefits to your farm and the environment.



Appendix 3E: Sustainable agriculture practices: answer keys

Growing cover crops

1. **Describe your group's sustainable agriculture practice.**
   A cover crop is a crop that is planted between growing seasons for the primary purpose of improving the soil it is being grown on. They are planted once the main crop has been harvested instead of leaving the soil bare. They are typically planted in the fall and left in the field over winter. For example, a farmer might harvest corn and then plant rye to cover the field.

2. **When or why is it used? Are there particular situations it is good for (for example, on a hill or near a road or a body of water)?**
   Cover crops can be planted to help slow erosion, improve soil structure, increase soil organic-matter, enhance water availability, sequester nitrogen, break soil compaction, supply nutrients to future crops, smother weeds, help control pests and diseases, and increase biodiversity on a farm.

   Incorporating cover crops into any production system is beneficial but they are particularly important to use on lighter soils with lower organic matter or on fields with short rotations and little return of crop residue or manure.

3. **What is the major environmental benefit of this practice?**
   The major environmental impact of this practice is the reduction in soil erosion.

4. **What are some additional benefits of this practice?**
   Aside from the environmental benefits, depending on the cover crop chosen, a second crop in a growing season can allow for increased economic gains for the farmer.

5. **How does this agriculture practice directly impact biodiversity?**
   Certain cover crops, such as tillage radish, stimulate earthworms and insects in the soil. Having those crops in a rotation can build the soil's population of beneficial organisms. Cover crops also provide habitat for birds and insects.

List any new vocabulary associated with the practice.

erosion, sequester, beneficial, organic matter, compaction

List all of the resources you used to answer the questions above.

- http://www.omafra.gov.on.ca/english/crops/facts/cover_crops01/cover.htm
- http://www.sare.org/Learning-Center/Topic-Rooms/Cover-Crops

Appendix 3E: Sustainable agriculture practices: answer keys

Inter-cropping

1. **Describe your group's sustainable agriculture practice.**
   Inter-cropping involves growing more than one crop in the same field at the same time.

   There are four types of inter-cropping:
   Mixed Inter-cropping: Growing two or more crops simultaneously with no distinct row arrangement.
   Row Inter-cropping: Growing two or more crops simultaneously where one or more crops are planted in rows.
   Strip Inter-cropping: Growing soil conserving and soil depleting crops in alternate strips running perpendicular to the slope of the land or to the direction of prevailing winds for the purpose of reducing erosion.
   Relay Inter-cropping: Planting two or more consecutive crops after flowering and before the harvest of the standing crop.

2. **When or why is it used? Are there particular situations it is good for (for example, on a hill or near a road or a body of water)?**
   Inter-cropping helps to maintain soil fertility and structure.

3. **What is the major environmental benefit of this practice?**
   The major environmental impact of this practice is reduction of soil erosion on hills.

4. **What are some additional benefits of this practice?**
   Additional benefits of this practice include a reduction of pesticide and fertilizer application, complementary sharing of plant resources, such as Nitrogen from Nitrogen fixing plants, weed suppression, and a reduction in susceptibility to insects and disease.

5. **How does this agriculture practice directly impact biodiversity?**
   Inter-cropping of compatible plants encourages biodiversity, by providing a habitat for a variety of insects and soil organisms that would not be present in a single-crop environment. This in turn can help limit outbreaks of crop pests by increasing predator biodiversity.

List any new vocabulary associated with the practice.

conserving, depleting, perpendicular, prevailing, erosion, predator, suppression, susceptibility

List all of the resources you used to answer the questions above.

- http://www.agriinfo.in/?page=topic&superid=1&topicid=492
- http://www.dutchopeners.com/news-events/the-benefits-of-intercropping
- http://umanitoba.ca/outreach/naturalagriculture/articles/intercrop.html

Appendix 3E: Sustainable agriculture practices: answer keys

No-till or minimal tillage

1. **Describe your group's sustainable agriculture practice.**
   No-till is soil preparation that leaves crop residue from the previous year's crop on the field. For example, corn stalks may be left on the field after harvest and soybeans planted directly into the corn residue the next spring. Keeping the soil covered in this manner reduces erosion and runoff.

   Minimum tillage generally refers to a set of tillage operations in which moldboard plowing is replaced by chisel plowing or additional disking, which is less disruptive to the soil. Chisel plows break and shatter the soil, but do not turn the soil over like a moldboard plow. Therefore, most of the crop residue is left on the soil surface when chisel plowing.

   No-till is the practice of planting without any seedbed preparation.

2. **When or why is it used? Are there particular situations it is good for (for example, on a hill or near a road or a body of water)?**
   No-till or minimal tillage practices are used on all types of farms but are particularly beneficial to lighter soils with little organic matter.

3. **What is the major environmental benefit of this practice?**
   The major environmental benefit of this practice is reduced soil erosion due to wind and water, (rain and/or runoff) and increased soil organic matter.

4. **What are some additional benefits of this practice?**
   Additional benefits to no-till or minimal tillage practices include better soil moisture conservation, reduced soil compaction, lowered fuel use/costs due to fewer trips over the field, a reduction in the amount of tillage equipment needed, which results in lower machinery investment, lower labour requirements, which reduce hired labour costs or free up operator time for other farm operations and a reduction in the release of greenhouse gases in farm fields.

5. **How does this agriculture practice directly impact biodiversity?**
   Because the soil is not being frequently agitated, no-till farming promotes biodiversity in and around the soil. Organisms like mycorrhizal fungi, which make commensal (i.e. benefit both the plant and fungus – a symbiotic relationship) associations with crop roots, and earthworms (which increase the water retention of the soil), are allowed to flourish through no-till farming.

List any new vocabulary associated with the practice.

residue, erosion, run-off, moldboard plow, beneficial, seedbed, organic matter, compaction, greenhouse gases, mycorrhizal

List all of the resources you used to answer the questions above.

- http://extension.psu.edu/plants/crops/soil-management/conservation-tillage/economics-of-conservation-tillage
- https://www.geneticliteracyproject.org

Appendix 3E: Sustainable agriculture practices: answer keys

Planting field borders and windbreaks

1. **Describe your group's sustainable agriculture practice.**
   Field borders and windbreaks are strips of herbaceous or shrubby vegetation on the edge of cropland fields to promote wildlife and improve environmental quality. Field borders increase plant diversity and provide wildlife habitats. They also provide erosion control and protect water quality by trapping sediment and pollutants.

2. **When or why is it used? Are there particular situations it is good for (for example, on a hill or near a road or a body of water)?**
   Field borders and windbreaks are used to create habitat for beneficial organisms (birds, pollinators, and the parasites and predators of crop pests), protect water quality, reduce soil erosion, create wind/dust breaks, provide habitat and cover for other wildlife, enhance aesthetic considerations, and even create additional income opportunities if a harvestable crop is used.

3. **What is the major environmental benefit of this practice?**
   Field borders and windbreaks are usually made up of one or more rows of trees or shrubs planted in such a manner as to provide shelter from the wind and to protect soil from erosion. They are commonly planted around the edges of fields on farms.

4. **What are some additional benefits of this practice?**
   If designed properly, windbreaks around a home can reduce the cost of heating and cooling and save energy. Windbreaks are also planted to help keep snow from drifting onto roadways and even yards. Other benefits include providing habitat for wildlife and in some regions the trees are harvested for wood products.

5. **How does this agriculture practice directly impact biodiversity?**
   Field borders and windbreaks provide habitat and cover for beneficial insects and wildlife. Properly managed field borders increase plant diversity and the availability of food sources for animals such as rabbits, wild turkeys, foxes, and many other birds and mammals. The benefits of field borders vary depending on the vegetative composition, the width of the borders, and the surrounding landscape. Field borders that are part of a network of habitats that include forested areas, grasslands, and a variety of crops are likely to attract a wider range of wildlife.

List any new vocabulary associated with the practice.

herbaceous, erosion, sediment, pollutants, beneficial, aesthetic

List all of the resources you used to answer the questions above.

- http://nac.unl.edu/documents/workingtrees/infosheets/WindbreaksOrganicFarmingMarch2014.pdf
- http://nac.unl.edu/practices/windbreaks.htm
- http://www.naturalresources.msstate.edu/wildlife/field-borders.asp

Appendix 3E: Sustainable agriculture practices: answer keys

Biocontrol agents

1. **Describe your group's sustainable agriculture practice.**
   Biological pest control is a method of controlling pests (insects, weeds, plant diseases) using living organisms. It relies on predation, parasitism, herbivory, etc. It can be an important component of Integrated Pest Management (IPM). There are three basic types of biological pest control strategies: importation (sometimes called classical biological control), augmentation, and conservation.

2. **When or why is it used? Are there particular situations it is good for (for example, on a hill or near a road or a body of water)?**
   Importation involves the introduction of a pest's natural enemies to a new area where they do not occur naturally. This is usually done by government authorities.

   Augmentation involves the supplemental release of natural enemies, boosting the naturally occurring population.

   Conservation involves modifying cropping systems to favour the natural enemies, a practice sometimes referred to as habitat manipulation. Providing a suitable habitat, such as a shelterbelt, hedgerow, or beetle bank where beneficial insects can live and reproduce, can help ensure the survival of populations of natural enemies.

   Plants are helped by numerous partners in an ecosystem:
   - Beneficial insects that attack crop insects and mites by chewing them up or sucking out their juices
   - Beneficial parasites, which commandeer pests for habitat or food
   - Disease-causing organisms, including fungi, bacteria, viruses, protozoa, and nematodes that fatally sicken insects or keep them from feeding or reproducing. These organisms also attack weeds.
   - Insects such as ground beetles that eat weed seeds
   - Beneficial fungi and bacteria that inhabit root surfaces, blocking attack by disease organisms

3. **What is the major environmental benefit of this practice?**
   Biological control agents can sometimes be used in place of pesticides, if pest threshold levels are not above any predetermined economic threshold levels (economic loss threshold)

4. **What are some additional benefits of this practice?**
   There is no risk of invertebrate biological control agents polluting the water, soil, or air.

5. **How does this agriculture practice directly impact biodiversity?**
   It is critical that the biological control agents introduced into an agro-ecosystem do not become pests themselves. Considerable testing is required prior to the release of biological control agents to ensure they will not pose a threat to non-target species such as native and agricultural plants. Although in the long term, biological control can be cost effective and can reduce the need for less desirable management practices, not all situations (pests) are suitable for biological control.

List any new vocabulary associated with the practice.

predation, parasitism, herbivory, agro-ecosystem, Integrated Pest Management

List all of the resources you used to answer the questions above.

- http://www.sare.org/Learning-Center/Books/Manage-Insects-on-Your-Farm
- http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex3445

Appendix 3E: Sustainable agriculture practices: answer keys

Biotechnology

1. **Describe your group's sustainable agriculture practice.**
   Agricultural biotechnology is a range of tools, including traditional breeding techniques, that alter living organisms (or parts of organisms) to make or modify products, improve plants or animals, or develop microorganisms for specific agricultural uses.

2. **When or why is it used? Are there particular situations it is good for (for example, on a hill or near a road or a body of water)?**
   Biotechnology can be used to grow plants that are resistant to herbicides and pesticides, removing the need to till for weed control and reducing the amount of pesticides that need to be used. This can help reduce carbon emissions and soil erosion, thereby reducing the impact that these cause.

3. **What is the major environmental benefit of this practice?**
   Scientists are using biotechnology to improve the process by which food is being produced in order to make it more environmentally friendly. For instance, certain biotech crops are designed to be resistant to biotic stresses (pests and diseases). This allows farmers to use fewer chemicals, such as pesticides and herbicides, while still maintaining a healthy, high-yielding crop.

4. **What are some additional benefits of this practice?**
   Additional benefits of biotechnology include:
   - a higher income potential for farmers because these crops have been shown to produce larger yields
   - a decrease in input costs for farmers because they are more easily able to adopt no-till or minimal tillage practices which helps to conserve water from rainfall and irrigation, reduce fuel consumption and therefore greenhouse gas emissions, and limits soil erosion and compaction
   - a decrease in the amount of land used for food production due to higher yield potential
   - increased resistance against abiotic stresses (severe heat or cold, flood or drought, and/or in soils with high levels of salt or metals) because plants have been modified to thrive in these environments
   - improvements in the nutritional quality of crops (e.g. Golden Rice)
   - enhanced nitrogen fixation and increased nutrient uptake and use efficiency therefore decreasing the amount of fertilizer needed to grow that crop

5. **How does this agriculture practice directly impact biodiversity?**
   By allowing farmers to produce more on the same amount of land currently in production, farmers won't require more land, that is more suitable or desperately needed to maintain wildlife habitat, to grow food for a growing global population.

List any new vocabulary associated with the practice.

biotic, abiotic, yield, nitrogen fixation

List all of the resources you used to answer the questions above.

- http://www.foodinsight.org/articles/sustainable-agriculture-can-biotechnology-play-role
- https://www.usda.gov/wps/portal/usda/usdahome?navid=AGRICULTURE&contentid=BiotechnologyFAQs.xml
- http://www.fao.org/fileadmin/templates/soilbiodiversity/Downloadable_files/singh.pdf

Integrated Pest Management

Learning goals

- students will investigate Integrated Pest Management (IPM)
- students will learn what IPM is and how farmers apply IPM strategies to a variety of common farm pest problems

Materials and resources

- copies of Appendix 4A: Descriptions
- copies of Appendix 4B: IPM information sheet
- copies of Appendix 4C: IPM strategy cards
- copies of Appendix 4D: IPM strategies answer key
- copies of Appendix 4E: IPM problem/solution chart
- copies of Appendix 4F: Game cards

Grade 6 and 7

Curriculum expectations

Grade 6: Biodiversity

1.2 Assess the benefits that human societies derive from biodiversity (e.g., thousands of products such as food, clothing, medicine, and building materials come from plants and animals) and the problems that occur when biodiversity is diminished (e.g., monocultures are more vulnerable to pests and diseases)

Grade 7: Interactions in the Environment

1.2 Analyse the costs and benefits of selected strategies for protecting the environment

Hook

Begin with a discussion about common pests. Ask students to name different types of pests that they encounter in everyday life. For example: bees, ants, common cold, flu, rodents, etc. Discuss ways to manage these pests. For example: chemical spray, traps, fences, vaccines, natural remedies (honey lemon tea, vitamins), etc.

Explain that farmers must manage many pests also. They can apply a variety of different strategies to do so.

Visit the Agri-trekking website (www.agscape.ca) and review the IPM section. This can be done individually in a computer lab, or can be teacher led on a projector/ Smartboard.

As a class, define IPM, or create a mind map of IPM ideas (remember: IPM stands for Integrated Pest Management). Pests such as insects, weeds, and disease can have serious negative effects on crops. Farmers can apply integrated pest management strategies to combat pests. First, farmers must scout their farms, looking for potential pest problems and always being aware and observant of the conditions on their farms. IPM strategies include cultural, chemical, and biological methods. Cultural= creating a farm culture that discourages pest problems. Example: rotating crops to break pest cycles, using cover crops, removing sources of pests such as rotten fruit. Chemical=using chemical substances to control pests. Example: pesticides. Biological=Using biological means to control pests. Example: introducing a pest's natural enemies.

Activity: IPM Board Game

1. Working in groups of 3-4, each group labels an IPM farm game card (appendix 4F: Game cards). There are 6 sections on the game page that match with 6 descriptions (appendix 4B: IPM information sheet). Sections on the game page each represent a different area on the farm.
2. Students roll a die, or draw numbers from a hat (numbers 1-6), to determine which section of the farm game page they will start on.
3. Students examine the designated section on the farm game page, as per their rolled/drawn number. Students refer to the IPM information sheet (4B: IPM information sheet) to read about various pest problems in that section of the farm game page. Example: 3 is rolled. 3=Wheat Field on the game page. Refer to IPM information sheet to read "#3 Wheat Field.")
4. Students examine all of the IPM strategy cards. Students choose one strategy to apply to the pest problem in the designated section of the farm game page. Place the IPM strategy card on the appropriate section of the game page. (Example: Students choose an IPM strategy card to apply to the pest problem in their Wheat Field. Place that strategy card on top of the Wheat Field section on the game page).
5. Students fill in the IPM problem/solution chart (appendix 4F: IPM problem/solution chart). Record the number rolled, farm area, pest problem, IPM strategy applied and why?
6. Continue rolling a die or drawing numbers from a hat until all 6 sections of the game page have been investigated and have an IPM strategy card assigned.

Notes:
There are more IPM strategy cards than pest problems. Some pest problems can be solved by applying more than one strategy. However, students must work together to decide which strategy is best and why.

Consolidation: record and discuss

To consolidate, have a class discussion about which strategies were applied in each area and why? Students can share the different strategies that they applied in each section and justify their decisions.

Assessment

- Observe groups as they play the board game. Take anecdotal notes about participation, teamwork, initiative.
- Collect and evaluate IPM Problem/Solution Charts.
- Rubric

Accomodations

- Groups can complete a few or all sections of the farm game page. Class can be split into 6 groups, and each group can be assigned one section of the farm to analyse.
- Students can conduct research to create their own IPM Strategy Cards.

Resources

Ontario IPM Crop:
http://www.omafra.gov.on.ca/IPM/english/index.html
Integrated Pest Management:
http://www.omafra.gov.on.ca/english/crops/insects/ipm.html
Agri-trekking
http://www.agscape.ca/Default.aspx?tabid=80 •

Appendix 4A: Descriptions

Read the following descriptions, then label the Farm Game Page.

Apple Orchard:
Rows and rows of apple trees can be found in an apple orchard. The trees bear sweet, tasty fruit that ranges in colour from green and yellow to red.

Fallow Field:
No crops are planted in a fallow field. Sometimes there may be debris left from the previous crop. For example: corn stalks, or straw.

Farmyard:
The farmyard surrounds a farmer's home. There are often many buildings on a farm, including a house, barns, sheds, storage facilities, and silos. The yard surrounding these buildings often has pathways to drive or walk on, and grassy, treed areas.

Soybean Field:
Soybeans are an oilseed commonly grown in Canada. They start growing as leafy green plants, developing green pods with edible beans inside. Before harvest, the leaves turn yellow/brown and fall off.

Vegetable Greenhouse:
Greenhouses are also known as glasshouses or hothouses. They are built primarily with transparent material like glass or plexi-glass. They are commonly used to grow vegetables. Greenhouses create a climate controlled environment for plants to grow and can extend the growing season.

Wheat Field:
Wheat is a grain commonly grown in Canada. In its early stages of growth, it looks like tall green grass. Seeds begin to develop at the top of the stalk, and the wheat turns golden yellow before harvest.

Appendix 4B: IPM information sheet

1. Apple orchard 	Your apple orchard has become overrun with insects- particularly mite pests. There are many varieties of mites, some are pests, and some are beneficial. Your fruit is being affected by pest mites, and you are concerned about how to control them while still allowing beneficial insects to thrive. Pesticides are often an effective way to control pests, but can also have negative effects on beneficial insects. What IPM strategies can you apply in your orchard to control pests?
2. Fallow field 	Every few years, you often leave a field "empty" or fallow. This means that no crops are planted in it which allows the soil to rest and to restore nutrients. It is very important to maintain and improve soil health. However, this year you scout your fallow field and notice that there are many weeds growing in it. These weeds are attracting unwanted insects, and taking nutrients from the soil. What IPM strategy can you apply to prevent unwanted weeds from growing, while also building soil health in your fallow field?
3. Farmyard 	As a steward of the land, you not only care about maintaining crops, you also want to maintain the land in and around your farm. Your farm is an important part of a bigger ecosystem. There is a creek that runs through the farm, its water must be protected. There are also many beneficial pollinating insects, such as bees, that must be protected. What IPM strategies can you apply to maintain a healthy farmyard ecosystem?
4. Soybean field 	It is late July and you are scouting your soybean field for potential pest problems. You examine 20-30 soybean plants at random and discover hundreds of small, pinhead-sized bugs on the plant leaves. You identify these bugs as aphids, a common soybean pest problem. If there are more than 250 aphids per plant, a pesticide can be applied. However, you also know that ladybugs are natural predators to aphids. What IPM strategy can you apply to combat this pest problem?
5. Vegetable greenhouse 	You are ready to plant tomatoes in your greenhouse. The tomato seedlings are very healthy, and you would like to keep them that way throughout and after the transplanting process. Last year, your tomatoes were infected with thrips, small insects that are a major pest in Ontario greenhouse crops. What IPM strategies can you apply in your greenhouse to ensure that your tomatoes thrive?
6. Wheat field 	For 3 years, you have planted wheat on the same plot of land. This year, you have noticed the quality of the crop is deteriorating, and your crop has become very susceptible to Fusarium, a harmful plant disease. You want to continue growing wheat, but a change must be made to improve the quality of the crop in future years. What IPM strategy can you apply to improve your wheat crop in the future?

Appendix 4C: IPM strategy cards

Plant a buffer zone or strip (an area around your farm yard, field, or orchard) with plant species to attract natural predators and pollinators.	Spray herbicide to kill weeds. Be sure to follow all manufacturer's instructions. Herbicides must be mixed and applied carefully. Wear personal protective equipment such as gloves, goggles, and long sleeves. Store and dispose of unused pesticide properly.	Introduce Smiley mites on your farm. This type of mite is a natural predator that feeds on fruit-eating mites.
Spray pesticide to kill insect pests. Be sure to follow all manufacturer's instructions. Pesticides must be mixed and applied carefully. Wear personal protective equipment such as gloves, goggles, and long sleeves. Store and dispose of unused pesticide properly.	Till land to uproot and kill weeds. Maintain caution, however, as tilling can lead to erosion and runoff problems.	Monitor weather conditions and act proactively. Spray fungicide if weather conditions are favourable for fungal growth.
Create a habitat for ladybugs. Ladybugs not only eat insects, they also enjoy pollen as a food source. Plant various flowers and herbs to attract ladybug populations.	Consult an agronomist. Agronomists can help a farmer to diagnose pest problems by properly identifying specific pests and giving advice about how to treat the problem.	Gather fallen fruit and vegetables from the ground to prevent them from rotting there and attracting insect pests.
Plant a cover crop. Cover crops have many benefits to farmland. They can be planted in fields that would otherwise be left fallow. Cover crops prevent erosion, prevent weeds, and often restore nutrients to the soil.	Keep farm environment clean. Plants need to be raised in sanitary conditions to avoid contamination by disease and pest problems. This is especially true of greenhouse crops.	

Appendix 4D: IPM strategies answer key

1. Apple orchard 	Introduce Smiley mites on your farm. This type of mite is a natural predator that feeds on fruit eating mites. Gather fallen fruit and vegetables from the ground to prevent them from rotting there and attracting insect pests.
2. Fallow field 	Plant a cover crop. Cover crops have many benefits to farmland. They can be planted in fields that would otherwise be left fallow. Cover crops prevent erosion, prevent weeds, and often restore nutrients to the soil. Till land to uproot and kill weeds. Maintain caution, however, as tilling can lead to erosion and runoff problems. Spray herbicide to kill weeds. Be sure to follow all manufacturer's instructions. Herbicides must be mixed and applied carefully. Wear personal protective equipment such as gloves, goggles, and long sleeves. Store and dispose of unused pesticide properly.
3. Farmyard 	Plant a buffer zone or strip (an area around your farm yard, field, or orchard) with plant species to attract natural predators and pollinators. Keep farm environment clean. Plants need to be raised in sanitary conditions to avoid contamination by disease and pest problems. This is especially true of greenhouse crops.
4. Soybean field 	Spray pesticide to kill insect pests. Be sure to follow all manufacturer's instructions. Pesticides must be mixed and applied carefully. Wear personal protective equipment such as gloves, goggles, and long sleeves. Store and dispose of unused pesticide properly. Create a habitat for ladybugs. Ladybugs not only eat insects, they also enjoy pollen as a food source. Plant various flowers and herbs to attract ladybug populations.
5. Vegetable greenhouse 	Keep farm environment clean. Plants need to be raised in sanitary conditions to avoid contamination by disease and pest problems. This is especially true of greenhouse crops.
6. Wheat field 	Consult an agronomist. Agronomists can help a farmer to diagnose pest problems by properly identifying specific pests and giving advice about how to treat the problem. Plant a cover crop. Cover crops have many benefits to farmland. They can be planted in fields that would otherwise be left fallow. Cover crops prevent erosion, prevent weeds, and often restore nutrients to the soil. Monitor weather conditions and act proactively. Spray fungicide if weather conditions are favourable for fungal growth.

Appendix 4E: IPM problem/solution chart

Number rolled	Farm area	Pest problem	Strategy applied	Why?

Appendix 4F: Game cards

Understanding GMOs - Part 1

Grade 8

Learning goals

- students will learn the science of genetic engineering and how it is applied to food production
- students will explore the potential benefits of and the concerns that surround genetic engineering

Materials and resources

- projector in order to show YouTube video clip and/or display Biotechnology Infographics
- access to the internet for research purposes
- copies of Appendix 5A: Genetically modified organisms
- copies of Appendix 5B: Worksheet
- copies of Evaluating Internet Sources: Focus on Agriculture & Food https://magic.piktochart.com/output/7248640-evaluating-internet-sources-focus-on-agriculture-and-food
- copies of Biotechnology Infographics – AgScape: Plant Biotechnology https://magic.piktochart.com/output/2342011-biotechnology and GMO Answers: What is a GMO? https://gmoanswers.com/sites/default/files/What_Is_GMO_Infographic_Oct2015_cover.pdf
- Good in Every Grain GMO background information on page 39

Curriculum expectations

Science & Technology, Grade 8, Understanding Life Systems: Cells

1. Assess the impact of cell biology on individuals, society, and the environment
2. Assess the potential that our understanding of cells and cell processes has for both beneficial and harmful effects on human health and the environment, taking different perspectives into account

Hook

Write GMO on the board. Ask the class, what they think the letters stand for. What things come to mind when they hear someone talking about GMOs? What do they know (or think they know) about GMOs? Create a KWL chart or a mind map to record student's responses.

Activity

Discuss with students where they learned the things they know about GMOs. Friends? Family? The internet? Other forms of media? Introduce the idea of a reliable resource. Who/what do they think would be considered a reliable resource? (Use Evaluating Internet Sources to print or display on board).

It is important that anytime we read or hear something that we critically think about that information and not always take it for face value. If something sounds too good to be true or not quite right, it probably is.

Show students the video clip The Life of a Seed – Jake, a GMO Seed (2:56)
https://youtu.be/L9tlirsBNg4

Have students read Appendix 5A: Genetically modified organisms and visit the websites listed. Students answer the associated questions provided in Appendix 5B: Worksheet. Using the information students gathered, complete the KWL chart as a class and take up the handout together.

Assessment

Assessment for learning – Complete a diagnostic assessment of student's familiarity of GMOs and agriculture in the activity introduction.

Assessment as learning – Evaluate student answers to the supplied questions for comprehension, knowledge application, and critical thinking.

Assessment of learning – Evaluate students participation and contributions to the KWL chart for their ability to demonstrate an understanding of genetic engineering. •

Background information

What do you want to know about GMOs?

What does genetically modified really mean?

Genetically modified (GM) crops are developed with genetic engineering. Just like traditional plant breeders do, scientists can transfer individual specific traits from one plant to another, or remove an existing trait altogether; the difference is genetic modification is much more precise.

Why do farmers grow genetically modified crops?

Farmers are not forced to grow any kind of seed by big companies – they choose what seeds to grow based on what they know grows best on their land, in their local climate, and according to consumer demand.

There are many reasons why farmers would choose to use GM crops:
- Easier to control diseases, weeds, and pests with less chemical application
- Easier to adopt no-till farming, which saves time, equipment usage, and carbon emissions
- Higher quality crops with higher yields which equals a higher farm income

Genetically modified foods are tested, and they are safe!

Before it becomes commercially available, the typical genetically modified crop is subject to an average of 13 years of study, at a cost of $136M (USD)! GM foods do not cause allergies, cancer, infertility, ADHD, autism, or any other diseases or conditions. No person or animal has ever died or been made ill by consuming genetically modified foods. Over one trillion meals containing GM foods have been consumed to date. GM crops are also safe for the environment:
- Increased yield on less land makes it easier to protect ecosystems
- Fewer pesticide applications
- Reduced tillage means less tractor fuel consumption, emissions, and erosion

The World Health Organization, Health Canada, the U.S. Food and Drug Administration, and dozens of other international health organizations have all concluded that GM crops are as safe as comparable, non-GM foods.

What genetically engineered/ genetically modified crops are currently grown in Canada?

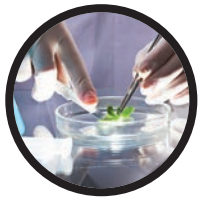
There are four GM crops that are currently grown in Canada: corn, soybean, canola, and sugarbeet. In the rest of North America, farmers also grow genetically modified cotton, alfalfa, papaya, and squash. Genetically modified potatoes and apples also exist, but they aren't available to consumers yet, as supply is still limited.

History of genetic modification in crops

10,000 years ago
Humans begin crop domestication using selective breeding. •

1700s
Farmers and scientists begin cross-breeding plants within a species. •

1940s and 1950s
Breeders and researchers seek out additional means to introduce genetic variation into the gene pool of plants. •



1980s
Researchers develop the more precise and controllable methods of genetic engineering to create plants with desirable traits. •

1990s
The first GMOs are introduced to the marketplace. •

Appendix 5A: Genetically modified organisms

Genetically Modified Organisms

The acronym GMO stands for Genetically Modified Organism. It refers to the changing of the genetic makeup of a plant or animal. Genetic modification has been done for centuries, using techniques like conventional breeding, which takes a long time and does not always produce the desired results. Today's technology is much more accurate. Therefore, a more accurate term for the crops created with today's technologies would be Genetically Engineered (GE).[1]

Genetic Engineering

Genetic engineering (GE) isn't a thing but a process. An organism is considered to be GE if it was genetically modified using techniques that:

- transfer a gene from one organism to another
- remove a gene from an organism
- silence or "turn-off" a gene in an organism[2]

With genetic engineering, scientists can change the traits of plants and animals by inserting DNA pieces, whole genes, or long stretches of DNA segments from many different organisms.

Genetically Engineered Crops

Plant genetic engineering methods were developed over 30 years ago. Since then, genetically engineered crops have become commercially available and widely adopted. Four genetically engineered crops account for 99% of worldwide genetically engineered crops grown.[3]

- soybeans (50%)
- corn (30%)
- cotton(14%)
- canola (5%)[4]

Since 1994, about 85 GE foods have been approved for sale in Canada. This includes food grown in Canada and food that has been imported from other countries. The four main GE crops that are currently grown in Canada include:

- canola
- soybeans
- corn
- sugar beet[5]

In 2016, the Innate® Potato and Arctic® Apple were also approved for production in Canada.

Other GM foods that are grown/raised around the world include:

- cotton
- papaya
- alfalfa
- squash
- potato
- tomato
- apples

Commonly known examples of GE crops are Bt corn and cotton. These plants have been modified to incorporate Bacillus thuringiensis (Bt) genes. Some types of the bacterium Bacillus contain protein crystals that are toxic to larvae of insects such as mosquito, black flies, and potato beetles. The crystals do not become toxic until they enter the gut of the insect larvae. Then the toxin becomes activated and destroys the insect intestine. The protein crystals are known as Bt toxin, after Bacillus thuringiensis. Because the toxin is not harmful to humans, the genes for Bt toxin have been incorporated through genetic engineering techniques into these plants to increase their resistance to insect attack.[6]

Concerns

Concerns around genetically engineered food include risk of increased allergies in people, contamination of natural vegetation, increased use of pesticides, increased beneficial insect (butterfly, bee, ladybug, etc.) deaths, and increases in food prices.

Food Safety

Health Canada assesses the safety of all genetically modified and other novel foods proposed for sale in Canada. Companies are required to submit detailed scientific data for review and approval by Health Canada. Novel foods are foods resulting from a process not previously used for food, products that do not have a history of use as a food, and foods that have been modified by genetic manipulation, genetically engineered foods, or biotechnology-derived foods. The World Health Organization, the American Medical Association, the National Academy of Sciences, and the American Association for the Advancement of Science have all declared that there is no good evidence GMOs are unsafe. Hundreds of studies back up that conclusion.[8]

Appendix 5A: Genetically modified organisms

Sustainability

Scientists research and develop genetically engineered crops to address a variety of reasons that fall under the three pillars of sustainability: environmental, economical, and/or social.

- Herbicide-resistant corn and soybeans can be sprayed with herbicides that are more effective, less toxic, and cheaper than the alternatives.
- Crops can be modified to protect the plant against viruses or fungi.
- GE crops can lower the costs of production by reducing inputs (machinery, fuel, and chemical pesticides) for the farmer.
- Crop yields are often higher due to more effective pest control. Higher yields mean farmers are able to produce more food on smaller amounts of land. It also means a higher economic return for the farmer.
- Growing herbicide-resistant crops means farmers do not have to till their fields to reduce weeds. This helps to maintain soil structure and reduces the chances of erosion and run-off that has the potential to pollute water systems,
- Health benefits result from reduced pesticide exposure for farmers and rural labourers and lower pesticide residues for consumers.

The Future

In Canada, there are a variety of options for food production (organic, conventional, genetically engineered, etc). Consumers have many options in the grocery store, or at the local farmers' market. The testing and regulation of all of these food products means that Canadians have an abundance of safe food. It is important to think critically about the information you hear/read/see about your food. Is your choice an informed choice?

Websites

Biotechnology Infographics:
- https://magic.piktochart.com/output/2342011-biotechnology

GMO Answers: What is a GMO?
- (https://gmoanswers.com/sites/default/files/What_Is_GMO_Infographic_Oct2015_cover.pdf)
- https://gmoanswers.com/sites/default/files/video/splash/Genetic_Traits_post%20card.pdf

GMO Answers www.gmoanswers.com
- Top 10 Consumer Questions About GMOs, Answered

Best Food Facts www.bestfoodfacts.org
- GMOs
- In Your Grocery Aisle: Non-GMO Foods
- What Foods are Genetically Modified?
- Could GMOs Be the Cause of an Allergic Reaction?

EatRight Ontario –
Understanding Genetically Modified Foods
www.eatrightontario.ca

Health Canada –
The Regulation of Genetically Modified Food
www.hc-sc.gc.ca

World Health Organization – Frequently Asked Questions on Genetically Modified Foods
www.who.int

Genetic Literacy Project
www.geneticliteracyproject.com

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1 https://www.bestfoodfacts.org/what-are-genetically-modified-foods-a-basic-explanation-of-a-hefty-topic/
2 http://www.who.int/foodsafety/areas_work/food-technology/faq-genetically-modified-food/en/
3 http://www.fao.org/docrep/015/i2490e/i2490e04d.pdf
4 Bradshaw, John E. Plant Breeding: Past, Present and Future. Springer International Publishing, 2016. Found online https://books.google.ca/books?id=8OO9CwAAQBAJ&lpg=PR3&dq=soybeans%20(50%25)%2C%20corn%20(30%25)%2C%20cotton(14%25)%20and%20canola%20(5%25)&pg=PR4#v=onepage&q=soybeans%20(50%25),%20corn%20(30%25),%20cotton(14%25)%20and%20canola%20(5%25)&f=false
5 http://www.eatrightontario.ca/en/Articles/Food-technology/biotechnology/novel-foods/understanding-Genetically-Modified-Foods.aspx#.V3Ps4LgrK00
6 Graham, Linda E., et al. Plant Biology 2nd Edition. Pearson Education, Inc., 2006
7 http://www.hc-sc.gc.ca/fn-an/gmf-agm/index-eng.php
8 http://www.slate.com/articles/health_and_science/science/2015/07/are_gmos_safe_yes_the_case_against_them_is_full_of_fraud_lies_and_errors.html

Appendix 5B: Worksheet

Using the Genetically Modified Organisms reading and information from the websites provided, answer the following questions.

Definitions

Use this space to record the definitions of any words you did not recognize from the GMO Information page and websites you visit.

1. **Describe the process of genetic engineering.**

2. **What four crops amount for the majority of genetically engineered crops grown today?**

3. **Who approves the sale of genetically engineered crops in Canada?**

4. **What foods have been genetically engineered?**

Appendix 5B: Worksheet, continued

Using the Genetically Modified Organisms reading and information from the websites provided, answer the following questions.

Definitions
Use this space to record the definitions of any words you did not recognize from the GMO Information page and websites you visit.

5. **What does Bt stand for?**

6. **What are some of the environmental benefits of farmers growing genetically engineered crops? What are some of the concerns?**

7. **How can society benefit from the production of genetically engineered crops?**

8. **What potential risks have been associated with the production of genetically engineered crops? Does the current research support these concerns?**

Understanding GMOs - Part 2

Learning goals

- students will gain an understanding of the possibilities that Genetically Modified Organisms offer
- students will apply their knowledge of the science behind Genetically Modified Organisms to assess the impact they may have on/role they play in today's society, the environment, and the economy

Materials and resources

- access to the internet for research purposes
- copies of, or electronic access to the Infographic on GMO Traits https://gmoanswers.com/sites/default/files/video/splash/Genetic_Traits_post%20card.pdf
- copies of Appendix 6A: Graphic organizer
- copies of Appendix 6B: Marketing campaign rubric

Grade 8

Curriculum expectations

Science & Technology, Grade 8, Understanding Life Systems: Cells

1. Assess the impact of cell biology on individuals, society, and the environment

1.2 Assess the potential that our understanding of cells and cell processes has for both beneficial and harmful effects on human health and the environment, taking different perspectives into account

Language Arts, Grade 8, Oral Communication

2. Use speaking skills and strategies appropriately to communicate with different audiences for a variety of purpose

Media Literacy

3. Create a variety of media texts for different purposes and audiences, using appropriate forms, conventions, and techniques.

Hook

Inform students that they are going to brainstorm some issues around food. Ask them to think about food issues which are experienced locally and globally. Prompt as necessary (Does everyone have access to healthy food? Is food affordable? Is food wasted? What impact does food waste have on the environment? How does food production impact the environment? How does the weather impact growing crops?). As a class, you should arrive at a list of issues which includes:

- Food Waste
- Food Affordability
- Nutrition
- Weather/geographic challenges
- Sustainability (economic, environmental, or social)

Activity - period 1

Direct students' attention to the list of issues. Ask them for ideas on how the issues can be addressed (composting, environmentally responsible food production, selling "ugly vegetables" at reduced prices).

Remind students of the GMO lesson Part 1 which they recently completed. Genetic engineering is one tool that has the potential to help alleviate a variety of problems that the world currently faces (examples: increasing the amount of a nutrient available in a certain staple food source or to create plants that can grow under stressful conditions such as drought).

As students discovered in the previous lesson, many genetically engineered crops on the market are designed to address challenges which are faced during growing (e.g. herbicide resistant corn, soybeans with a 'built-in' insecticide, etc). However, there are now also food products which are engineered with the end-consumer in mind. The Arctic® apple is one example of that – and it was developed right here in Canada!

Break students into small groups or pairs. Direct student attention to the Infographic on GMO traits. Inform students that they will have to complete the graphic organizer to identify a GMO trait, the issue it addresses, and the audience it most benefits.

As an example, discuss drought resistant corn and/or Arctic® apples with the students, using the information in the chart. Have students complete one to two other examples and assess their answers for understanding.

In groups, tell students that they are going to become plant geneticists. Their assignment will be to genetically engineer a crop in order to improve it. Their improvement must address one of the following issues:

- Food waste
- Food affordability
- Nutrition
- Weather/geographic challenges

*Students must also highlight how their crop impacts sustainability (concept should have an economic, environmental, or social impact).

Students can use the bottom row of the graphic organizer to identify the GMO trait, the issue it addresses, the audience it most benefits, and how it impacts sustainability.

Activity - period 2

Based on their GMO idea, they will develop a name and a marketing campaign that shares the benefits of their crop with the appropriate audience (for an example of a marketing campaign, see the website for the Arctic® apple: http://www.arcticapples.com/). Students may choose the type of media (video, blog post, web page, poster, slide-show) they wish to use in their presentations of their genetically engineered crop and associated marketing campaign. Remind students that their improvement must look to solve a current issue e.g. food waste. As a class, go over the rubric so students gain a clear understanding of what they will be evaluated on.

Provide students with time to research other novel foods that have been developed through genetic modification – either already on the market and/or are in the research and development stage.

Examples include herbicide resistance soybeans, drought resistant corn, golden rice, Innate® potato, Flavr Savr™ tomato. Once groups have had time to brainstorm and decide on what they will create, provide classroom time for them to develop their media on the benefits of their novel food.

Students should present their media to the class and provide a written summary of why they created their genetically modified organism for assessment.

Assessment

Assessment for learning – Observe students as they work together to develop their marketing campaigns. Adjust classroom instruction and scaffolding according to their understanding of the task and application of prior knowledge to produce their marketing campaign.

Assessment of learning – Evaluate student presentations for application of knowledge and understanding of genetically engineered crops and the impact they have on the economy, the environment, and society. •

Appendix 6A: Graphic organizer

Crop	GMO trait	What issue(s) does the GMO trait address?	Who (which audience) does this GMO trait benefit?	How does the GMO trait impact sustainability (environment, economy, social)?
Example: Corn	Drought resistance	• Corn dying or doing poorly during drought • Farmers losing money because of lost crops	Farmers	• less water used for irrigation • farmers have successful crops ($)
Example: Arctic® apple	Non-browning	• food waste from fruit being thrown out	Consumers	• less food waste = less money wasted • less food waste is better for the environment
Choose another crop from the infographic				
Choose another crop from the infographic				
Use this space to plan your GMO project				

Appendix 6B: Marketing campaign rubic

Genetically engineered crop: _____

Group: _____ _____

_____ _____

Category	Level 1	Level 2	Level 3	Level 4
Thinking				
Use of planning skills (e.g., generating ideas, gathering information, focusing research, organizing information)	uses planning skills with limited effectiveness	uses planning skills with some effectiveness	uses planning skills with considerable effectiveness	uses planning skills with a high degree of effectiveness
Application				
Application of knowledge and skills (e.g., concepts, strategies, processes) in familiar contexts	applies knowledge and skills in familiar contexts with limited effectiveness	applies knowledge and skills in familiar contexts with some effectiveness	applies knowledge and skills in familiar contexts with considerable effectiveness	applies knowledge and skills in familiar contexts with a high degree of effectiveness
Knowledge				
Expression and organization of ideas and information (e.g., clear expression, logical organization) in oral, visual, and written forms, including media forms	expresses and organizes ideas and information with limited effectiveness	expresses and organizes ideas and information with some effectiveness	expresses and organizes ideas and information with considerable effectiveness	expresses and organizes ideas and information with a high degree of effectiveness
Understanding				
Knowledge of content (e.g., forms of text; strategies associated with reading, writing, speaking, and listening; elements of style; terminology; conventions)	demonstrates limited knowledge of content	demonstrates some knowledge of content	demonstrates considerable knowledge of content	demonstrates thorough knowledge of content

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* formerly known as Ontario-Agri-Food Education Inc.

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