This master curriculum includes lessons for 7th Grade. Seventh graders will become away of the future successes and stresses on our world. Technology can make things very easy, however, our population is putting a lot of stress on farmers to do more than they ever have before.

Educators may find this curriculum useful to use prior to attending the Borlaug farms. The Norman Borlaug Heritage Foundation provides educational opportunities for schools to attend. Whether attending a tour or participating in Inspire Days, children will become aware of Norman Borlaug's work and his everlasting impact on the current day.

Want to learn more about Norman Borlaug or the Norman Borlaug Heritage Foundation? VISIT OR CALL!

Contact Chamber of Commerce for more information
101 2nd Ave. SW, Cresco, IA 52136
Email: Jason@howard-county.com
Call: 563-547-3434

Borlaug Farms Addresses
Birthplace farm: 20399 Timber Ave Cresco, IA 52136
Boyhood Farm: 19518 200th St. Cresco, IA 52136

LESSONS FROM BORLAUG

Curriculum - Grades K-8

7th Grade

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Modifications have been made to the original Iowa Agriculture Literacy Foundation lesson plan to meet the goals of the Norman Borlaug Heritage Foundation.
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Journey 2050: Sustainable Agriculture

Grade: 7th grade
Time: 90 minutes

Purpose:

- Students will explore and understand the core question, "How will we sustainable feed nearly 10 billion people by the year 2050?" and begin to think about the challenges and opportunities presented by this question.
- Students will explore factors such as expected population growth, food waste, and various positive and negative factors impacting sustainable agriculture.
- Students will understand how Norman Borlaug contributed to the evolution of agriculture.

Materials:

- Introduction to Sustainable Agriculture PowerPoint
- Journey 2050 Introduction video
- Sustainability Farming Game: Level 1 Demo
  - Download App
  - Create Free Teacher Account to track student progress and print reports on *Sustainability Farming Game*.
- Computer or tablet device for each student
- Optional Student Handout: World Population Growth

Vocabulary:

- Sustainable: meaning the economic, social and environmental needs of the present without compromising the needs of the future
- Sustainable agriculture: using best farming practices to grow the most food and fiber on the land for long term economic, social, and environmental success.

Spark Curiosity By…

1. Project the *Introduction to Sustainable Agriculture* PowerPoint. Begin with slide 2 and ask your students, "How much is 1 million?" Allow students to offer their answers as they begin visualizing the quantity and value of 1 million. Then ask, "If I spent $1,000 every day, how long would it take me to spend 1 million dollars?" *(2.7 years, or 1,000 days)*
2. Once students seem to grasp the value of 1 million, move to slide 3 and ask, "If I spend $1,000 every day, how many days would it take to spend 1 *billion* dollars?" *(1,000,000 days or 2,740 years)*
3. Now that your students are beginning to visualize the sheer quantity of 1 billion ask, "What is the current world population right now?" *(over 7 billion).* Follow up by

asking, “Do you know what the world population is projected to be in the year 2050?” *(nearly 10 billion).*

- Optional: If time allows, use one of the following activities to help students further visualize and understand the growth trends in world population:
    1. Show the World Population video/animation (5:46 min)
    2. Show the 7 Billion: How Did We Get So Big So Fast? Video (2:33 min)
    3. Have students complete the attached student data log*: World Population Growth*.
    4. Review the student data logs and compare their responses with the data found on the interactive Our World in Data website.

Agricultural Background

It is estimated that by 2050, Earth will be crowded with 2 billion more people. They’re all going to need water, homes, jobs and medicines. But most importantly, how are they all going to be fed?

This growing population will eat the equivalent of all the food grown in the last 500 years put together.[1] That’s over 60 percent more than we grow today[2] or 1 billion tons more cereal[3] and 50 percent[4] more freshwater every year.

This additional food has to be grown on less land and in a way that protects the environment and animals, while also ensuring there’s enough food for generations to come. This is called ***sustainability***, and it can only be achieved by improving its three interconnected elements: economy, society and the environment.

The **economic** component of sustainability is about earning money—creating jobs and incomes to support the national and local community. The **social** element encompasses things like food, education, medical care and infrastructure, including the roads used to transport food from the farm to your plate. And finally, there are **environmental** needs to consider. Soil quality needs to be maintained, habitats need protection, water must be conserved, and we need to protect our atmosphere by keeping greenhouse gas emissions to a minimum.

Imagine a barrel with parts made equally from the three elements of sustainability. You can only fill this barrel to the level of its lowest piece. If the environment is the lowest piece of the barrel, it limits sustainability. This element must be improved to make the world’s sustainability better.

World leaders in the United Nations have committed to 17 Global Goals[5] in order to achieve extraordinary things such as: end extreme poverty, fight inequality and injustice, and fix climate change. Sustainable agriculture is key to meeting these goals and creating a stronger 2050 for our people and our planet.

The planting of a single seed creates a ripple effect that helps the farmer's family, their community, their country and ultimately, the world. The more farmers grow and sell, the more they have to spend on seeds, machinery and fertilizer to produce even more food and fiber. Income that's spent locally is invested in the community, providing education, medical care and infrastructure and protecting the environment. If farmers around the world start a ripple, it could improve global economies and help billions rise from poverty. Different farmers raise different crops and animals according to their local soil, climate, technology and markets. But they all have one thing in common. They love agriculture.

On our journey to the year 2050, we're going to be spending time with farm families around the world who are growing food sustainably. First, you'll meet the Madges. They're a three-generation farming family from Central Alberta, Canada. Then we'll fly across the Atlantic to meet the Oloos. They own a small farm in Kenya, East Africa. Finally, we'll visit the Singhs, who live in India where multiple generations farm together. These families and agricultural experts will be giving you advice on what we call *best management practices*, which will allow us to grow more with less, protect the environment, build stronger communities and feed the growing population of our planet. It's a long journey ahead, but even the longest journey starts with a single step forward. Take it now and join us on our Journey to 2050.

Lesson

Activity 1: Introduction to Sustainable Agriculture

Journey 2050

- Slide 4: Play the Journey 2050 Introduction video, (3:51 min). Prepare students for the video by asking them to discover three things: 1) Why is 2050 a significant year? 2) What is the sustainability barrel? and 3) What is the ripple effect? (Background and discussion prompts are outlined in the steps below and in the PowerPoint notes.)

Why 2050?

- Slides 5–6: Ask students, "If it is [insert current year] right now, how many years until we reach the year 2050?" Then ask, "How old will you be in the year 2050?" Explain that scientists and world leaders have identified 2050 as a key moment in time when the world's population will be nearly 10 billion—that is over 2 billion more than today. Point out to students that they will be adults! They will have an influence on the decisions that impact everything from what is taught in schools to what they buy at the grocery store.
- Slide 7: Ask students to identify some items we will need more of in order to provide for 2 billion additional people on Earth. Brainstorm and list several items on the board. Use questioning to help students identify items such as water, homes, jobs, medicines, food, etc.

Remind students of all the products they get from agriculture (food, fiber, fuel, timber, medicines and by-products that are used in manufacturing or end up in items such as lipstick, paint and batteries). Explain that farmers and many other agricultural professionals are responsible for producing each of these daily necessities.

- Slide 8: Explain that in order to feed 2 billion additional people, it is predicted that farmers will need to produce 60 to 70 percent more food than we currently produce today on the same amount of land or even less.[9] Ask, "Will this goal of sustainable agriculture be easy to accomplish? Will the pressure on farmers increase, decrease or stay the same?" As students are thinking and offering answers, draw their attention back to the *Interest Approach* at the beginning of the lesson, picturing an additional 2 billion people that agriculture must feed. Students should conclude that farmers will have increased pressure to produce more food and fiber for a growing population.
    1. Before moving on, formatively assess students to ensure they understand the term *sustainability*.

What is the sustainability barrel?

- Slides 9–10: Tomorrow's farmer will have to feed even more people. It is estimated that by 2050, our growing population will require the equivalent of all the food grown in the last 500 years.[10] That's a lot of food! Ask, "Do farmers have limitations to how much they can produce?" As students think about the answer to this question, give an example of a corn farmer with 100 acres. Can this farmer take their same land, soil, corn seeds, water and tractors and double their crop from one year to the next simply because there is a demand for more corn? No, there are limitations if a farmer wants to produce agricultural goods in a sustainable manner.
- Slide 11: Ask students to picture a wooden barrel made up of several wooden slats. Explain that we are going to call it a *sustainability barrel*. Each wooden slat of the barrel represents a factor influencing sustainable agricultural production. Each factor can be placed into one of three challenges to sustainable agriculture—producing sustainably while maintaining economic, social and environmental systems. For example, in order to be able to grow enough food to feed the world sustainably, we have to make sure that farmers are able to earn a profit, that communities have access to education and healthcare, and that the soil stays healthy and we don't destroy habitats.
- Slide 12: Ask students, "What are some examples of limiting factors?" *(water, available land, soil health, climate, economy, education, etc.)* Ask students to explain how each factor influences our ability to produce our food. Remind students that we must

continually improve the weakest part of our sustainability, whether it is education or soil health. They all impact our ability to feed the world. A community or program is only as successful as its least developed sustainability factor.

What is the Ripple Effect?

- Slide 14: Ask, "Can a single drop of water impact an entire body of water?" *(Yes, it creates a ripple.)*
- Slides 15–16: Use these slides to illustrate how sustainable practices in agriculture can create a positive ripple effect.

Activity 2: *Sustainability Farming Game* Level 1 Demo

- Slides 17–18: Inform students that they are about to embark on a "Journey to 2050." There are many challenges that lie ahead, but they will focus on tackling the following for now: plant nutrients, water, economies, geography, land use and careers. Inform students that they will be using a game to farm virtually in different parts of the world. Along the way they will learn more about where our food, fiber (clothing and shelter) and fuel comes from and how farmers can sustainably produce these items for a growing population.
- Introduce the *Sustainability Farming Game*. Inform students that they will experience the lives of three actual farm families in Kenya, India and Canada. As they interact with each family, they should pay attention to the farming practices they choose, the technology they use and the community investments they make. Remember, agriculture is the foundation for life, and its success creates ripples locally and globally that will determine whether we meet the challenge of feeding the world.
- Write on the board a reminder of what the sustainability barrel includes:
    1. Social: food, education, infrastructure, healthcare
    2. Economy: profits, income, jobs, community
    3. Environment: habitats, soil health, water, greenhouse gases
- Open the *Sustainability Farming Game* Level 1 Demo on each student's computer or device.
- Explain that the sustainability barrel will determine their score, and help students understand the significance of balancing the social, economic and environmental pillars of the sustainability barrel throughout the game (e.g., investments in soil health produce better crops, earning more money; investments in roads allow products and people to travel easier, improving access to markets and labor).
- Explain to the students that it is very important that they listen to you as they will have to stop and wait every time they finish a level. Every student must start and end the game (roughly) at the same time to ensure your class time flows smoothly.
    4. Note to teacher: The first level is a demonstration of the game designed to teach students how to play. Students will be in Kenya and will play one round, which will take about five minutes. The game stops after they have completed each teaching moment (such as how to plant, water and harvest).

- Once time is up, the game will pause on the Results page. When all students have reached the Results page, instruct them to press "continue," and help them understand what the Ripple Effects screen shows. They will then move on to the Surplus Contribution Opportunities page. Encourage them to invest in their limiting factors (there will be a red arrow under the limiting factor). If the investment matches that factor, there will be a red arrow on the left, beside the investment name. Once their score stops going up they can press "continue" and finish with the demo level.
- Slides 19–20: Once students have completed the game, use the following questions to help students synthesize what they have learned:
    5. After growing your first crop, did you invest some of your money to purchase additional land? Why or why not?
    6. What was the limiting factor in your sustainability barrel? What did this mean? *(Answers will vary)*
    7. What were some of the ripple effects of your farming choices?

Activity 3: Do People Waste Food? (Option to teach as an independent lesson another day)

- Slide 21–22: It's important for students to understand why resources are important. Take some time to help your students understand the risks of food security as we strive to feed a growing population. There are food security risks in all parts of the world, and there is one prominent threat that we all contribute to—food waste. Unfortunately, about one-third[11] of our current global food supply is wasted. There are an estimated 1.4 billion[12] people living in extreme poverty, and about 870 million[13] people that are hungry, malnourished and food insecure (have difficulty acquiring food). In developed countries, food is thrown out and overconsumed, and in developing countries, food is lost to unreliable storage and transportation. Hunger is often caused by food waste and inequality of distribution, not scarcity. Ask your students this question, "How often do you throw food out, and what else could you do with that uneaten food?" Discuss ways students can reduce their personal food waste, such as making or ordering only what you NEED to eat, composting, saving food for leftovers to eat later, etc. Sustainable agriculture is critical in the global effort to eradicate hunger and poverty, and reducing waste can improve the sustainability of agriculture.
- Slide 23: Play the video clip The Ugly Carrot *(*0:54 min). Then ask the following questions: Have you ever seen a carrot or other similarly misshaped produce item at a grocery store? If you did see this carrot (or another similarly misshaped produce item), would you buy it? Why or why not? Would you pay the same price as if it was perfectly shaped?
- Slide 24: Ask students, "How does food waste impact sustainability and hunger?" Students will likely associate food waste with hunger and recognize the moral, economic and social implications. Provide guiding questions to help students also recognize the impact food waste has on our environment and natural resources. Ask, "Besides the food itself, what else is wasted?"

- Slide 25 (Optional): On the board, brainstorm potential challenges that could arise when the people of a country are hungry *(malnutrition and health care risks, violence and thievery, vulnerability to markets and storage, decline in education attendance, political distress/corruption, decline in infrastructure, decline in investment in technology and innovation and risk of unsustainable practices across industries).* On the board, brainstorm potential challenges that could arise when a country has an overabundance of food *(quality food is thrown out, obesity, increasing calorie-intake (eating more per meal)*, rise in Western-style diets, desire for food from other places *(increased markets, infrastructure)*, shift to more urban population which can result in disconnect with life on the farm, consumer demands and perspectives influence food value chain *(genetically modified foods, organic, free range vs barn raised animals, herbicides, pesticides, food labels, country of origin traceability, animal care, food preparation, sanitation, packaging, preservatives, etc.).*
- Optional questions for higher grades: How can governments be involved in food security? *(Governments can provide regulations, policies, education programs, low interest loans, investment in research and development, and share practices with other countries.)* What happens when there is corruption in government or a huge gap between the rich and poor?

Wrap-Up:

Review and summarize the following key concepts (Slide 26):

- Our population is growing. By 2050 it is expected that our world will grow from the current 7 billion people to nearly 10 billion people.
- Sustainable agriculture is the practice of producing our food, fiber and fuel in a way that is profitable to the farmer, supports a healthy quality of life and protects our natural resources (land, air and water).
- Many factors can limit our ability to produce food for a growing population. These limiting factors are depicted in the sustainability barrel.
- Using sustainable agricultural practices can improve our society through the ripple effect.
- Over one-third of our food is wasted in both developing and developed countries.
- Hunger is often caused by food waste and inequality of distribution, not scarcity.
- Food waste decreases sustainability due to the inefficient use of natural resources, such as arable land, soil nutrients, water and energy.
- Food waste can negatively affect our quality of life and create undesirable outcomes in a country.

Connection to Norman Borlaug

While Norman Borlaug studied across the world, he was exposed to life without food. In fact, many countries that are in power today were once starving nations.

1. Ask students "why do some countries experience starvation while others are thriving?" Some answers may include…
    a. Little resources (seed, money, equipment)
    b. Harsh weather
    c. Limited water
    d. Time/energy allocated toward other necessities
2. Have students come up to the white board and write down their thoughts after they share their ideas with the class.

For these reasons, the struggling countries such as Mexico, India, and Pakistan were importing nearly all of their seed. Norman recognized the issue and began to evaluate possible solutions for each country by starting in Mexico.

3. Students should open their computers and begin to research an answer to this question – *What 3 main qualities (starting with D) did Norman Borlaug develop while breeding wheat?*
    a. Dwarf size
    b. Disease resistant
    c. Drought resistant

Producing high yielding wheat dramatically changed the scope of agriculture. Norman Borlaug is now noted as the Father of the Green Revolution. Since the time of his research, many questions have been raised about conventional agriculture. However, the human population keeps climbing, pressuring agriculturalists to grow more. We are now in search of more sustainable means for growing food and fiber for the growing population.

Sources/Credits

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2. Sustainable Development Network Solutions (2013). Solutions for Sustainable Agriculture and Food Systems http://unsdsn.org/mwg-internal/de5fs23hu73ds/progress?id=EHV3NQH3C4-PP-EivDwXY4i2HzIjIWty8lBnkNioco0,
3. http://www.fao.org/mwg-internal/de5fs23hu73ds/progress?id=HXecPI0p3XpJtFbAsjLRZd3G4ZjPgUW5N3PqtZYwwio
4. http://waterfortheworld.net/index.php?id=12
5. http://www.un.org/sustainabledevelopment/sustainable-development-goals/
6. Sustainable Development Network Solutions (2013). Solutions for Sustainable Agriculture and Food Systems http://unsdsn.org/mwg-

internal/de5fs23hu73ds/progress?id=EHV3NQH3C4-PP-EivDwXY4i2HzIjIWty8lBnkNioco0,
7. http://www.un.org/en/globalissues/briefingpapers/population/vitalstats.shtml
8. http://www.worldfooddayusa.org/food_waste_the_facts, and http://www.un.org/waterforlifedecade/food_security.shtml
9. Sustainable Development Network Solutions (2013). Solutions for Sustainable Agriculture and Food Systems http://unsdsn.org/mwg-internal/de5fs23hu73ds/progress?id=EHV3NQH3C4-PP-EivDwXY4i2HzIjIWty8lBnkNioco0,
10. http://www.economist.com/node/18200702
11. http://www.worldfooddayusa.org/food_waste_the_facts
12. http://www.un.org/en/globalissues/briefingpapers/population/vitalstats.shtml
13. Sustainable Development Network Solutions (2013). Solutions for Sustainable Agriculture and Food Systems http://unsdsn.org/mwg-internal/de5fs23hu73ds/progress?id=EHV3NQH3C4-PP-EivDwXY4i2HzIjIWty8lBnkNioco0

National Agriculture Literacy Outcomes

Agriculture and the Environment

- Describe benefits and challenges of using conservation practices for natural resources (e.g., soil, water, and forests), in agricultural systems which impact water, air, and soil quality (T1.6-8.b)
- Discover how natural resources are used and conserved in agriculture (e.g., soil conservation, water conservation, water quality, and air quality) (T1.6-8.c)
- Discuss the comparative environmental pros and cons of populations relying on their local and regional resources versus tapping into a global marketplace (T1.6-8.e)
- Recognize the factors of an agricultural system which determine its sustainability (T1.6-8.h)

Education Content Standards

CAREER

Natural Resource Systems Career Pathway

- NRS.02.02
- NRS.03.01

Environmental Service Systems Career Pathway

- ESS.02.03

ECONOMICS

Standard 15: Economic Growth
Standard 1: Scarcity
Standard 2: Decision Making

HISTORY

NCSS 3: People, Places, and Environmental: Objective 7
NCSS 7: Production, Distribution, and Consumption: Objective 1

NCSS 8: Science, Technology, and Society: Objective 2,4

SCIENCE

MS-ESS3: Earth and Human Activity

Common Core Connections

Reading: Anchor Standards

- CCSS.ELA-LITERACY.CCRA.R.4
- CCSS.ELA-LITERACY.CCRA.R.6
- CCSS.ELA-LITERACY.CCRA.R.8

Speaking and Listening: Anchor Standards

- CCSS.ELA-LITERACY.CCRA.SL.1
- CCSS.ELA-LITERACY.CCRA.SL.5

Students now understand the complexities that surround a growing population and modern stressors on agriculture. Moving forward, agriculturalists will be thinking critically about how they produce crops. Next, students will learn how farmers make decisions about the land when in the fields.

Journey 2050: Land Use

Grade: 7th grade
Time: 30 - 45 minutes

Purpose:

- Students will recognize that arable land (ideal land for growing crops) is a limited resource, identify best management practices that can be applied to every stake holder's land-use decisions; and analyze and discuss the impacts of food waste on our environment.
- Students will learn about Norman Borlaug's concerns for future generations. Population, available land, and agriculture will meet a point where all are competing for more space.
- Students will identify ways in which agriculture can meet the demands of a growing population without cultivating more arable land.

Materials:

- Apple, knife and cutting board
- Apple Land Use Model, available for purchase from agclassroomstore.com (optional)
- *Land Use* PowerPoint
- Journey 2050: Land Use Video: https://www.youtube.com/watch?v=RMu7NtScdhU&feature=youtu.be
- Sustainability Farming Game: Level 5
    - Download App: http://www.journey2050.com/play-the-game/
    - Create Free Teacher Account to track student progress and print reports on Sustainability Farming Game: https://journey2050.rnp.io/teachers/sign_up

Vocabulary:

- Best Management Practices: the best way to do something, best management practices and technology enable us to grow more with less
- Habitat: the place where a plant or animal naturally lives
- Population Density: a measurement of population per unit area or unit volume
- Sustainable: meeting the economic, social and environmental needs of the present without compromising the needs of the future

Spark Curiosity By…

4. Open the *Land Use* PowerPoint.
5. Begin by reminding students how many people are currently on planet Earth *(7.6 billion in 2018)* and that expert demographers are anticipating nearly 10 billion people by the year 2050 (www.Worldometers.info).
6. Optional: Remind students what one billion looks like by asking:
    1. "If I give you one million dollars and you spend $1,000 every day when will you run out of money?" *(2.7 years)*
    2. "How long would it take to spend a billion dollars if you spent $1,000 every day?" *(2,740 years)*

3. This mental exercise will help students to understand that 10 billion is a very large number.

7. Slide 2: Ask students, "How can we feed the growing population?" Students will likely say that we need to grow/produce more food. Before you offer any additional information, conduct the following demonstration (the Apple Land Use Model can be used as an alternative demonstration option):
    1. Hold up an apple and explain that it represents planet Earth. Ask, "How much of the Earth's surface do you think is ideal for growing crops?"
    2. Ask, "If you look at a globe or map, what is the main color you see?" *(Blue)* Cut the apple into four equal-sized wedges. Nearly three of these quarters represent land covered in water. Set these aside.
    3. The remaining quarter represents land, which occupies roughly 30 percent of Earth's surface. Take this piece, and cut it in half lengthwise so you have two, one-eighth sections.
    4. One of these sections represents deserts, swamps, mountains and polar regions; this half of our land, or one-eighth (12.5 percent) of Earth's surface, is not suitable for people to live or grow crops on. Set this section aside.
    5. The other eighth represents land where people can live. There are some places where people can live but crops can't be grown. Slice this section into four equal parts. Now you have four 1/32nd pieces of apple, each representing roughly 3.1 percent of Earth's surface.
    6. The first section represents the areas of the world with rocky soils that are too poor for growing crops. Set this section aside.
    7. The next two sections represent land that is too wet or too hot for crops. Set these sections aside also.
    8. The fourth section represents the area of the world that is most suitable for development and agricultural cultivation. The best lands for agriculture are often desirable places to build homes and towns as well.
    9. Carefully remove the peel of the last 1/32nd section. This small bit of peel represents all the soil on Earth, which humans depend on for growing crops. Display slide 3 of the PowerPoint for further illustration.
8. Ask students, "Can farmers simply plant more acres of crops to feed a growing population?" *(No)* Point out that the population may increase, but the amount of arable farmland will stay the same.
9. We use our land for many different things, and we need to make smart choices to take care of the land. As a result of science and innovation, nearly 40 percent of Earth's land is used for agriculture.[1] Raising livestock on land that is too hilly or rocky for growing crops, growing urban gardens, and planting seeds that grow in tough conditions like drought are all ways to grow more food on the same amount of land.
10. Explain that in order to feed 10 billion people, farmers will need to use best management practices, like preserving soil nutrients, improving water conservation and using arable land efficiently to grow the food, fiber, fuel and by-products that we use every day. This will need to be done in a sustainable way to minimize environmental impacts and maintain a high quality of life.

Agricultural Background

Journey 2050 takes students on a virtual simulation that explores world food sustainability and answers the question, "How will we sustainably feed nearly 10 billion people by the year 2050?" The lesson plans and online simulation program allows students to make decisions on a virtual farm and witness their impact on society, the environment, and the economy at a local and global scale. The lessons engage students with the important concepts regarding sustainable agriculture. The online simulation contextualizes these concepts as students experience the lives of three farm families in Kenya, India and Canada. As students interact with each family, they learn the role of best management practices in feeding the world, reducing environmental impacts and improving social performance through greater access to education, medical care and community infrastructure. These lessons can be taught individually or as an entire unit. See the links below for the remaining lessons:

Land is one of our most vital resources. We build our civilizations on it. It is **habitat** for thousands of species and a critical part of our ecosystem. We need land for agriculture, but how much land is actually available for us to sustainably grow the food, clothing and shelter we need?

The vast majority of Earth's surface (over 70 percent) is water. This means that only 30 percent of Earth's surface is land. Only a small portion of that land, 10 percent,[1] is ideal for growing crops. However, with technology, innovation and **best management practices**, farmers can grow food on nearly 40 percent of the land.[2] For example, on land that is not ideal because it is too wet for many crops, we can grow crops like rice that thrive in wet soil. On land that is too rocky to grow crops we can raise livestock that can adjust to the landscape. If we're going to feed the world, we need to consider different ways to use Earth's land to grow more food. For example, do we convert more land to farmland for agriculture, or do we use the land we currently have and focus on increasing crop yields?

We have the ability to influence how much land is used for things like agriculture, urban development, industry development, oil and gas, mining and forestry. The choices we make with the land can bring both social and economic benefits, ensuring sustainable development.

Achieving a sustainable balance requires a great deal of thought. For example, if you want to increase your agricultural land, what are you willing to give up? Natural habitats? Industries? Homes? Recreation? You could convert natural habitats to farmland, but there will be consequences. For example, the Amazon rainforest is home to thousands of unique living things, and it plays an important role in helping regulate the Earth's atmosphere and ecosystem; these factors must be considered before converting the land to

a different use. Before you decide what you're going to change, it is important to consider how one choice about land use will impact another.

To feed the world sustainably, we will need to increase how much food we can produce on a given area of land. It is estimated that one hectare of productive agricultural land, roughly the size of two soccer fields, is lost every eight seconds.[3] Growing more food on the land that is available to us is only possible through the use of best management practices.

Farmers can use best management practices to help ensure they grow foods sustainably. Precise application of crop nutrients, making sure crops are watered at the best time of day, planting shelter belts or hedge trees, and replenishing soil nutrients used by plants during growth are all examples of practices that can help grow more food on less land. Sometimes best management practices are costly, but they can have a positive impact on the environment, crop yields, economic growth and society.

The implementation of best practices on farmland and in urban areas will help us move toward our goal of becoming a more **sustainable** civilization. For example, expanding cities upward, rather than outward, allows for more homes on less land.
Land is the source of life, but it is limited. It cannot be replaced or constructed. We need to grow more food on existing land using best management practices so that we can sustainably maximize our land resources and address other issues related to land use choices.

Lesson

Preparation: Prior to class, review the *Background Information*, video clip and PowerPoint slides (including the speaker notes) associated with the lesson. Review the Teacher's Guide: Getting Started document for further information to prepare for class.
Activity 1:

1. Slide 4: Play the Journey 2050: *Land Use* video (4:41 min). Prepare students for the video by asking them to discover two things: 1) Why is land a precious resource? 2) How are best management practices applied to land use choices? (Background and discussion prompts are outlined in the steps below and in the PowerPoint notes.)
2. **Why is land a precious resource?**
    - Slide 6: Ask, "What is our land used for?" *(habitat, food, recreation, homes, industries, agriculture, etc.)* Explain that land is a precious resource. There are many things that influence how land is used and what it is used for.
    - Slide 7: Display the Worldometers website to show your class the live population statistics for the 20 largest countries in the world.

- Optional: If time allows, challenge students to discover which of these countries has the highest and the lowest population density. *(Russia has only 9 people per km^2, and India has 452 people per km^2.)* Make it a race with a prize to see who can figure it out first. This statistic can be found on the Worldometers website by clicking on each individual country in the list *Top 20 Largest Countries by Population*.

- Slides 8–9: Display the *Population Statistics by Country Map* and *Agricultural Land Map*, and ask students if they can see a relationship between human population and agricultural land. Students should recognize that we are building our homes and businesses in the areas that have the best climate and soil for growing crops! Historically, people have settled near water and fertile land in order to grow crops. As cities grow the urban footprint expands into areas that are habitat and farmland.
  - Note: India and China have nearly 40% of the population between the two countries (As of 2018, China has 1.415 billion people and India has 1.354 billion people making 2.769 billion or 36.28% of the world share (compared to the next largest population: USA [326,766] is in 3rd place and Canada [36,953,765] is 38th.)[8]
  - Optional: If time allows, explore the interactive world population density map and the Land Use in Agriculture map with your student to further illustrate population and agricultural land.
- Explain that farmers have increased yields (food production) by using improved practices, science and technology. For example, plant scientists like Norman Borlaug have developed plants that are resistant to insects, disease and drought; soil scientists and land managers have developed soil conservation practices; and irrigation engineers have developed systems and delivery mechanisms to minimize water use and still grow a bountiful crop. Yields have constantly gone up.

3. **How are best management practices applied to land use?**
   - Slide 11: Ask, "How do we improve our land-use choices so that we can feed a growing world and still maintain a high quality of life and healthy environment?" We need to use best management practices (see the *Best Management Practices* video; 1:06 min). Best practices are simply the best way to do something. For example, in school, if you attend class, engage in the content and study, you will do well in the course. Similarly, we can also think about the best ways to use our land sustainably by preserving

natural habitats, using agricultural best management practices and planning for urban growth.

- Slide 12: Open Level 5a of the *Sustainability Farming Game* on each student's computer or device. Explain the following, "In this level, you will make predictions for the percentage of land used by nature, urban and agriculture in the 1900s compared to the year 2000". Next, explore best management practices that each stakeholder should employ in our journey and come up with your own ideas that could be implemented to make better land-use choices.
- Slides 13–16: Review slides as a class and discuss the noted best management practices.

Wrap-Up: Review and summarize the following key concepts: (Slide 17)

- Three percent of Earth's surface (10% of the Earth's land) has ideal conditions for growing crops.
- Most of our urban areas were built on ideal crop land. Our ancestors settled where they could grow food and cities grew from there.
- The quality of the soil under our homes and businesses is the real challenge in the journey. The challenge also spreads to our natural areas. Protecting the Earth's biodiversity and natural resources is vital to our survival.
- Every land use decision we make has a consequence. Best management practices are essential in our journey to sustainably feed the world while balancing social, economic and environmental needs.

Connection to Norman Borlaug

Briefly go over Norman Borlaug, his story, and his impact. Have one student volunteer to read a bullet point.

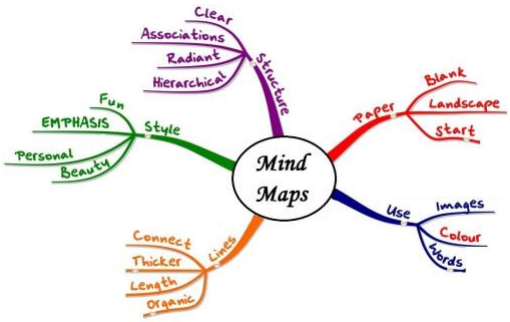
- Norman Borlaug grew up in Cresco, Iowa on a small family farm. They raised many animals and grew many fruits and vegetables while living in near poverty.
- He was one of the lucky few that attended high school at the time. Later he attended the University of Minnesota to wrestle and study forestry. His professors and colleagues throughout college led him to wheat research in Mexico in the early 40's.
- Norman spent nearly 20 years in Mexico hoping to develop a wheat variety that was resistant to stem rust; a common wheat killer at the time. He also implemented dwarf wheat that possesses a strong stalk and high yielding grain heads. By doing so, he helped Mexico become self-sufficient in wheat production. This ultimately steered the country away from starvation and famine.
- Learning of his success, the countries of Pakistan and India leaned on him for knowledge. At that time, they were experiencing famine at the most extreme

degree. With the help of American export capabilities and negotiating skills, India and Pakistan received the stem rust resistant, high yielding wheat just as Mexico had. Each country is now an economic world leader.

- Later in Norman's life, he was called to Africa to apply the same knowledge as he did in India and Pakistan. Norman understood well before that agriculture production was a three-legged stool. This means that farmers needed policies that allow them to grow their own food, fair market prices to keep them in business, and access to fertilizer to keep soil healthy. The infrastructure of Africa has posed challenges in each area - especially gaining access to resources to be successful. Although Norman made great strides in Africa, there is still a lot of work to be done.
- Norman received the 1970 Nobel Peace Prize in honor of all his hard work. He now is referred to as "The Father of the Green Revolution". Around that time, he created the World Food Prize. The World Food Prize is an organization that works towards ending world hunger.
- In 2009, the famous Dr. Norman Borlaug passed away due to Lymphoma (Cancer). A year later, his childhood homes became a historical landmark. Since then, people have come to visit Cresco, IA in hopes to learn more about Norman Borlaug and his everlasting impact on the world.

Using the farming game and knowledge gained from this lesson, students should be able to communicate various ways in which we can protect our land. Examples may include cover crops, fertilization, conservation restoration programs, no till cultivation.

1. Decide as a class which land protection practice you plan to evaluate.
2. As a class, brainstorm different resources needed to apply that practice. The instructor should construct a mind-map of these ideas starting with the practice on the inside and resources building off of the center. This can be done on a white board or large piece of paper.



3. Ask students how their mind map is similar to Norman Borlaug's life. This can be an open discussion. Their explanation should be similar to the idea of starting small and working towards the big idea over time. This is an example of how Dr. Borlaug started with small tasks to accomplish his end goal.
    - From an early age, Norman Borlaug understood the importance of providing for others as he was part of the first generation of Borlaug's to sell their products to others. His central idea was to "End World Hunger". To begin his journey to that large idea was to learn the basics of farming.

He learned this from his father and grandfather living on the farm. Then, he gained an education by attending one room schoolhouse, high school, and college. When studying forestry, he once again learned how to live off the land. In addition, he learned about stem rust - a major wheat killer. From there, he obtained a job in Mexico creating wheat varieties that can withstand stem rust and feed a country. He was successful in Mexico and then took his talents to India and Pakistan to do the same. Those countries are now full bellied world leaders. He then moved on to Africa to accomplish the same thing. Although he fell short there, he still contributed a large majority to "Ending World Hunger".

Watch this video as a message from Norman Borlaug to your students.
https://www.youtube.com/watch?v=hg4A_Bm-JG4

Sources/Credits

1. http://data.worldbank.org/indicator/AG.LND.ARBL.ZS
2. http://data.worldbank.org/indicator/AG.LND.AGRI.ZS
3. http://www.tranquileye.com/clock/
4. http://water.usgs.gov/edu/earthhowmuch.html
5. http://one-simple-idea.com/Environment1.htm
6. http://www.worldfooddayusa.org/food_waste_the_facts
7. http://data.worldbank.org/indicator/AG.LND.AGRI.ZS
8. http://www.worldometers.info/world-population/population-by-country/

National Agriculture Literacy Outcomes

Agriculture and the Environment

- Describe benefits and challenges of using conservation practices for natural resources (e.g., soil, water, and forests), in agricultural systems which impact water, air, and soil quality (T1.6-8.b)
- Discuss (from multiple perspectives) land and water use by various groups (i.e., ranchers, farmers, hunters, miners, recreational users, government, etc.), and how each use carries a specific set of benefits and consequences that affect people and the environment (T1.6-8.d)
- Recognize how climate and natural resources determine the types of crops and livestock that can be grown and raised for consumption (T1.6-8.g)
- Recognize the factors of an agricultural system which determine its sustainability (T1.6-8.h)

Education Content Standards

CAREER

Natural Resource Systems Career Pathway

- NRS.02.02
- NRS.02.03
- NRS.04.01

ECONOMICS

Standard 1: Identify what they gain and what they give up when they make choices.
Standard 2: Make effective decisions as consumers, producers, savers, investors, and citizens.

HISTORY

NCSS 7: Production, Distribution, and Consumption

- Individuals, government, and society experience scarcity because humans want and needs exceed what can be produced from available resources

NCSS 8: Science, Technology, and Society

- Society often turns to science and technology to solve problems
- Science and technology have had positive and negative impacts upon individuals, societies, and the environment in the past and present

SCIENCE

MS-ESS3: Earth and Human Activity

- Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment
- Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems

Common Core Connections

Reading: Anchor Standards

- CCSS.ELA-LITERACY.CCRA.R.4
- CCSS.ELA-LITERACY.CCRA.R.6
- CCSS.ELA-LITERACY.CCRA.R.8

Speaking and Listening: Anchor Standards

- CCSS.ELA-LITERACY.CCRA.SL.1
- CCSS.ELA-LITERACY.CCRA.SL.5

Students now understand the land takes on many different characteristics based on its environment. Understanding the land is a crucial element to farming successfully. Let's take a look at the new-day technology that farmers use to meet the needs of consumers across the world.

Journey 2050: Technology & Innovations

Grade: 7th grade
Time: 1 hour

Purpose:

- Students will explore new technologies that will impact the future of farming, understand the role of developing countries in food security, and explain how consumers influence that production of food.
- Students will understand what the Green Revolution is and how it impacted the world.
- Students will identify 3 ways in which Norman Borlaug used technology (plant breeding) to create a sustainable wheat plant.

Materials:

Introduction

- *Technology and Innovation* PowerPoint
- TED Talk, A Global Food Crisis May be Less Than a Decade Away by Sara Menker

Activity 1: Technology and Innovation

- *Technology and Innovation* PowerPoint
- *Future of Agriculture: Technology and Innovation* Handout, 1 technology sheet per group
- Journey 2050 Technology & Innovation video
  - Based on The Future of Farming & Agriculture video

Activity 2: Developing Nations

- *Technology and Innovation* PowerPoint
- TED Talk, A Global Food Crisis May be Less Than a Decade Away by Sara Menker

Activity 3: Impact of Consumer Choice

- *Technology and Innovation* PowerPoint
- SnapAG Information Sheets

Essential Files

- Technology and Innovation PowerPoint
- Technology and Innovation: Find Someone Who Handout (Enriching Activity)
- Future of Agriculture: Technology and Innovation Handout

Vocabulary:

- **Innovation**: a new method, idea, or product
- **Technology**: the application of scientific knowledge for practical purposes, especially in industry

Spark Curiosity By…

1. *Technology and Innovation* PowerPoint Slide 2: Show students the TED Talk, A Global Food Crisis May be Less Than a Decade Away by Sara Menker.
2. Pause the talk at 2:29 (15:04 remaining) and discuss Sara's statement, "We could have a tipping point in global food and agriculture if surging demand surpasses the agricultural system's structural capacity to produce food." Discuss the concepts of supply and demand as well as a "capacity" to produce food. As demand (population) rises, what limits our capacity to produce food? (*arable land, water, soil nutrients, etc.*)
3. Next ask, "What are some things that can increase our capacity to produce food?" Allow students to brainstorm their own ideas.
4. Explain to the students that they will be exploring three ways to expand our capacity to produce food:
    1. Developing and implementing new technologies,
    2. Helping developing countries improve farming efficiency, and
    3. Learning how consumer choices can either support or challenge food sustainability.

Agricultural Background

Journey 2050 takes students on a virtual simulation that explores world food sustainability and answers the question, "How will we sustainably feed nearly 10 billion people by the year 2050?" The lesson plans and online simulation program allows students to make decisions on a virtual farm and witness their impact on society, the environment, and the economy at a local and global scale. The lessons engage students with the important concepts regarding sustainable agriculture. The online simulation contextualizes these concepts as students experience the lives of three farm families in Kenya, India and Canada. As students interact with each family, they learn the role of best management practices in feeding the world, reducing environmental impacts and improving social performance through greater access to education, medical care and community infrastructure. These lessons can be taught individually or as an entire unit. See the links below for the remaining lessons:

Life on the farm 100 years ago looked vastly different compared to today, and it will continue to change to meet the needs of the world. Cutting-edge **technology** and **innovations** are being used in agriculture. These new technologies are being developed with a purpose to overcome the challenges we face in providing food, fuel, and fiber for a growing population.

The use of technology can be found in nearly every aspect of our daily lives and has revolutionized farming with more innovation on the horizon! Some technologies are emerging while others have been adopted globally.
Here are a few examples. Have you seen any of these innovations in action?

Autonomous robots	Agriculture requires a significant amount of manual labor. What do you think a robot can do on a farm? Autonomous pickers identify and pick ripe fruits and vegetables. Other specialized find and eliminate weeds and pests that damage crops.
Agriculture sensors	Precise timing is key! When it comes to nutrient management, watering, pest management, and harvest, too early or too late doesn't cut it. High-tech sensors located in fields send alerts to farmers through an app on their phone when it's time to take action.
Aerial crop imaging	Arable land suitable to produce our food is a limited resource. Aerial images taken with drones, satellites, and planes can help farmers map their fields and use the land to its greatest potential. Drones can perform crop monitoring, planting, and even spraying tasks.
Agriculture data systems	Record keeping and data collection helps farmers identify successful solutions and areas that need improvement. Notebooks are being replaced with digital platforms. Farm data, such as annual crop yield, market forecasts, soil nutrients and weather, are collected and stored electronically to give farmers valuable information as they make decisions.

Global Positioning Systems (GPS)	GPS-based applications are being used for farm planning, field mapping, and more! The farmer is always present, but one of the most popular features of GPS is that the tractor can drive itself to ensure perfect rows and the farmer can program precise applications of seeds and fertilizer.
Vertical and indoor farming	Growing crops up, instead of out! Now that's a good idea! Vegetables and fruits tend to work best in vertical farming, but who knows what the future will hold? Vertical farming is ideal where land isn't available and it can even be used as a way to repurpose abandoned structures.
Livestock health and activity monitors	The livestock industry utilizes technology in a variety of ways to ensure animal health, safety, and welfare. For example, "smart collars" are used like a personal fit bit, tracking daily activity, behavior, and health. Breath analysis can be achieved with high-tech equipment allowing farmers to evaluate potential health problems and diet. Thermal imaging and 3D cameras have the capability of analyzing an animal's body muscle and weight to advise farmers when to sell their livestock.
Fish farms and aquaponics	Specialized fish farms involve raising fish in tanks or enclosed ponds. Aquaponic systems are a unique way to grow fish and plants symbiotically. By using a zero-waste system, waste from the fish is cycled through the system serving as a source of nutrients to grow the plants.

Insect protein	Meat, milk, and eggs are common sources of protein in our diet. But, what about bugs as a source of protein? Insects are affordable and require fewer natural resources. Known as entomophagy, the eggs, larvae, pupae, and adults of certain insects are eaten as part of a meal.
Cultured meats	Another alternative protein source is cultured meat. It isn't "meat" in the traditional sense as it doesn't come from processing an animal. It is formed in a lab using animal cells. Cultured meat uses techniques to engineer tissues to form a meat alternative.
New seed varieties	Genetically modified organisms (GMOs) and CRISPR technologies edit genes in plants to overcome a challenge, such as a disease. A lot of time and money is required to produce a GMO plant. It takes approximately 13 years to research and ensure its safety and can cost around $136 million dollars.[1]

After looking at these emerging technologies, it's easy to see that farms of the future may look very different than they do today. Will these technologies and more answer the question, "How will we sustainably feed nearly 10 billion people by the year 2050?" Surely it will make a difference, but each innovation must be understood for the benefits and limitations it brings. There is no one-size fits all agricultural solution to address the different needs of a growing population.

Consider robotics. Many fruit and vegetable crops are still highly dependent upon manual labor. Technologies such as robotic crop harvesting machines could decrease the demand and production cost for human laborers. However, even the most sophisticated technology may not compare to the efficiency and precision of human laborers to harvest fruits and vegetables at the precise size and maturity and in a way that does not bruise or damage the produce. The road ahead includes significant amounts of research and financial investment to engineer robots to work on large-scale farming operations. Some robots will need to work on thousands of acres in varying terrains and with varying crops. Others may be needed to perform delicate and timely harvesting.

What about vertical farms? They seem like an easy solution to save land, but are they a solution for all crops? Microgreens, like herbs and vegetables such as lettuce, seem to have the most success and may be grown with less water and crop inputs; however, the high energy cost to provide artificial lighting and adequate growing temperatures for the plants must be decreased for vertical farming to be economical. Not all crops can be grown with the methods used in vertical buildings.

Innovative technologies will be part of the solution to meet the needs of a growing population, but there are complex structural and environmental challenges that will need to be addressed. What technologies can be implemented in developing nations to secure a more sustainable food supply? How do consumer food choices impact the sustainability of our food supply? How can we use the United Nations Sustainable Development Goals to alleviate sudden disruptions in the food supply and famine? Most importantly, what can each of us do to be part of the solution today?

We have a lot of challenging problems that require critical thinking and creative solutions to sustainably increase our food supply for a growing population. New solutions are being researched and tested each day to solve this global challenge.
What ideas do you have to help feed the world?

Lesson

Preparation: Prior to class, review the *Background Agricultural Connections*, video clip, and lesson procedures associated with the lesson. Review the Teacher's Guide: Getting Started document for further information to prepare for class.

Activity 1: Technology and Innovation

1. Explain that our ultimate goal is to produce a sustainable food supply for the growing population. Along the path to the year 2050, there are many obstacles and challenges to overcome. Define the word *innovation* and explain that new technologies help overcome challenges in agriculture.
2. Prepare students for the video clip by letting them know that they will be introduced to several innovations that can be used in agriculture. As they watch, they should also consider the challenge(s) that each innovation could help to overcome.
3. *Technology and Innovation* PowerPoint Slide 3: Play the Journey 2050 Technology & Innovation video.
    - Please note the above video was based on The Future of Farming & Agriculture video. The views shared in this video do not necessarily reflect those shared by Journey 2050.
4. Slide 4: After the video, have students share their thoughts. Ask questions such as, "Which innovation do you think could be most impactful and why?" or, "What are some pros and cons of using these technologies?"

5. Slide 5: Give each pair (or small group) of students one copy of the *Future of Agriculture: Technology and Innovation* handout.
    - **Note:** You should have one copy (printed single-sided) of this PDF per group. The sheet they receive represents the specific technology they will be researching. There are three blank sheets at the end of the document, if your students would like to research an innovation not currently on the list.
6. Provide time for the students to perform research and create a digital presentation about their technology to share with the class. Students should use the four sections found on their handout to outline their research and presentation:
    - **Describe it.** Students should describe the technology, how it is used, where it is used, etc. If possible, include details such as how much it costs and where it is currently being used in agriculture today.
    - **What are the benefits?** What obstacle(s) does this innovation overcome?
    - **What are the limitations?** Each form of technology has limitations. What are they? Is it the expense of the equipment, accuracy of its use, etc.?
    - **See it in Action!** Have students find images or a demonstration video of the technology in action.
7. Slide 6: As each team presents to the class, have the class consider what changes in society, environment, or economy would have to be made for the innovation to be adopted globally.
8. As a class or as an individual assignment, have students select what they believe are the three most promising innovations that will make a difference in the future of agriculture. Remind students to focus on the goal of providing a sustainable food supply for a growing population.

Activity 2: Developing Nations

1. *Technology and Innovation* PowerPoint Slide 7: Discuss, compare, and contrast the terms "developing" nation and "developed" nation with your students. Help students recognize the meaning of these terms in the context of various topics such as economics (access to capital and markets), health, safety and sanitation, educational opportunities, etc.
2. Slide 8: Once students have a foundational knowledge of developing nations, have students watch the remaining portion of the TED talk that they began during the *Interest Approach* portion of the lesson. Start at 2:29 (15:04 remaining).

Teacher Note:
At 3:40 (13:40 remaining), Sara makes the statement "…the world lacked an actionable guide for HOW we can avoid a global food crisis…" If you continue to the Summary Level of Journey 2050, students will engage in a Project-Based Learning activity to create their own action plan to improve our world's sustainability.

3. After listening to the TED talk, explore which countries in the world have potential to increase crop yields on existing farmland (remember the goal is not to turn more land into farmland but to maximize the land already in production). Make sure at least one group explores India and African countries. Instruct students to consider the growing crop conditions (i.e. arable land, soil health, pests/diseases, water/climate), transportation/storage to get products to markets/market access, technology available, level of education within the country, access to capital to invest in new innovations/best practices, and anything else that would contribute to the success or failure of growing food sustainably. Then respond to the question, "Does the country I have selected have the ability to increase crop yields on existing farmland with all the resources required?"
4. Have the students share their findings, and ask them to evaluate the potential for stakeholders (producers, consumers, governments, environmentalists, non-profits, educators etc.) to contribute to successful advancements in the countries identified.
5. Summarize by discussing answers to the following questions:
    - What can developed and developing countries do to prevent a famine as we move toward 2050?
    - What can developed and developing countries learn from each other? Can technology and innovations be integrated from one country to another?

Activity 3: Impact of Consumer Choices
Teacher Note:
Food choices are not covered in Journey 2050 directly. As you carry out this activity, it's important that students understand that it's not always black or white when deciding what food choices support sustainability the most. For example, in recent years cattle have been criticized for producing methane which contributes to greenhouse gases and there has been a concern that developed countries over-consume red meat. However, it is important to consider the comparative and competitive economy, essentially recognizing that not all land is suitable for growing crops and that cattle can provide a protein source for people. Cattle are ruminants, so they graze on grasslands not suitable for growing crops. As they graze, their manure helps sequester carbon in the soil. In developing countries where few food choices exist, owning cattle reduces malnutrition. It's important that students understand the entire picture and make science-based decisions when making food choices. A similar discussion can be held around the practice of fish farming in land-based pools versus the ocean. The goal in feeding nearly 10 billion people is to ensure everyone has access to affordable, safe, and nutritious meals.

1. *Technology and Innovation* PowerPoint Slide 9: Direct the attention of the students to themselves. Ask, "How do consumers like yourself influence what producers grow?" As an example, ask students to raise their hand if they would eat insects as a source of protein. If they will eat insects, then demand for insects increases. If they won't, then demand decreases. Explain that every time we shop at a grocery store, we are sending a message to the agricultural value chain about what preferences we have.
2. What other ways do consumers influence growers? Ask students if they have seen campaigns ("Meatless Mondays" or "Milk: It Does a Body Good") or food labels (organic, Non-GMO, natural, cage-free, antibiotic free, etc.) that could influence someone positively or negatively about food. The following discussion should prompt the students to take a science-based, informed approach when viewing information they may see on social media or in marketing campaigns that is trying to influence their purchasing behavior.
3. Slide 10: Separate the classroom into small groups. Give each group one or two snapAG information sheets (i.e. What are GMOs and are they okay to eat? What does organic farming look like? How are chickens raised?). SnapAG is a series of resources that help students explore hot topics affecting the agriculture industry. Each group should answer the following questions:
    - Are their own perceptions different or the same as the industry perceptions?
    - Why do they have the perceptions that they do?
    - Are their views based on science?
    - How do consumer perceptions influence producers growing crops and raising animals.

Wrap-Up: (Slide 11)
After conducting these activities, review and summarize the following key concepts:

- Technology and innovation play a critical role in the future of agriculture. Each innovation must be understood for the benefits and limitations it brings as there is no one-size fits all solution.
- If supported, developing countries have the greatest potential to make the most improvements.
- Consumers have a direct influence on what is grown and how. It's important that students take a science-based, informed approach when viewing information, they may see on social media or in marketing campaigns trying to influence their purchasing behavior.
- As we strive to feed a growing population, every stakeholder must act in a way that encourages sustainable solutions. We need to begin to solve the problems today. Waking-up to address these issues on January 1, 2050 is too late!

Connection to Norman Borlaug

Norman Borlaug is considered "The Father of the Green Revolution".

1. Ask students to open their laptops and research the Green Revolution. They should be able to answer these questions:
    - What is it?
    - When did it start?
    - How did it start?
    - What was life like before the Green Revolution?
2. Allow students to share what they discovered about the Green Revolution with the class. Dr. Borlaug initiated the revolution by breeding wheat for specific characteristics. These characteristics include Stem Rust resistant, Dwarf stalks, and High Yielding.
3. Assign each student a number 1, 2, or 3.
    - 1 = stem rust resistance
    - 2 = dwarf stalks
    - 3 = high yielding
4. Students will use their computer to research the significance of their gene. They should be able to answer these questions:
    - Describe the gene.
    - Why is it important to selectively breed for that gene?
    - How has the gene impacted the world?

    Potential answers may include…
    - Stem Rust: is a fungi that usually appears on wheat plants in the spring. It takes multiple days for it to visually appear after infection. This fungus is notorious for taking out an entire country's wheat crop. Selectively breeding for plant resistance against stem rust will increase production and stop the overall spread in spring. In the mid 90's it was the leading cause of wheat loss.
    - Dwarf stalks: Before the mid 90's, the stalks of wheat were typically long and fragile. Norman Borlaug selected for a shorter, thicker stalk. This characteristic supports the seed heads and ultimately allows the plant to focus on growing seeds rather than growing tall, resulting in large seed heads. This has impacted the wheat industry because it allows the stalk to be strong despite weather events. Before, the wheat heads were too heavy and would cause the stalk to bend and break; ultimately leading to the loss of that seed head.
    - High Yielding: Breeding wheat to high yielding simply means selecting for the gene that produces the most seed heads. Doing so allows the harvest to be more plentiful with a higher seed head to plant ratio. This has impacted the wheat industry immensely. Countries have been able to come out of starvation due to the higher producing wheat plants.
5. Ask a volunteer from each gene number to share their findings with the class.

6. Have an open discussion with the class after asking whether or not they feel Norman Borlaug's research of selecting for specific genes could be considered technology & innovation.

Sources/Credits

1. https://croplife.org/wp-content/uploads/pdf_files/Getting-a-Biotech-Crop-to-Market-Phillips-McDougall-Study.pdf
2. https://johndeerejournal.com/2016/03/agricultures-past-present-and-future/
3. https://croplife.org/news/agriculture-then-and-now/
4. https://www.kqed.org/science/16676/drones-the-newest-water-saving-tool-for-parched-farms

National Agriculture Literacy Outcomes

Agriculture and the Environment

- Recognize the factors of an agricultural system which determine its sustainability (T1.6-8.h)

Science, Technology, Engineering, and Math

- Identify specific technologies that have reduced labor in agriculture (T4.6-8.h)
- Provide examples of science and technology used in agricultural systems (e.g., GPS, artificial insemination, biotechnology, soil testing, ethanol production, etc.); explain how they meet our basic needs, and detail their social, economic, and environmental impacts (T4.6-8.i)

Education Content Standards

CAREER

Biotechnology Systems Career Pathway

- BS.01.01

  Career Ready Practices
- CRP.10.4

SCIENCE

MS-ETS1 Engineering Design

- MS-ETS1-1
- MS-ETS1-2

Common Core Connections

Speaking and Listening: Anchor Standards

- CCSS.ELA-LITERACY.CCRA.SL.1
- CCSS.ELA-LITERACY.CCRA.SL.5

Language: Anchor Standards

- CS.ELA-LITERACY.CCRA.L.6