USING ANCHORING PHENONMA TO CONNECT AGRICULTURE & BIOLOGY

Finding the integration of agriculture in a science-based classroom through real world examples.

Abstract

I developed the "Using Anchoring Phenomena to Connect Agriculture & Biology Guide" to help science-based teachers, specifically biology teachers, find the integration of agricultural topics in their classroom. By showing the connection between agriculture and biology/science through natural phenomena, students will be able to articulate the relevance of their learning within real world contexts, while gaining an understanding of where their food comes from. This guide discusses how to create a phenomenon, examples of various anchoring phenomena, and how to implement these phenomena into science and agricultural classrooms.

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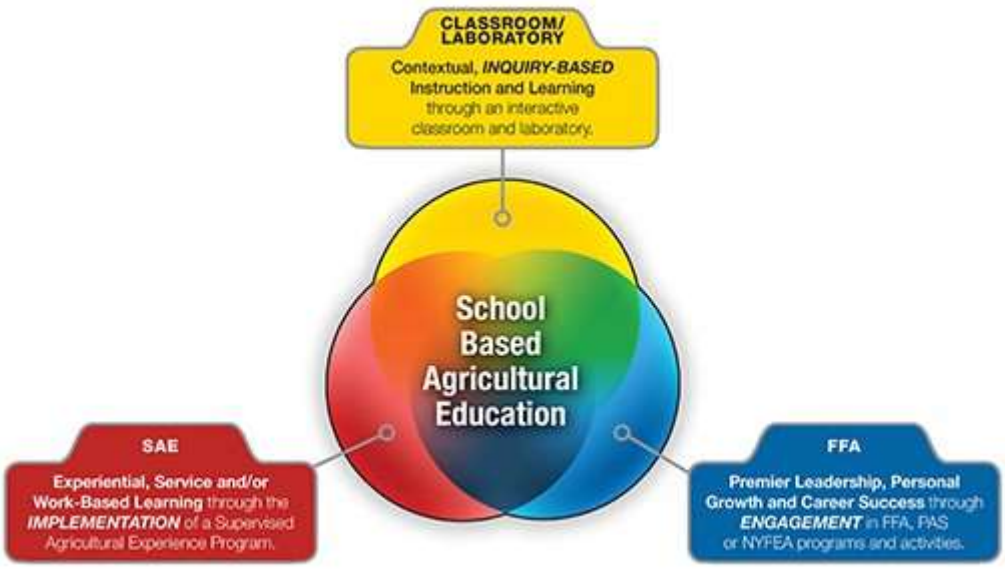
Purpose of the guide

As the shortage of teachers continues to be present, it becomes more critical for teachers to have multidisciplinary content knowledge. This guide will provide the content for what agriculture education is, how it can be connected to other subjects and the use of an "anchoring phenomena" from the Next Generation Science Standards teaching techniques.

In agriculture education there is a common approach called the "three circle model". The model below shows the three different parts of agriculture education which include classroom instruction, National FFA organization, and Supervised Agricultural Experiences (SAEs).[1] This model should be used throughout a program to strengthen students' knowledge of agriculture (classroom), develop their leadership skills (FFA), and create a network that can potentially set them up for success in their future career (SAE). While this model is known by agriculture teachers, it is not known outside of the discipline and can lead to some confusion with other educators in your district.

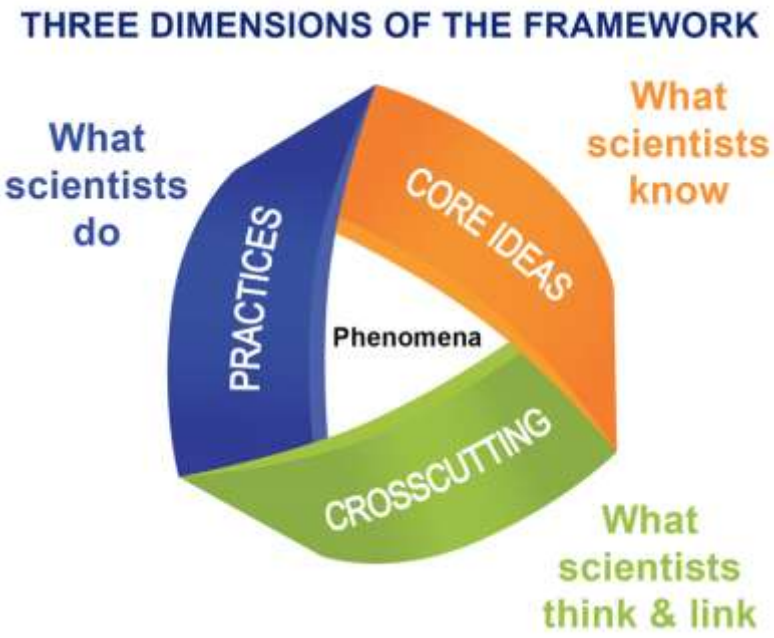


This guide will help to bridge the gap between agriculture content and other disciplines, such as math, science and writing. The main focus of integration is for a science classroom, but the guide will also give way to other disciplines that can have connections to these topics. As the guide progresses, you will discover how to use anchoring phenomena, part of the Next Generation Science Standards (NGSS). It will teach others about how to develop an anchoring phenomenon and how it connects to standards and topics. Students shift their focus from learning about a topic to figuring out why or how something happens. The phenomenon is used to connect the disciplinary core ideas and crosscutting concepts through the use of the science and engineering practices

[1] *Agricultural education*. National FFA Organization. (2019, January 14). https://www.ffa.org/agricultural-education/.

Next Generation Science Standards & Michigan Biology Curriculum

The Next Generation Science Standards (NGSS) were developed at the national level to create science-based curriculum across the entire country in 2013.[2] This was developed by collaboration from the National Science Teachers Association, American Association for the Advancement of Science, and the National Research Council. These standards aim to gain student interest in science concepts, and to have a common practice taught for students to critically think, analyze and evaluate science in their lives.[3] Like the three circle model in agriculture education, NGSS has three "pillars" that help to construct the science curriculum. These pillars are disciplinary core ideas (what students know), cross cutting concepts (connecting science), and science and engineering practices (doing science). [4]



The standards required for Biology Curriculum through NGSS and the State of Michigan are as follows:

1. *B1 Inquiry, Reflection, and Social Implications*
2. *B2 Organization and Development of Living Systems*
3. *B3 Interdependence of Living Systems and the Environment*
4. *B4 Genetics*
5. *B5 Evolution and Biodiversity*

To see the full list of segments & standards for biology, please see 1.0 in the appendix.

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[2] *Development overview*. Development Overview | Next Generation Science Standards. (n.d.). https://www.nextgenscience.org/development-overview.

[3] NextGenScience, & Achieveinc. (n.d.). *Using Phenomena in NGSS-Designed Lessons and Units*. Issuu. https://issuu.com/achieveinc/docs/using_phenomena_in_ngss.

[4] *Three dimensional Learning*. Three Dimensional Learning | Next Generation Science Standards. (n.d.). https://www.nextgenscience.org/three-dimensions.

What is an anchoring phenomena?

When working in a science or agriculture-based classroom, educators may know the terms place or project-based learning. Project-based learning is described as a teaching method in which students gain knowledge and skills by working for an extended period of time to investigate and respond to an authentic, engaging, and complex question, problem, or challenge.[5] This allows students to discover real world problems and think through solutions to issues that may be present in their own communities.

Teachers use something called an "anchoring phenomena" to pique students' interest in a science-based topic. The phenomenon presented engages students to think about two questions – "What Do I Notice" and "What Do I Wonder" about the phenomenon. [6]This process also gives teachers a chance to monitor their learning by comparing the phenomenon to the disciplinary core ideas and crosscutting concepts of the standard.[3] It can use pictures to ask students that question, give them a prompt or use both. To create phenomena, you can use a variety of options like:

1. Draw upon their everyday experiences or their family's experiences who they are, what they do
2. Draws upon what they are interested in with everyday life
3. Phenomena in the media

These are the steps to consider when developing anchoring phenomena for students to engage with:

1. An anchor builds upon student experiences. Ideally, students should have some prior knowledge of or experience with the material.
2. an anchor is too complex to explain or solve after just one lesson.
3. an anchor is observable
4. an anchor should have resources available that students can explore for themselves: data, images, and texts that can provide students with what they need to know to explain the phenomenon or solve the problem.[7]

Now that there is an explanation for what the phenomenon is, and how it is used. The "product" of this impact project is given as examples which are located on the next page and within the appendix. These pages provide readers with information on the thought process behind the phenomena, the various biology and agriculture standard the phenomena hits, suggested unit/topic ideas to correlate the phenomenon with, and the given example of an anchoring phenomenon. The suggested unit/topic ideas contain links to resources like lesson plans, worksheets, etc. that teachers can use to enhance the learning experience for students, and save them some time in the process as an educator!

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[5] *What is PBL?* PBLWorks. (n.d.). https://www.pblworks.org/what-is-pbl.

[6] *Phenomena basics*. Iowa Science Phenomena. (n.d.). https://phenomena.iowapbs.org/using.

[7] *Finding a good anchor phenomenon for Your NGSS UNIT*. iExploreScience. (2021, April 23). https://iexplorescience.com/anchor-phenomenon/.

Example #1 of Anchoring Phenomena for Biology

It's spring time, and you go to a greenhouse with your parent/guardian to help them select plants. When you get out of the car, the day is sunny and breezy. You walk into the greenhouse and start to sweat. You think to yourself, it's hot in here, wondering how it got hotter in such a short amount of time. As you look around the greenhouse at various plants, you notice there is condensation on various plants, and on the greenhouse structure. What is the condensation created from? Could you create condensation with plants that you have at home?

NGSS Standard Connection [8]*:*

- HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.
- HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.

Agriscience Standard Connection [9]*:*

- Apply knowledge of plant physiology and energy conversion to plant systems (Technical II.A.3)
- Determine the influence of environmental factors on plant growth (Technical II.B.1)

Thought process behind the developed phenomena:

This phenomenon is getting students thinking about what causes condensation, why & how it forms, and if it is coming from plants. That can then lead to how students think about the energy that plants create through various processes (photosynthesis & cellular respiration).

Suggested units after using phenomena: each column/row has link to various resources like websites, pdfs, PowerPoints for you to use when planning material to partner with the phenomena.

Units to discuss	**Resources to content**	**Activities in a biology classroom**	**Activities in an agriculture classroom**
Photosynthesis	Ameboa Sister - Photosynthesis Video	Reactions & Products Relay Race	Reactions & Products Relay Race
Cellular Respiration	Khan Academy - Cellular Respiration Unit	Photosynthesis/Cellular Respiration poster project Cellular Respiration Lab	Cellular Respiration with Beans Lab Experiment Cellular Respiration with Yeast Experiment

To see an example of an idea organizer/chart that you can use with your students to journal for introducing anchoring phenomenas, see appendix 3.0.

To see the rest of the phenomena examples and resources, please reference the appendices 4-7.

Reflection of impact project and uses in future AFNRE & Science Based Classrooms

It is recommended that teachers try this concept once a month with various lessons. While the phenomena should last more than a day, it does not need to go on a month. Students can reference the initial phenomenon when they are completing work related to the original phenomenon. Using this concept more often will encourage students to become curious thinkers and wonder about various items they see happening in everyday life. It is also recommended to try and create your own phenomena and find another teacher to test them out on or even have students try to create their own by giving them a unit that is discussed in the class. This allows them to see the thought process and think about what they have seen outside of school that connects to the content they are learning in school.

Extensions to the project could include creating an interactive notebook for teachers to use on a digital platform. Due to COVID-19, a lot of educators had to convert their materials to an online platform for the 2020-2021 school year. Teaching these phenomena could be difficult without proper templates and explanation of what is expected of the students. Having an online discussion is completely different from an in-person discussion.

This project could have been laid out differently by having a different format in terms of organization. All of the biology and agriscience standards could have been on one page, along with the phenomenon, and unit resources. I also could have surveyed agriculture teachers in Michigan to ask them if they teach biology or if students in their agriscience classes get their biology credit through that class. That data would help create material for other teachers who are looking to implement the biology credit into their classrooms. Teachers could then share how they currently integrate biology and agriculture concepts to develop phenomena from there.

As I reflect on this impact project, I come to the realization that these phenomena are what make curious individuals in the world. It is important to have students recognize changes that are happening in the environment around them and wonder why it is happening. This concept of anchoring phenomena helps to get students thinking in more ways than they could imagine. It also encourages problem solving, critical thinking and collaboration skills. One student might wonder something that another student didn't even think of, and that is key to discuss and show one another. I strongly believe that all disciplines could benefit from using this concept and encouraging students to think outside the box or be curious more often. While you will not have the answer to every one of the questions that they ask, it is a starting point for them to drive their learning and understanding of concepts that are required in the state.

Thanks and appreciation

Many thanks go to my committee member, Dr. Brook Wilke and my program advisor, Dr. Aaron McKim for their support and collaboration in this project. Their expertise in teaching others about agriculture and the natural world inspire me to continue to work hard as a teacher. Additional thanks to the support from other agriculture educators who are finalizing their projects for their feedback, as well as my family for being encouraging and supportive as I finish my degree.

Appendix

1.0 Full List of Biology Standards & Segments

STANDARD B1 Inquiry, Reflection, and Social Implications
B1.1 Scientific Inquiry
B1.2 Scientific Reflection and Social Implications

STANDARD B2 Organization and Development of Living Systems
L2.p1 Cells (prerequisite)
L2.p2 Cell Function (prerequisite)
L2.p3 Plants as Producers (prerequisite)
L2.p4 Animals as Consumers (prerequisite)
L2.p5 Common Elements(prerequisite)
B2.1 Energy Transfer and Growth
B2.1x Cell Differentiation
B2.2 Organic Molecules
B2.2x Proteins
B2.3 Maintaining Environmental Stability
B2.3x Homeostasis
B2.4 Cell Specialization
B2.5 Living Organism Composition
B2.5x Energy Transfer
B2.6x Internal/External Cell Regulation

STANDARD B3 Interdependence of Living Systems and the Environment
L3.p1 Populations, Communities, and Ecosystems (prerequisite)
L3.p2 Relationships Among Organisms (prerequisite)
L3.p3 Factors Influencing Ecosystems (prerequisite)
L3.p4 Human Impact on Ecosystems (prerequisite)
B3.1 Photosynthesis and Respiration
B3.2 Ecosystems
B3.3 Element Recombination
B3.4 Changes in Ecosystems
B3.4x Human Impact
B3.5 Populations
B3.5x Environmental Factors

STANDARD B4 Genetics
L4.p1 Reproduction (prerequisite)
L4.p2 Heredity and Environment (prerequisite)
B4.1 Genetics and Inherited Traits
B4.2 DNA
B4.2x DNA, RNA, and Protein Synthesis
B4.3 Cell Division – Mitosis and Meiosis
B4.4x Genetic Variation
B4.r5x Recombinant DNA (recommended)

STANDARD B5 Evolution and Biodiversity
L5.p1 Survival and Extinction (prerequisite)
L5.p2 Classification (prerequisite)
B5.1 Theory of Evolution
B5.2 Molecular Evidence
B5.3 Natural Selection

You can also access the Michigan NGSS Biology Standards at the NGSS website - located here.

2.0 Agriculture Education & Career Technical Education Segments and Standards

Throughout public education, there are standards set by the federal education system, along with each state's educational system. Career and Technical Education in Michigan has various CIP codes that have standards set for career area that need to be met for school districts or county ISDs to be granted funding. This process is a lot more in depth, but as a summary, the 01.000 CIP code for Agriculture, Food and Natural Resources has twelve segments that standards are broken into. These twelve segments are:

1. *Safety*
2. *Animal Anatomy & Physiology*
3. *Animal Genetics & Reproduction*
4. *Domestic Animal Production*
5. *Animal Health & Nutrition*
6. *Plant Anatomy & Physiology*
7. *Soils & Plant Nutrition*
8. *Plant Culture & Propagation*
9. *Natural Resource Systems*
10. *Environmental Service Systems*
11. *Agriculture Business & Marketing*
12. *Career Readiness & Leadership*

These segments help to frame the curriculum taught in agriculture education programs throughout the state of Michigan. In each segment, there is a certain number, half plus one of standards in that segment that need to be covered to "complete" that segment.

To find the complete list of segments and standards, use the Michigan State University website, https://www.canr.msu.edu/agriscience/curriculum/segments/ to access the full list of standards. Along with resources on what topics to teach to cover each standard, a document version of the list is found at the bottom of the page labeled "File of Core Idea Titles by Standard".

3.0 – Journal Template for Introducing Anchoring Phenomenas

What I notice…?	**What I wonder…?**

Use this template as a resource to better guide students thinking and discussion on anchoring phenomena. This template was cited from Iowa PBS, in a document titled “ISP Wonder Chart” (Home | Iowa Science Phenomena (iowapbs.org)

4.0 - Example #2 of Anchoring Phenomena for Biology & Agriscience

Living in Gratiot County, Michigan, you drive around and see A LOT of commodity crop fields like corn, soybeans, wheat, etc. You drive to town on a Tuesday in June and notice the corn field on the side of the road is about ankle high. When you drive past the same field in a week, it is as if the height of the corn has doubled and is now at your knee. How did that happen so quickly? What causes corn to grow so fast?

NGSS Standard Connection:

- HS-LS1-4. Use a model to illustrate the role of cellular division (mitosis) and differentiation in producing and maintaining complex organisms.
- HS-LS1-1. Construct an explanation based on evidence for how the structure of DNA determines the structure of proteins, which carry out the essential functions of life through systems of specialized cells.

Agriscience Standard Connection:

- Examine unique plant properties to identify/describe functional differences in plant structures including roots, stems, flowers, leaves, and fruit (Pathway II.B.1)
- Determine the influence of environmental factors on plant growth (Technical II.B.1)
- Apply principles and practices of sustainable agriculture to plant production (i.e., calculate cost/benefits, plan production, identify certifying options) (Pathway II.C.5)

Thought process behind the developed phenomena:

Students may have heard the saying “knee high by the fourth of July” when it comes to commodity corn crop. Do they really know how corn gets to be knee high? They may know the various factors that play into how plants grow like water, nutrients, air, etc., but they have to think on a deeper level to better understand how all living organisms grow, through cellular replication. Students can explore this development in plants and in animals by talking about the specific process but also the growth stages living things go through to become sexually mature to reproduce.

Suggested units after using phenomena: each column/row has link to various resources like websites, pdfs, PowerPoints for you to use when planning material to partner with the phenomena.

Units to discuss	Resources to content	Activities in a biology classroom	Activities in an agriculture classroom
Mitosis	Genes in Motion - Mitosis Unit	Teachers Pay Teachers FREE Activities Edvotek Mitosis & Meiosis Guide	Melons, Mitosis & Meiosis Activity CPALMS - Agriculture & Mitosis Video Playlist
Meiosis	Cell Cycle Unit - Mitosis & Meiosis	Meiosis Project Ideas & Rubric	Melons, Mitosis & Meiosis Activity
Life cycles of plants & animals	Agriculture & Plant Life Cycle Plant Growth Stages Growth Stages of Swine	Teachers Pay Teachers Plant Life Cycle Options Biology Cafe - Plant Life Cycle Resources	National Ag in the Classroom - Remarkable Ruminants National Ag in the Classroom - Plant Parts Hatching Science with Classroom Chicks

5.0 - Example #3 of Anchoring Phenomena for Biology & Agriscience

You are walking down the street with your family, and see one of your friends from school walking a new puppy. As you get closer to the puppy, you notice it has wavy hair and is red/brown in color. You stop to ask your friend what breed the dog is and they say "a goldendoodle". You think to yourself, how does the puppy end up looking like that? Discuss questions you have about the dog breed.

NGSS Standard Connection:

- HS-LS3-1. Ask questions to clarify relationships about the role of DNA and chromosomes in coding the instructions for characteristic traits passed from parents to offspring.
- HS-LS3-3. Apply concepts of statistics and probability to explain the variation and distribution of expressed traits in a population.

Agriscience Standard Connection:

- Apply scientific principles in the selection and breeding of animals (Technical I.E.3)

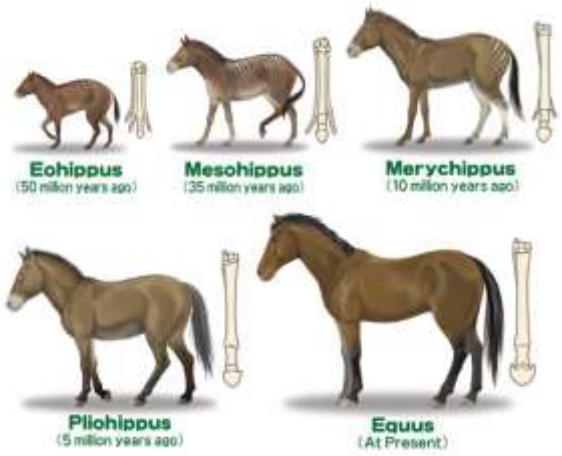
Thought process behind the developed phenomena:

The majority of students have interacted with a dog at some point in their life. They have seen different colors and coat types to know that genes can get passed through generations. Giving them a real life example helps them to think about concepts of genes that are hard to actually see with the naked eye.

Suggested units after using phenomena: each column/row has link to various resources like websites, pdfs, PowerPoints for you to use when planning material to partner with the phenomena.

Units to discuss	**Resources to content**	**Activities in a biology classroom**	**Activities in an agriculture classroom**
Genetics – Gene Expression	Genes in Motion - Basics of Genetics	Modeling Gene Expression with Short Sentences Hands on activities for teaching biology	Genetics: Selective Breeding & Transgenics Strawberry DNA Extraction Lab
Difference between genotype & phenotype	BioDifferences - Genotypes & Phenotypes Explained	Teachers Pay Teachers Genotype & Phenotype Activities	Double the Muscle: Probability & Pedigrees Inherited Traits in Living Corn Necklaces

6.0 - Example #4 of Anchoring Phenomena for Biology & Agriscience



Question to go with picture: *Describe what is happening in this image. How and why are these changes occurring over time?*

Reflection questions after initial time to wonder & think: *What would happen if the modern horse looked like the one from 50 million years ago? What other examples of evolution can you think of? How are evolution and science connected?*

NGSS Standard Connection:

- HS-LS4-4. Construct an explanation based on evidence for how natural selection leads to adaptation of populations.
    - [Clarification Statement: Emphasis is on using data to provide evidence for how specific biotic and abiotic differences in ecosystems (such as ranges of seasonal temperature, long-term climate change, acidity , light, geographic barriers, or evolution of other organisms) contribute to a change in gene frequency over time, leading to adaptation of populations.]
- HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
    - [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]

Agriscience Standard Connection:

- Evaluate the development and implications of animal origin, domestication and distribution (Technical I.A.1)
- Classify animals according to hierarchical taxonomy and agricultural use (Technical I.B.1)
- Explain the historical development of animal systems around the world (Pathway I.A.2)

Thought process behind the developed phenomena:

By having students look at an image and describe it, they have to notice key differences in the various pictures and explain how that may be occurring. You can ask reflection questions afterwards to help students to think about the time period, the environment the various species were living in and how evolution has played a role in animal agriculture.

Next steps after using phenomena: Suggested units after using phenomena: each column/row has link to various resources like websites, pdfs, PowerPoints for you to use when planning material to partner with the phenomena.

Units to discuss	Resources to content	Activities in a biology classroom	Activities in an agriculture classroom
Evolution of Animals & Plants – Taxonomy	Evolution of Horses Article Animal Evolution	NOVA Teachers - Evolution of Plants & Animals Activities Evolving Trees - Cornell Lab Activities Teachers Pay Teachers - Evolution Activities	Growing an Era: Seeds of Change Dichotomous key worksheets and activities Dichotomous Key Lesson Plan
Domestication of Livestock Animals	History of Livestock Presentation	Teachers Pay Teachers - Domestication	Taming the Wild Aurochs From Foraging to Farming

7.0 - Example #5 of Anchoring Phenomena for Biology & Agriscience

Video to show students - Googel Earth Timelapse or Use the picture to the right

Have students answer these questions while they watch the video: **What did you notice? What did the video make you think about?**

Reflection question: do you believe that Earths landscape is changing? Why or why not? Do you think that positively or negatively affects biodiversity in ecosystems? Why or why not?

NGSS Standard Connection:

- HS-LS2-7. Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
    - [Clarification Statement: Examples of human activities can include urbanization, building dams, and dissemination of invasive species.]
- HS-LS4-5. Evaluate the evidence supporting claims that changes in environmental conditions may result in: (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
    - [Clarification Statement: Emphasis is on determining cause and effect relationships for how changes to the environment such as deforestation, fishing, application of fertilizers, drought, flood, and the rate of change of the environment affect distribution or disappearance of traits in species.]

Agriscience Standard Connection:

- Demonstrate evidence of interest and concern for natural resource stewardship (Career Cluster I.D.1)
- Describe current issues impacting AFNR activities (Career Cluster I.A.2)
- Reduce the effects of animal production on the environment (Technical I.H.1)
- Evaluate the effects of environmental conditions on animals (Technical I.H.2)

Thought process behind the developed phenomena:

Landscapes will be changing around students as they continue to live. Understanding how humans impact the environment is an important aspect of biology. This phenomenon is designed to show students impacts and get them thinking about how they can reduce the current impacts.

Next steps after using phenomena: Suggested units after using phenomena: each column/row has link to various resources like websites, pdfs, PowerPoints for you to use when planning material to partner with the phenomena.

Units to discuss	Resources to content	Activities in a biology classroom	Activities in an agriculture classroom
Increasing Biodiversity in the natural environment	Increasing biodiversity Increasing biodiversity at home	Teachers Pay Teachers - Biodiversity Biodiversity Hands On Lessons	Soils & Sustainability The benefits of biodiversity Journey 2050 Resources
Native vs. Non-Native Species in your community	Native & Invasive Plants	Khan Academy - Invasive Species Project Learning Tree - Invasive Species	Hungry Pests - Invasive Species Invasive Species Space Invaders

8.0 - List of Michigan Place Based Learning resources to connect phenomena with

Since anchoring phenomenas are observations that take place out in nature or outside of the classroom. Here are some suggestions on where you could take students within the state of Michigan for tours to connect to various phenomena.

1. **Chippewa Nature Center** - 400 S Badour Rd. Midland, MI 48640, website link
2. **Potter Park Zoo** – 1301 S Pennsylvania Ave, Lansing, MI 48912, website link
3. **Kellogg Biological Station** – 3700 E. Gull Lake Drive, Hickory Corners, MI 49060: website link
4. **Sleepy Hollow State Park** – 7835 East Price Road, Laingsburg, MI 48848: website link
5. **Fredrick Meijer Gardens** – 1000 East Beltline Ave NE, Grand Rapids, MI 49525: website link
6. **Dairy Discovery (Swisslane Farms)** - 12877 84TH ST, Alto, MI - website link
    a. You can also find local dairy farms in your area and reach out to the owners to schedule a visit.
7. **West Michigan Agri-toursim** – this link will provide you with a resource to search local farmers markets or farms within the area that you can visit. Some are U-Pick Farms with fresh produce, while some have animals and petting zoos. Access the website link here!
8. **Bowers School Farm** – 1219 E Square Lake Rd, Bloomfield Hills, MI 48304 - website link
9. **State of Michigan Fish Hatcheries** – find one closest to you with this link! - website link
10. **Planetarium** – this link will help you find planetariums that are closest to you! - website link

References:

Agricultural education. National FFA Organization. (2019, January 14). https://www.ffa.org/agricultural-education/.

Development overview. Development Overview | Next Generation Science Standards. (n.d.). https://www.nextgenscience.org/development-overview.

Finding a good anchor phenomenon for Your NGSS UNIT. iExploreScience. (2021, April 23). https://iexplorescience.com/anchor-phenomenon/.

Michigan State Board of Education. (2015). *Michigan K-12 Science Standards* (pp. 26–34). Michigan Department of Education.

NextGenScience, & Achieveinc. (n.d.). *Using Phenomena in NGSS-Designed Lessons and Units*. Issuu. https://issuu.com/achieveinc/docs/using_phenomena_in_ngss.

Phenomena basics. Iowa Science Phenomena. (n.d.). https://phenomena.iowapbs.org/using.

Segments. Curriculum Resources for Michigan Agriculture Teachers. (n.d.). https://www.canr.msu.edu/agriscience/curriculum/segments/.

Three dimensional Learning. Three Dimensional Learning | Next Generation Science Standards. (n.d.). https://www.nextgenscience.org/three-dimensions

What is PBL? PBLWorks. (n.d.). https://www.pblworks.org/what-is-pbl.