INSECT FOOD COURT: GMOS AND FEEDING PATTERNS

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HIGH SCHOOL BIOLOGY

This curriculum module was developed by the Sci-LiFT program at the University of Missouri.

Introduction:
The focus of this lesson is how genetically modified (GM) plants are related to natural selection. This will be directly demonstrated in the choice assay when students see that genetically modified plants deficient in a defense hormone called jasmonic acid (JA) are quickly eaten by the insects. The connection is that plants without certain genes are much weaker and will die off (as in survival of the fittest / natural selection), and conversely, if we genetically modify the plants to have certain beneficial genes (“assisted natural selection”), then the plants will thrive and continue on. Currently there is a lot of controversy over genetically modified organisms (GMOs) that has led to a large amount of misinformation. A secondary goal of this unit is to reduce the misinformation and myths about GMOs, and provide students with factual information to go out and make the most ethical decision(s) possible. The teacher should encourage student discussion throughout the course of the unit.

NGSS:

HS-LS4-3: Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. [Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.] [Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.]
LEARNING OBJECTIVES/GOALS:

1. Students will apply their understanding of organisms with an advantageous heritable trait tend to increase in proportion compared to organisms lacking this trait.
2. Students will construct an explanation for how natural selection could lead to the adaptation of populations.
3. Students will design and support a claim about the effects of environmental conditions related to the increase in the number of individuals of some species.

MATERIALS:

- Insect eggs (*Trichoplusia ni*)
  - From Benzon Research ([http://www.benzonresearch.com](http://www.benzonresearch.com)), you typically have to order a minimum of 1,000 eggs at a time and have them shipped overnight.
- Artificial insect diets
- Insect feeding cages
- Soil
  - Can be purchased online or purchase from a home improvement store.
- *Arabidopsis thaliana* seeds
- Plant pots and trays
- Scissors
- Spatula
- PPE
  - Safety goggles, heat insulated gloves
- Weighing scale
- Hot plate or stove
- Magnetic stir rod or spoon
- Freezer (for storage of powdered insect diet)
- Petri plates/mold/plate (for insect food)
- Water
- Parafilm/ziploc bags
- Measuring glass/beaker
- Permanant markers
- Paper towel/kimwipe
- Foil
ADVANCE PREPARATION:

One month before class:
The model plant Arabidopsis thaliana takes about one month to grow leaves with satisfying size for insect choice assay. Therefore, start growing the plants ahead of time. Each plant will have approximately 6 leaves for use. So be sure to grow enough plants for the whole class (instructions for proper amount of leaves listed below). By incubating the seeds in water at 4 °C for several days, it increases germination rates and helps synchronize germination of the seeds (optional). When planting Arabidopsis thaliana, you only need to place the seed on top of the soil. It is important to not overwater the plant or let the soil get dry to prevent stress in the plant. The soil must be kept moist, but not overly wet. Water once a week or every 4-5 days as needed.

Number of plants to grow (for one class):
The class is to be divided into 3 groups. Each group will have 4 dishes (48 leaves per group), 144 leaves for the whole class. Considering each plant would have 6 leaves, it is necessary to sow at least 24 plants total, 12 plants being for each genotype. To ensure enough plants, it is recommended that 20 plants to be prepared for each genotype. The plan is for each class to compare two genotypes (e.g. wild type vs. JA deficient mutant), so you will prepare 40 plants per class.

Each group needs 8 plants (4 one genotype, 4 second genotype) because each plant yields about 6 leaves.
SAFETY:

- GM plants should not be released into the environment so that they don’t spread. The materials you are using are of less concern because they are sterile mutants that do not reproduce.
- The plant seeds and insect eggs are for scientific use only. It is important to not plant the seeds outside of the lab or release the insects so that you do not disrupt the local ecosystem.
- Liquid nitrogen is suggested to euthanize the insects used in the lab. Alternatively, a freezer can be used. Be careful while handling and working with liquid nitrogen. Make sure to use proper personal safety equipment, such as goggles and heat insulated gloves.

MODULE OVERVIEW:

This module is estimated to take seven 90-minute periods. This module is suggested toward the beginning of your natural selection unit.

NOTE: 1 day is considered a 90-minute class period. Days are consecutive (e.g., if you have block periods every other day, Monday represents Day 1, Wednesday is Day 3, Friday is Day 5, etc.)

Day 1: Unit Overview- Introduction/Start Lab, start insect hatching (2-days are typically needed for hatching)
Day 2: Continue growing insects on artificial diet
Day 3: Designing Choice Assay Apparatus
Day 4: Choice Assay Experiment Setup
Day 5: Observation and Data Collection of Choice Assay Experiment/ Lab Clean Up
Day 6: Data Analysis
Day 7: GMO Discussion

ACTIVITIES:

**Day 1:** Unit Overview- Intro/ Start Lab:

https://munsfsclift.files.wordpress.com/2017/08/powerpt-for-sciliftmodule.pptx
Plant vs. Insect competition [Powerpoint slide 1]
- [Powerpoint slide 2-3] To introduce the theme of the module, show examples of competition and continuous co-evolution in animals, and all kingdoms. (a few slides with super photos/ pictures, e.g. a lion chasing a deer (both need to become fast--coevolution), a bacteria defending against virus (virus wants to invade bacteria, and bacteria is defending to prevent invasion--coevolution)), short!
- [Powerpoint slide 4-6] Link to plants vs. insects, mention that even if plants are not moving around like animals, they are trying to defend themselves against insects, and such competition is happening all the time.
- [Powerpoint slide 7] To continue the explanation of competition between plants and insects, the class will watch a funny video on plant defense mechanisms against insects. This will help inform students to make a connection: https://youtu.be/8Ofgj2KDbfk (6 minutes)
- [Powerpoint slide 8] Activity: You are a plant. How do you defend yourself against insects? (Goal of this: Address the idea that plants can become “toxic”, release chemicals against insects, which leads to introduction of jasmonic acid mechanism). ~10 mins
- [Powerpoint slides 9-14] Jasmonic acid as a defense against insects. By genetically modifying a plant, we can directly deprive their defense system so that we can see the result. Therefore, GMOs are also helpful in scientific research.

Food & Farming relationship [Powerpoint slide 15]
- [Powerpoint slide 16] Formative assessment is distributed to students to test their understanding of GMOs: Opposing Claims Probes (Science Formative Assessment, Volume 2, Page Keeley 2015)
  - Pose the question: Are GMOs harmful/bad? (a few minutes)
  - Students will select which claim (yes or no; true or false) that most reflects their views and with supporting evidence, they must explain why they chose this claim over the other.
  - This is a great pre-assessment before diving into the GMOs discussion, as well as, to see where students’ preconceptions are at. The teacher can make adjustments to the curriculum if there are multiple misconceptions that need to be addressed.
  - Optional: Teacher can have students get into small groups to discuss what their claims are (teacher will be walking around to spark discussion and pose questions: play both sides of the argument (true/false), and then after going to each group, bring it back to class and ask for student participation to share their thoughts to the entire class… which will lead to the poster/discussion/lecture (5-7 mins).
- [Powerpoint slide 17] Introduce the GMO poster: The good, the bad, and the ugly; which talks about everything you should know
about GMOs. This is a balanced poster with both sides for and against GMOs (10 mins).
- This is a brief, but informational poster that the teacher can lecture from, explaining to the students about GMOs. Students should take notes off of this (have provided guided notes to any students with accommodations: a handout of the poster or have a designated note taker to share their notes with those students)
- Pose discussion questions over any controversial points and ask if students' claims have changed or not from the pre-assessment they had did before.
  - Quick discussion points:
    - GMO labeling on food
    - Feeding the large population
    - Potential allergens
    - Benefits of not using chemical pesticides/fertilizers

- Intro to the lab (Day 1): Transition from the GMO lecture to the day 1 of the lab by explaining to students the purpose of the lab and what will be accomplished from the lab. The connection between plant versus insect and the GMO discussion: How plants adapt to their environment depending on different traits they have. Which trait increases in population than other traits; defense mechanism

Lab: Protocol
Day 1: Beginning of Lab for Insect Hatching:

The insect eggs can be ordered from Benzon Research, which is a reliable source of lepidopteran insects. Ordering around 1000 eggs should be sufficient for this lab, and they are usually shipped overnight. The eggs typically start to hatch within 48 hours of incubation at 28 °C.
  - (See Protocol for Insect Hatching)
  - Students will be working in 3 groups (or more at teacher's discretion), completing the experiment; walk around and help students as needed. Pose discussion questions to the groups to promote learning.
  - Students will be putting insect eggs that were bought from Benzon Research (e.g., Trichoplusia ni) into feeding cages with the already prepared insect diet. Feeding cages will be sealed so insects can't escape. A small vent should be made ahead of time for the feeding cages (using cloth materials) for air exchange. Students will put the prepared petri dishes in 28 C° for 6 days, so insects can hatch and grow into a sufficient size for the choice assay. If 28 degree incubator is not available,
the eggs can also hatch at room temperature, but this might take the eggs a day or so longer to hatch.

- Depending on the class schedule insect hatching and growing can be done by the teacher in advance.

Day 2: Wait for insects to hatch and upon hatching make observation of hatched insects.

Day 3: While insects grow, have students design a choice assay apparatus (such as the ones pictured below). Explain to students that this is a type of standard scientific procedure used to compare choice between the control and the independent variable (the GMO mutant). A main reason for genetic modification has to do with resistance to insects and other pests. This activity demonstrates that the knockout or expression of a specific trait can have a drastic effect on the feeding patterns of insects. It will give students a visual on how drastic this could be. This is important in the real world in the sense of farming patterns and the ability for farmers to grow different crops without having to use harmful pesticides. At the end of lesson, have students explain why they picked their design. Is it most effective? Why? Some designs allow little or no choice for the insect to turn around after their initial decision. How would this affect the experiment?

- Student can use creativity in designing an apparatus for the choice assay experiment. The teacher can focus on skills needed for designing investigations by having students create their own apparatus. If needed, teachers can have students follow pre-planned petri dish apparatus with the control wildtype and JA deficient leaves setup. Some examples are shown below.

images

http://biology-web.nmsu.edu/~hansen/bioassays.htm
Day 4: Choice assay experiment setup:
- To start this lesson you can have students hypothesize which genotype they think the insects will feed on and why they think that.
- Assemble the choice assay that the students designed on day 3 or the pre-designed choice assay included in this module. After apparatus setup, insects should start out in the center of petri dish to avoid any bias. There should be at least 5 insects per petri dish. Each group should prepare at least 4 petri dishes to have enough replicates. Once the experiment is established, let it sit overnight and revisit the following class period.
- To close this lesson, ask students if they notice a pattern among the insects. Do the students see an insect preference already? Students may or may not see a preference this early.

Day 5: Observation and data collection of choice assay experiment / Lab clean up:
• Ideally, this should be done within 24 hours since the last class period. If this is not possible, make adjustments to delay insect feeding (e.g., use less number of insects, use more and bigger leaves, use smaller insects).
• Get ready to find out which genotype the insects prefer to eat. Invite students to collect the data by counting genotypes.
• Student will record number of insects on each genotype in each dish. Then students can put the data of whole class together to reach a conclusion.
• Ask students if their hypothesis from the previous day was correct and how do they know this? Did the insects have an obvious preference or was it about equal? Do the different choices in food have an influence in the natural selection and breeding habits of the insects? Why or why not? To conclude ask the students if they are surprised about their results and the overall class results. Maybe here they could discuss any experimental error they thought may have influenced the insects one way or another.
• Euthanize all insect and dispose of bio material properly.
  • To euthanize the insects, pile the insects in 1 or 2 petri dishes and put that in liquid nitrogen for a minute or so. This is a humane way to kill them as this should freeze the insects immediately, making them feel no pain. If liquid nitrogen is not available, the insects can be put in a freezer until frozen and then be disposed of.
  • Wipe down counters and wash all lab materials.

Day 6: Data Analysis
The previous day concluded with the topic of natural selection and breeding habits. The definition of natural selection is “the process whereby organisms better adapted to their environment tend to survive and produce more offspring.” Why would natural selection be relevant with food choices available? Would the evolution of the insects have an impact on the evolution of the plants?

• Students will be using excel sheets to organize their data collection and analyze their data. For students that have previous statistics knowledge, a statistical analysis is recommended.
  • Sample Excel Handout (for students who are new to excel): http://www.osceolalibrary.org/pdfs/Excel2010.pdf

<table>
<thead>
<tr>
<th>Insect Tray</th>
<th>Genotype 1</th>
<th>Genotype 2</th>
<th>No Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>2</td>
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<td>3</td>
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<td></td>
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<tr>
<td>4</td>
<td></td>
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<td></td>
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<tr>
<td>Total # of Insects</td>
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</tbody>
</table>
In each box, tally the number of insects that is present on each genotype in that particular tray. Count up the total for each genotype. Insects that are present on the lid or not on a plant should be counted as "No Preference".

<table>
<thead>
<tr>
<th></th>
<th>Genotype 1</th>
<th>Genotype 2</th>
<th>No Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A Total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B Total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group C Total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Class Total</td>
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</tbody>
</table>

With the data presented in this class table, it will be easy to see which genotype the insects preferred to eat. There should also be visual evidence that supports this data (easily seen which leaves are eaten, and which are not).

To conclude the lesson, you could ask the students “Do you see why it is important for plants to evolve to be insect resistant, and why it is important for these insects to select mates that will give their offspring the best chance at being able to eat the plants?” How does this relate to modern day GMOs (this could lead into the discussion for tomorrow).

Day 7: GMO Discussion

**Discussion Activities:** After concluding the investigation of a genetically modified plant, this class will focus on the societal issues of GMOs. Here are 2 ideas that could be used to mediate a class discussion about these issues.

Option 1: Have students choose whether they want to be on the pro-GMO, no-GMO, or neutral groups. Students can go home and research and write down 3-5 arguments (or questions) to bring up and debate for the next day. The next day, split the desks up into two different sides and mediate a class debate. As the class debates, the indifferent student will have an opportunity to ask questions. At the end, take a vote to see which side “won.”

Option 2: Have student go home and research 3-5 arguments (or questions) to bring up for discussion the next day. The next day, form a circle with the desks and go around the circle (or throw a ball) with the person discussing what they learned, any questions they have, or an argument for a previous statement.

**Reading:** Provide literacy strategies for students to read the following text. Then discuss students’ ideas about the reading with the class (see the discussion points below).

Since the beginning of time, plants and animals have been co-evolving to meet each of their needs for survival. The prey evolves to evade the predator, the
predator evolves to feed on the prey; a never ending cycle of evolution. This is done through naturally occurring changes in their genetic materials which, by definition, is a genetic modification. Some misconceptions about GMOs are that scientists are just injecting chemicals into organisms and turning them into “Frankensteins”. In reality, many practices of genetic modification are those we have mimicked after naturally occurring processes. Agrobacterium, for example, is a soil bacterium that naturally injects its own genes into plant cells for stable integration into plant's genome—this same process is responsible for emergence of sweet potatoes, a naturally transgenic food crop. This same bacterium is used as a very useful vessel of transformation for GM plants. There is a consensus belief among the scientific community that without this and other GM technologies (such as genome editing by CRISPR-Cas9) it would be difficult to meet the increasing food demand for the exponentially growing human population in the near future. On the other hand, there are a number of ethical and safety questions, including whether taking these natural processes and speeding them up ourselves is too fast for nature to handle or whether they could have long-term effects that we don’t know about. In this experiment, agrobacterium was used to transform the model plant Arabidopsis into a JA deficient mutant to evaluate its effect on plant resistance against insect pests. How does this relate to real-life agriculture? Is being able to manipulate these plants a useful tool to farmers regarding crop protection?

Discussion points of GMO ethics for teacher:
These can be part of a larger discussion near the end of the unit and or used throughout the unit

- **Biodiversity and GMOs** (targeting specific pest instead of killing everything except crop)
- **Habitat Fragmentation and GMOs** (reducing the amount of agricultural land necessary)
- **Health and Nutrition**
  - Biofortification of foods (especially staple foods in poorer countries)
    - Eliminating vitamin deficiencies, i.e., vitamin A “golden rice”
  - Eliminating “food deserts”
  - Feeding the growing population
- **Intrinsic health concerns**
- **Labeling of GMO foods** (right to know? Or negative connotation?)
- **Insect and weed tolerance** (superbugs/weeds, analogous to antibiotics issue in medical field)
- **Uses of pesticides/herbicides/fertilizer**
  - “Roundup ready” crops
  - Using less chemicals due to GMOs
BACKGROUND FOR TEACHER:

Genotype choice:
To teach students about significance of GMO and jasmonic acids, it is suggested to use wildtype and jasmonic-acid-deficient (which is genetically modified) *Arabidopsis thaliana*. Note that there are multiple proteins that are involved in jasmonic acid pathway inside plants. JA biosynthetic mutant, *aos*, mutated in a gene encoding Allene Oxide Synthetase enzyme and the wildtype seeds can be requested to Dr. Koo’s Lab (kooaj@missouri.edu). A link to order Arabidopsis seeds from public depositary can be found in the “Resources” section below.

On the day of class:
Teach the class to hatch the eggs on the diet. It takes about 48 hours for all eggs to hatch. Then wait another two to four days for insects to grow big enough for choice assay.

Choice Assay Setup:
The goal of a “choice” assay is to have the insects choose which plant to feed on inside a petri dish. Therefore, in order to minimize influence of other factors, make sure to select leaves of similar sizes from both genotypes. Also, the insects have to be transferred to the center of the dish to minimize influence of their locations. It is important to prepare at least 4 replicates for statistical purpose. Number of replicates can be increased to improve the confidence level of the obtained results.

During Assay:
The insects consume plants fast. Leave the insects in the dish just overnight. If the leaves of one genotype are completely consumed, it is necessary to start data collection as soon as possible to avoid insects from going to other leaves. Number of insects, amount of leaves, developmental stage (size) of insects, and duration of feeding are variables that can be used for optimization.

PROTOCOLS:

Pre-Designed Protocol for Choice Assay
This is an option if the students aren’t designing their own choice assay.

Materials:
- WT *Arabidopsis thaliana* & JA deficient *Arabidopsis thaliana*
- Scissors
- Petri dish
- Paper towel/kimwipe
- Water
- Foil
1. Each group will need 4 petri dishes and 1 fully grown plant of each *Arabidopsis thaliana* genotype (1 WT & 1 JA deficient) per petri dish used (8 plants total). Label the petri dishes on the bottom numbers 1-4.

2. Cut small squares of foil and paper towel/kimwipe. Big enough for 3 leaves to sit side by side. Slightly wet the paper towel, place inside of foil, and fold the foil into a pocket where the leaves will eventually sit. (See picture for example). The wet paper towel will keep the leaves from drying out while the choice assay is completed. You will need 4 of these per petri dish.

3. Each petri dish will need 6 leaves from the WT genotype and 6 leaves from the JA-deficient lab. Cut 6 leaves of about the same size from each plant. Avoid mixing up the genotypes.

4. Place 3 leaves of a genotype into each foil with paper towel. Be careful to not damage leaves. Label the foil with the genotype used. (You can assign a number or color to each genotype and use a sharpie or colored sticker to label the foil).

5. Arrange the leaves of 3 in the petri dish with the same genotype across from each other. (See picture for an example). You can tape the foil to the petri dish so that the leaves don’t move.

6. Place 5 insects in the middle of the petri dish. (This way they can choose which leaves they want to go to and aren’t influenced.) Close lid. Make sure not to shake the petri dish after placing insects.

7. Observe the insects and leaves the next day and record data of how many insects were on each genotype and which genotype was eaten more. (See empty data chart provided). Record how many insects are on each genotype.
<table>
<thead>
<tr>
<th>Plate</th>
<th>Genotype 1</th>
<th>Genotype 2</th>
<th>N/A (Lid, middle, not on plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>4</td>
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</table>

**Protocol for food (insect diet):**

The reason for using the insect diet is to grow the insects to sufficient sizes before they are put in an environment with WT and JA deficient plants. The insect diet comes as a powder from Southland Products (http://www.tecinfo.com/~southland/). The powder must be stored in a freezer for long term storage. Makes sure to wear the proper safety gear (PPE), which includes safety goggles and heat insulated gloves.

1. Weigh out the proper amount of diet powder per amount of water. In the case of the *Spodoptera exigua* diet, it is 162g/1L. An example would be if you wanted to make 100 mL of diet, weigh out 16.2g of powder.
2. Bring the water and metal stir rod (if on magnetic hot plate is used) to a boil. The diet will not solidify (gel) if it is added to only warm water, since it will not melt completely.

3. Add the weighed out powder to the boiling water and stir.

4. Once the powder is completely melted and suspended, pour into a mold of choice and let solidify. Partially cover to keep contaminants from getting in, but have it open enough for it to cool.

5. The insect diet can be used immediately, or stored in a cool environment and sealed with parafilm or in a ziploc bag to avoid drying out.

**Protocol for Insect Hatching**

We will need to hatch insects for our choice assay. These insects are the pests that will eat our plants. We will be viewing which plants the insects prefer in our choice assay.

Materials:
- Insect feeding cages
- Insect food
- Insect eggs (*Trichoplusia ni* also known as cabbage looper)
- Scissors
- Spatula

1. Prepare insect feeding cages for hatching insects by scooping out and placing the already prepared solid insect food into the bottom of the feeding cage. (Feeding cages can also be made DIY with tupperware container and sealed vent holes).

2. Cut the insect egg sheet (wax paper with eggs attached on its surface) so that the sheet is able to fit into the bottom of the feeding cage.

3. Place the sheet with the eggs, egg side down on top of the food.

4. Seal lid tightly to ensure no insects can escape.

5. At 28 degrees C, it should take 2 days for the insects to hatch. Since you are probably completing this lab at room temperature, it may take 3 days for your insects to hatch.

(Note: The insect eggs can be stored at 4 degrees C for at least 7 days for later use, however, cooler temperatures reduce the uniformity of hatching time and eggs will lose viability after about 10 days.)
EXTERNAL LINKS FOR REFERENCE:

GMOs and Climate Change:  

Coevolution:  
http://evolution.berkeley.edu/evolibrary/article/evo_33

Crops and Technology:  

Ethics of GMOs:  
https://www.macalester.edu/~montgomery/GMOs2.htm

RESOURCES:

Video used for Day 1:  
- https://youtu.be/8Ofgj2KDbfk

GMOs and Climate Change:  

Coevolution:  
- http://evolution.berkeley.edu/evolibrary/article/evo_33

Crops and Technology:  

Ethics of GMOs:  
- https://www.macalester.edu/~montgomery/GMOs2.htm

Scientific Review Paper, "Plant-insect interactions: an evolutionary arms race between two distinct defense mechanisms:"
Arabidopsis Wild Type (WT) Seeds:
- [https://www.arabidopsis.org/servlets/TairObject?type=species_variant&id=90](https://www.arabidopsis.org/servlets/TairObject?type=species_variant&id=90)
  - CS1092, CS1093, or CS6673 are all eligible WT candidates.

**DIFFERENTIATED/ACCOMMODATIONS/MODIFICATIONS/INCREASE IN RIGOR:**

- Consider providing guided notes that can be available to all students, unless they prefer to write down their notes anytime throughout the unit. The guided notes can be based off any notes we have in powerpoints and anything that is being discussed throughout the lessons.
- If students need a reader or writer, a special education assistant could be available to help students throughout the unit or have one of their group members to aid in their work.
- Assign students into groups where they will be able to achieve successfully and where they feel the most comfortable.
- For English language learners, consider uploading the notes on their iPad to be read to them in their language. The app will be able to type in their answers.

**EXTENSIONS:**

*Activities for early finishers that extend students’ understanding of and thinking about the learning objectives by applying their new knowledge in a different way.*

- Terminator Technology Case Study (20 mins):
  [http://sepuplhs.org/pdfs/sgi_genetics_sb_act17.pdf](http://sepuplhs.org/pdfs/sgi_genetics_sb_act17.pdf)
- For Day 2: Discuss food with/without GMOs as an additional engagement activity. This can be done either way: (1) The teacher brings in different food items that contain GMOs and ones that do not contain GMOs, or (2) the students are all assigned to bring in food items from their house that contain GMOs and one that does not. Have students compare and contrast both of the food items:
  - What they found similar/different in nutritional facts.
  - Do the food items with GMOs look similar/different than the food items without GMOs?
- Video Sources:
  - [https://vimeo.com/131465397](https://vimeo.com/131465397)
    - MU genetic study of co-evolution
  - [https://youtu.be/WTdtXJcrTR4](https://youtu.be/WTdtXJcrTR4)
    - Plant defense
  - [https://youtu.be/ZRxVjuVR4YM](https://youtu.be/ZRxVjuVR4YM)
    - NSF plant defense against herbivory
- https://youtu.be/7TmcXYp8xu4
  - GMO ethics
- https://youtu.be/2G-yUuq1Z0
  - Good example of GMO papayas
  - Positive use of GMOs

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This curriculum module was developed by the 2017 Sci-LiFT program at the University of Missouri. Undergraduates investigated plant defense mechanisms in the laboratory and then produced related lessons for high school.


Let us know how this curriculum module worked in your classroom! Please provide feedback to the Sci-LiFT program by going to our webpage at: https://munfsclinift.wordpress.com/contact/