Genetically Modified Organisms (GMO) Unit Plan

Major Themes for the Unit

- Scientific themes: Gene expression, genetic modifications
- Scientific practice: Computational thinking
- SSI: Genetically modified food

Driving Question: What role should GMOs play in creating a safe, diversified and stable food economy?

Concepts needed to explore the driving question

- Science concepts: transcription, translation, protein folding, genetic modifications
- What social ideas and concerns influence negotiation of the issue?
    - History of food production
    - Food regulation
    - Food production and availability
    - Sustainability

Unit-level performance expectations

NGSS: HS-LS1-1	**STANDARD / PE:** 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. **ASSESSMENT BOUNDARY:** Assessment does not include identification of specific cell or tissue types, whole body systems, specific protein structures and functions, or the biochemistry of protein synthesis.
GM Technology	Construct an algorithmic explanation of the process of genetically modifying plants.
GM Food Issue	Investigate stakeholder perspectives on the issue of GM food and argue the issue based on evidence with other perspectives.
GM Food Issue	Take an informed stance on the issue of GM food based on social and scientific evidence.

Unit assessment(s)

- Algorithms created throughout the unit
- Stakeholder symposium

Lesson sequence

Lesson (time)	Lesson Focus	Learner Objectives	Activity/assessment
1 (180 min)	Introduce the issue	Students will experience the issue of genetic modification for food production.	Pre-Assessment, GMO poll, GMO debate, argumentation web
2 (90 min)	Introduce GM food	Students will discuss the	Reflect about GMO

		history of food production and investigate common GM foods.	debate, history of food production presentation, investigate common GMOs, discussion
3 (90 min)	Introduce computational thinking	Students will explore creating algorithmic explanations of common processes.	Play Lightbot, CT discussion, algorithms of getting ready in the morning
4 (120 min)	Gene expression	Students explore and simulate gene expression.	Transcription and translation videos, body model translation and protein folding, algorithms of gene expression, inheritance and genetic engineering presentation and videos, algorithms of gene expression
5 (90 min)	Local Stakeholder Presentation	Students experience and discuss the issue with a local stakeholder.	Local stakeholder presentation and discussion
6 (105 min)	Food Inc. video	Students learn more about food production by watching the Food Inc. movie.	Food Inc. movie, discussion
7 (90 min)	GM food issues	Students investigate GM food issues and evaluate sources of information.	Reflective scientific skepticism discussion, GMO issues and questions activity, mini seminar
8 (180 min)	Stakeholder symposium	Students generate and communicate arguments based on evidence for stakeholder perspectives on the issue of GM food.	Introduce the stakeholder symposium, work time, conduct stakeholder symposium, final stance writing

Additional Resources

Socratic Seminars:

Adler, M. (1982). A revolution in education. American Educator 6(4): 20–24.

Billings, L. and Roberts, T. (2003). *The Paideia seminar: Active thinking through dialogue.* Chapel Hill, NC: National Paideia Center.

ChowningJ. T. (2009). Socratic seminars in science class. *The Science Teacher, 76*(7), 36.

Critical Thinking and Reflective Scientific Skepticism:

Kinslow, A.T., Sadler, T. D. Teaching critical thinking through a socio-scientific instructional approach. *The Science Teacher*, (In Press).

Kinslow, A.T. Reflective scientific skepticism: theory to practice. (In Review).

Lesson #1: Introduce the issue

Goals for the lesson/learner objectives:
Students will experience the issue of genetic modification for food production.

Lesson assessments:
Pre-Assessment algorithm

Materials:

- Algorithm Packet
- GMO Poll- this can be created on paper or with whatever software or app is available to the class. Questions include: What is your position on GMOs at this point?
  How informed are you on GMOs? (Likert scale)
- GMO Debate: https://www.intelligencesquaredus.org/debates/genetically-modify-food

Instructional sequence

Timing	Activities	Materials
5 min	Students complete the pre-assessment algorithm, allowing teacher to see what ideas and understandings students begin the unit with.	Algorithm Packet
5 min	Students take a GMO opinion poll to set a baseline for their ideas.	GMO Poll
1 min	Introduce the argumentation web to students. Students should create a web of the arguments each side is making throughout the debate. They should connect the evidence presented to the arguments made throughout the debate.	
~120 min	Watch the GMO debate and pause the video where concepts need elaboration. For example, when BT crops are discussed, pause and discuss: What is BT? What are BT crops? Pause the video after both opening statement, giving students time to begin creating their argumentation webs. Students continue argumentation webs throughout the video.	GMO Debate Video
5 min	Students take the GMO poll again to see if their ideas have changed.	GMO Poll

Lesson #2: Introduce Genetically Modified (GM) Food

Goals for the lesson/learner objectives:
Students will discuss the history of food production and investigate common GM foods.

Lesson assessments:
Students will create initial algorithms for gene expression, allowing teacher to assess students' prior knowledge.

Materials:
- History of food production slides
- Laptops, or some device to use for research

Instructional sequence

Timing	Activities	Materials
15 min	Reflect about GMO debate: Students should complete their argumentation webs about the arguments presented during the debate. Students then share their charts with others and discuss the arguments made in the video. The reflection should end with a class discussion of the arguments each side made and the evidence they used to support those arguments.	
30 min	Teacher presents the "history of food production" presentation, discussing how food production has changed over time and the factors that influenced those changes. The focus of this presentation is to show and discuss how science is intertwined with the social aspects of food production.	History of food production slides
15-30 min	Students work individually or in pairs to investigate common GMOs. Students should look up common GMOs, and choose one to research more about. Students should identify why the GMO was made, and what it is used for.	Laptops, or some device to use for research
15 min	After work time, the teacher should lead a class discussion about the students' findings. • What are some of the common GMOs you found? • Why was that GMO made? • What is it used for in our society? Some common examples of GMOs: bacteria that produce insulin for diabetics, bacteria that produce rennet enzymes to make cheese, and common GM crops include corn, cotton, and soybeans.	

Lesson #3: Introduce Computational Thinking (CT)

Goals for the lesson/learner objectives:
Students will explore creating algorithmic explanations of common processes.

Lesson assessments:
Student generated algorithms can be used to assess CT understanding.

Materials:

- Peel and Friedrichsen (2018) article. Email Mandy Peel at anpn98@mail.missouri.edu for an electronic copy of the article.
- Lightbot: Download "Lightbot: Code Hour" from the app store for tablets and phones, or go to http://lightbot.com/flash.html for computers

Instructional sequence

Timing	Activities	Materials
60 min	Students play the Lightbot game and teacher introduces CT concepts as described in Peel and Friedrichsen (2018) article. The game can be played as homework.	Tablets, computers, or smart phones; Lightbot
30 min	Students apply CT Principles they just learned about to a common process. Students work in groups with white boards to create algorithms of getting ready in the morning. Prompt students to use the CT principles in their algorithms. After students finish, their group algorithms, students share their algorithm and explain it to another group, or the whole class if time permits.	White boards, markers

Lesson #4: Gene expression

Goals for the lesson/learner objectives:
Students explore and simulate gene expression.

Lesson assessments:
Students' algorithms of gene expression can be used to evaluate their understanding of gene expression.

Materials:

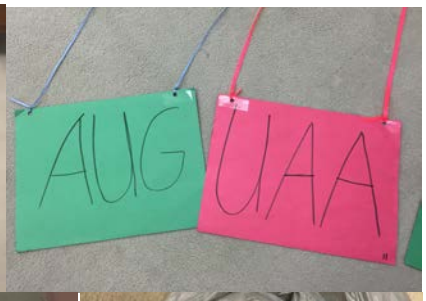
- Algorithm packets
- Transcription video: http://www.hhmi.org/biointeractive/dna-transcription-basic-detail
- Translation video: http://www.hhmi.org/biointeractive/translation-basic-detail
- Gene expression video: https://www.youtube.com/watch?v=gG7uCskUOrA&t=6s
- Body Modeling Materials: Construction paper labeled with 10 different triplet codons and on the backs of the signs, write the property of that amino acid (Hydrophilic/polar, hydrophobic/nonpolar, positively charged, or negatively charged) **See table below**; three chairs labeled A, P, and E; chain blocks labeled as amino acids; codon chart projected. a set of Velcro "gloves" and a ball that sticks to them, a paper airplane

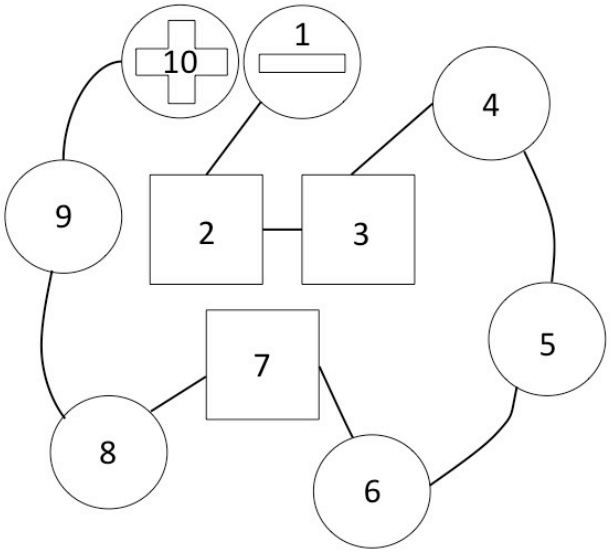
Order Number	Triplet Codon	Amino Acid	Property
0	AUG	Start (Met)	Cleaved
1	GAU	Asp	Negatively charged
2	UGG	Val	Hydrophobic
3	AGU	Trp	Hydrophobic
4	CAA	Ser	Hydrophilic
5	ACA	Gln	Hydrophilic
6	UUU	Thr	Hydrophilic
7	UGC	Phe	Hydrophobic
8	AAC	Cys	Hydrophilic
9	AAG	Asn	Hydrophilic
10	UAA	Lys	Positively Charged

- GMO Videos:
  - Genetic Engineering with Restriction Enzymes and DNA Ligase (1 min) http://www.hhmi.org/biointeractive/genetic-engineering
  - Agrobacterium Transformation (~1.5 min) https://www.youtube.com/watch?v=L7qnY_GqytM
  - What is CRISPR Cas-9 (6 min) https://www.youtube.com/watch?v=52jOEPzhpzc&t=214s
  - Are GMO's Good or Bad (9min) https://www.youtube.com/watch?v=7TmcXYp8xu4

Instructional sequence

Timing	Activities	Materials
10 min	Watch transcription, translation, and gene expression videos, and	

	briefly discuss the process with students.	
20 min	Teacher leads the class through body modeling of the translation process. Ten students wear signs that have triplet mRNA codons on them and line up to form an mRNA strand (make sure START is first and STOP is last). Three seats are set up as the ribosome and are labeled A, P, and E for the three ribosome sites. A bag with chain blocks that are labeled as the 20 amino acids is placed on the A site chair. The first person sits in the A site and reads the table for his/her codon and finds the corresponding amino acid chain block in the bag. The mRNA strand shifts, and now person 1 is in the P site with their amino acid, and person 2 is in the A site. Person 2 reads the table for his/her codon and finds the corresponding amino acid chain block in the bag and the chain shifts again. Person 1 is in the E site and hands their amino acid to person 2, who is in the P site. Person 2 connects his/her amino acid chain block to person 1's, thus beginning the polypeptide chain. Person 3 continues the process. These steps are repeated until the STOP codon is reached and the mRNA disassembles from the ribosome. During this process, 10 students are acting out the sequence and the rest of the class is helping them figure out the process and make meaning around what is happening. The teacher should facilitate and lead discussion of the steps and overall sense-making around the process.    	Body Modeling Materials
15 min	Students body model protein folding using the same amino acid sequence produced in the previous lesson. Note that in this activity, Met is not part of the polypeptide chain because it is cleaved in eukaryotes. The students wearing Asp and Lys put on the Velcro bands around their arms (Lys left arm and Asp right arm). Have the students stand in order and hold hands, and tell them that they have to	Body Modeling Materials; PTC Paper

	fold based on their amino acid properties (hydrophobic towards the center of the protein, hydrophilic on the outside of the protein, and positive and negative attract each other). When folded correctly (see picture below), the active site (two Velcro arm bands should be next to each other) should form between the positive and negatively charged amino acids (Asp and Lys). Place the ball on the Velcro bands so that it is touching both. In this scenario, the arm bands are the active site of the enzyme, the ball is the substrate, and the paper airplane is the taste signal sent to the brain. Use PTC and its taste receptor as an example. When PTC (the ball) binds to the receptor (attaches to the Velcro), the receptor sends a signal of bitter taste to the brain (throw the paper airplane to represent sending the signal). To further the experience, have students taste PTC paper to determine if they have functioning receptors or not.   Body Modeling Folded Protein Top View 	
10-15 min	Students use evidence from videos and modeling to create algorithms of gene expression.	Algorithm Packet
20 min	Watch GMO videos. Discuss inheritance and genetic engineering with students.	

Lesson #5: Local Stakeholder Presentation

Goals for the lesson/learner objectives:
Students experience and discuss the issue with a local stakeholder.

Materials:

- Stakeholder presentation/ visual aids, if he/she chooses to provide.

Instructional sequence

Timing	Activities	Materials
60 min	Local stakeholder presentation: Contact a local stakeholder to discuss his/her connection with food production, and how that is impacted by GMOs. In our unit, we had a local cattle rancher come in and discuss how he raises calves. He discussed how cattle production works from beginning to end (beef sales). The rancher showed how cattle are raised on his ranch vs other ranches. He continued to talk about his stance on food production and GMOs, and why he raises cattle the way he does. Next, he discussed organic, grass fed, and hormone free labeling, and what that really means. Students were able to experience food production from a local rancher's perspective and learn about the decisions he has to make, and why he makes them.	
30 min	Discussion: Students should interact with the speaker, and ask questions as he/she is presenting. Afterwards, students should discuss what they learned, and how the presentation has influenced their ideas about food production and GMOs. Attention should be brought to the social aspects influencing the speaker's decisions, such as economics, ethics, food safety regulations, food labeling, etc. Now that students have learned about some of the social connections to the issue, draw their attention to the science that needs to be understood about the issue: gene expression and how GMOs are made. This will be the focus of the next lesson.	

Lesson #6: Food Inc. video

Goals for the lesson/learner objectives:
Students learn more about food production by watching the Food Inc. movie.

Materials:
- Food Inc. movie
- Food Inc. Watching Guide

Instructional sequence

Timing	Activities	Materials
95 min	Students watch the Food Inc. movie, and fill out the Watching Guide. The purpose of the video is to show students more about how food is produced.	Food Inc. movie; Watching Guide
10 min	After the video, there should be a class discussion with the following discussion questions: • What are your reactions to this movie? • What did you learn? • What surprised you? • What were some of the social aspects discussed in the video? • What are some science connections in the video? • How are GMOs used in food production today? (This may require more research)	

Lesson #7: GM Food Issues

Goals for the lesson/learner objectives:
Students investigate GM food issues and evaluate sources of information.

Lesson assessments:
The handout students complete about the GMO issues can be used to assess student work and understanding of the issue. The mini seminar can also be used to assess student participation and understanding of the issue.

Materials:

- Reflective Scientific Skepticism slides
- GMO Issues & Questions Activity Handout
- Know your sources tool: email atkz8b@mail.missouri.edu for the tool and associated materials

Instructional sequence

Timing	Activities	Materials
30 min	Present the Reflective Scientific Skepticism slides to students, focusing on how to be skeptical of scientific claims and research. With significant socio-scientific issues, media claims about the science behind the issue can often be misleading or fake news. In order to negotiate the opposing scientific claims, students need to know what constitutes a good scientific study, vs a misleading scientific study. This PowerPoint goes through what scientific skepticism is, and how to delineate the scientifically accurate studies from the "studies".	Reflective Scientific Skepticism slides
30 min	GMO issues and questions activity: Students will be assigned to a group of five. Each student will be assigned on of the five sets of questions. Students will research their set of questions using a variety of sources. Each student will analyze two of those sources using "Knowing Your Sources Tool". Students will return to their group and share what they learned from their set of questions. Students will participate in a seminar next class using the research they've gathered. See GMO Issues & Questions Activity Handout for full instructions and details.	GMO Issues & Questions Activity Handout
30 min	Seminar: Students share the research they did to answer their assigned questions with the other members of their group. Students should discuss the issue in light of the new information they have learned.	

Lesson #8: Stakeholder Symposium

Goals for the lesson/learner objectives:
Students generate and communicate arguments based on evidence for stakeholder perspectives on the issue of GM food.

Lesson assessments:
- Stakeholder position summary
- Final stance writing

Materials:
- Stakeholder Symposium Instructions
- Final Response Instructions

Instructional sequence

Timing	Activities	Materials
10 min	Introduce the stakeholder symposium using the Stakeholder Symposium Instructions document. Students should be assigned a stakeholder to research and participate as in the symposium.	Stakeholder Symposium Instructions
80 min	Students use work time to research and prepare for the symposium.	
60 min	Conduct stakeholder symposium: The class is split into two groups, with each stakeholder represented equally in both groups. One group forms an inner ring of desks, and the second group forms an outer ring of desks. The students should sit in the outer ring behind someone assigned the same stakeholder. The inner student will be the "pilot", and the outer student the "co-pilot". The pilot student will participate in the discussion, while the co-pilot can feed the pilot additional information about the topic. For example, if the discussion is about pesticide used, the co-pilot can look up how much pesticides are used annually and feed the information on a piece of paper to the pilot, who can then add that statistic to the conversation. After 30 minutes, the pilot and co-pilot switch roles and seats, and the discussion continues.	Co-pilots may want notes and computers to look up additional information.
30 min	Students should reflect on the issue of food production and write their final stance using the Final Response Instructions document.	Final Response Instructions