Pollinators in the Biology Classroom

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Translating Applied STEM Research into Secondary Science (TASRs)

- Partnering of high school teachers with STEM researchers
- Develop lesson plans aligned to NGSS and National Agricultural Literacy Outcomes (NALOs)

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Honey Bee Lesson Plans

1. **Good Taste: Forager Food Preference (Lab with DNA Fingerprinting)**
2. Fermentation of Honey (Lab with Respiration)
3. Preservation Power of Honey
4. Honey as a Biomolecule
5. Honey Laundering- Imported Food Safety

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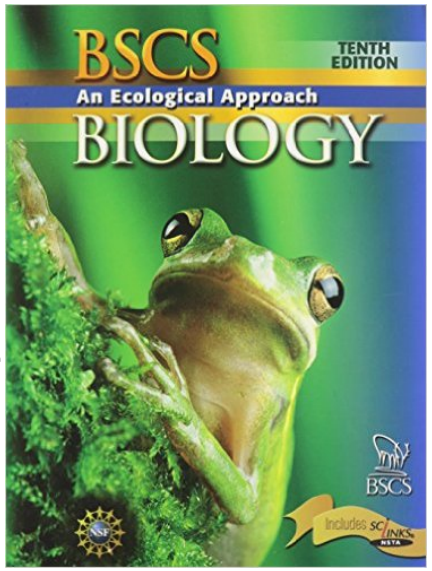
Student Prior Knowledge

- Before starting this lesson, students should be familiar with:
  - How to design a controlled experiment
  - How to identify variables
  - How to draw a conclusion from evidence
- Investigation 1.3 from BSCS Biology: An Ecological Approach (10th edition) teaches experimental design using a bee example



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NGSS and Common Core Standards

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.

RST.11-12.9

- Synthesize information from a range of sources (e.g. texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

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Good Taste: Forager Food Preference

Engage
Explore
Explain
Extend
Evaluate

- If you had a choice, would you rather have a bag of chips or a candy bar?
- Why is that? What factors impact our preferences?

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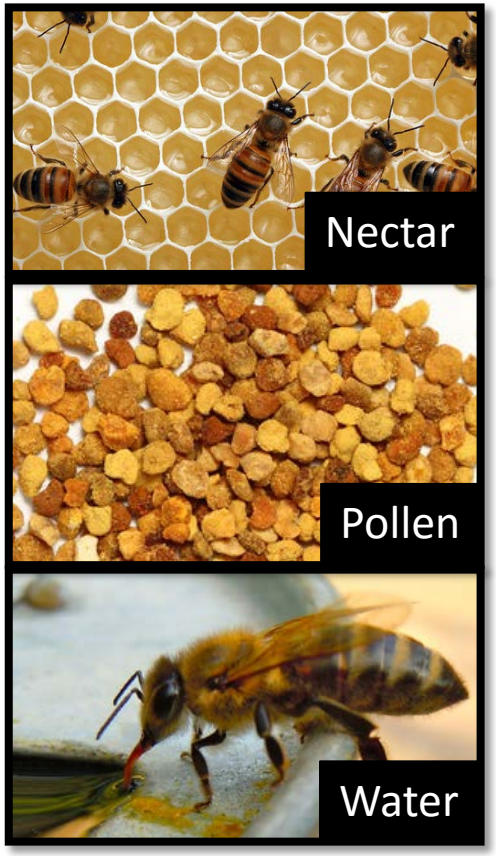
Activity 1

Engage
Explore
Explain
Extend
Evaluate

- **Do individual honey bees experience a similar preference for particular resources?**
  - A honey bee colony needs **nectar**, **pollen**, **water**.
  - A student conducted an experiment to determine which resources foraging bees brought home.



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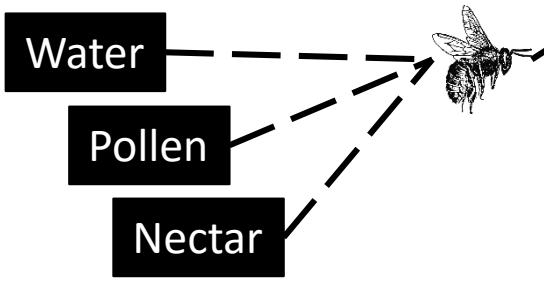
Activity 1

Engage
Explore
Explain
Extend
Evaluate

- Student Experiment
  - Apply numbered tags to 50 worker bees, return them to the hive
  - Monitor foraging activity at the hive entrance at four time points, capture numbered bees
  - Record which resources each bee brought back to the nest in field notes and release bees



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Activity 1

Engage
Explore
Explain
Extend
Evaluate

- Examine the experimental field notes and fill in the data table.

Field Notes

Experiment 1	Field Notes: Foraging Behavior
Time point 1 8:00am	
Weather: Overcast, 66°F, wind speed 12 mph	
Bee #	Resource collected
17	Pollen
34	None
42	Pollen
44	Nectar

Data Table

Bee number	Time Point 1	Time Point 2	Time Point 3	Time Point 4
10				
17				
23				
26				
34				
37				
42				
44				

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Activity 1

Engage
Explore
Explain
Extend
Evaluate

- What did you observe?

Bee number	Time Point 1	Time Point 2	Time Point 3	Time Point 4
10	-	Pollen	Water	Water
17	Pollen	Pollen	Water	Water
23	-	Nectar	Nectar	Nectar
26	-	Nectar	Nectar	None
34	None	None	Nectar	Nectar
37	-	Pollen	Water	Water
42	Pollen	Pollen	-	-
44	Nectar	None	None	Nectar

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Activity 1

Engage
Explore
Explain
Extend
Evaluate

- What pattern did you observe in the types of resources individual bees collected?
- Provide and discuss 3 possible reasons to explain foraging preferences in honey bees.

Activity 1

Engage
Explore
Explain
Extend
Evaluate

- Guide students to discuss how to test for a bee's ability to detect sweetness
  - Testable question: **Is a honey bee's foraging behavior related to its ability to detect sugar?**
  - Students will need more information on how to measure a bee's ability to detect sugar
  - Introduce students to a research tool, Proboscis Extension Response (PER) Assay

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Activity 2

Engage
Explore
Explain
Extend
Evaluate

Proboscis Extension Response (PER) Assay

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Activity 2

Engage
Explore
Explain
Extend
Evaluate

- A stimulus is something that brings about a response.
- A response is the reaction to a stimulus.
- In this video…
  - To what part of the bee is stimulus being applied?
  - How does the bee respond?

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Activity 2

Engage
Explore
Explain
Extend
Evaluate

- Which stimuli bring about a positive response?

Stimulus applied	Bee response
50% sugar solution	Tongue extends
30% sugar solution	Tongue extends
10% sugar solution	Tongue does not extend
Pollen	Tongue does not extend
Water	Tongue does not extend

- A PER threshold is the level at which a positive response is achieved. What is this bee's PER threshold? Explain.

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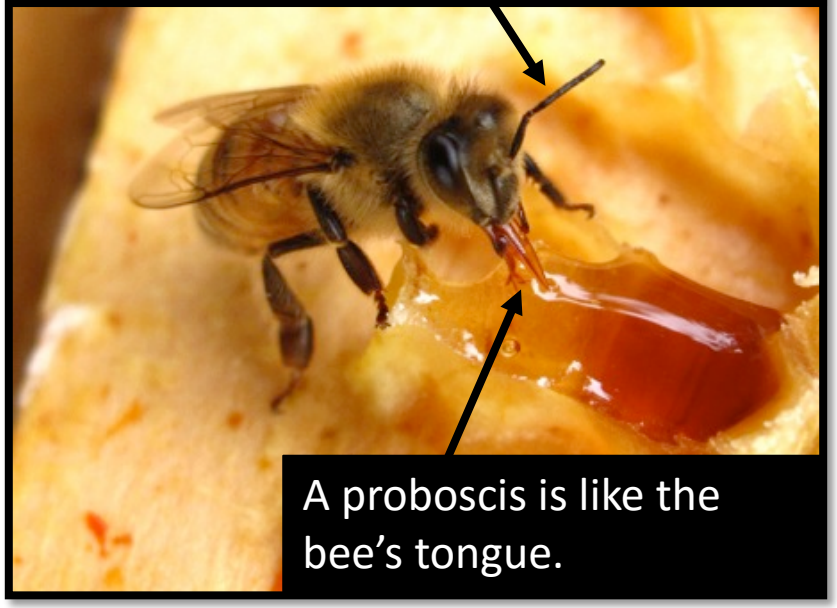
Activity 2

Engage
Explore
Explain
Extend
Evaluate

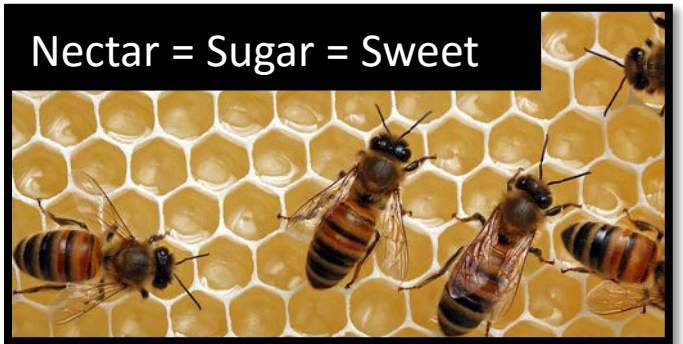
A Few Helpful Facts to Review

Antennae act like the nose and can detect a resource's concentration of sugar.



A proboscis is like the bee's tongue.

Nectar = Sugar = Sweet



Some nectars are sweeter than others.

Pollen = Protein = Not sweet

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Activity 2

Engage
Explore
Explain
Extend
Evaluate

Predict resource preference based on a bee's PER threshold.

Stimulus is applied

Sugar concentration needed to elicit response	Ability to detect sugar	PER threshold	Resource Preference: Nectar or Pollen?
Low	High	Low	?
High	Low	High	?

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Activity 2

Engage
Explore
Explain
Extend
Evaluate

- **Student Experiment**
  - Bees from the first experiment were tested using the PER Assay
  - Refer to you data table from experiment 1.
  - Predict which bees will have…
    - high PER thresholds
    - low PER thresholds

Bee number	Time Point 1	Time Point 2	Time Point 3	Time Point 4
10	-	Pollen	Water	Water
17	Pollen	Pollen	Water	Water
23	-	Nectar	Nectar	Nectar
26	-	Nectar	Nectar	None
34	None	None	Nectar	Nectar
37	-	Pollen	Water	Water
42	Pollen	Pollen	-	-
44	Nectar	None	None	Nectar

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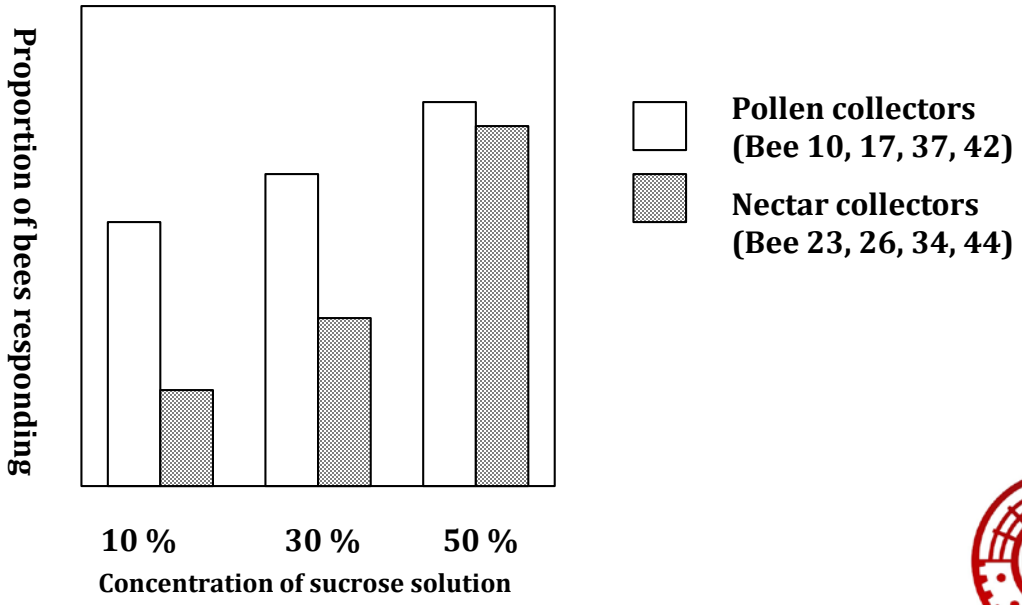
Activity 2

Engage
Explore
Explain
Extend
Evaluate

- Does the evidence in the graph support the student's hypothesis? Explain.
  - *Student's hypothesis: If a bee is a nectar collector, then that bee is more likely to be able to detect high concentrations of sugar. Conversely, if a bee is a pollen or water collector, then that bee is more likely to respond to a lower concentration of sugar.*



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Activities 3 & 4

Engage
Explore
Explain
Extend
Evaluate

- We know that a bee's preference for particular resources is connected to their ability to detect sugar.
  - Testable question: **Is there a genetic component to this ability?**
  - Students will need more information on what genetic tools are available
  - Introduce students to gel electrophoresis and DNA fingerprinting

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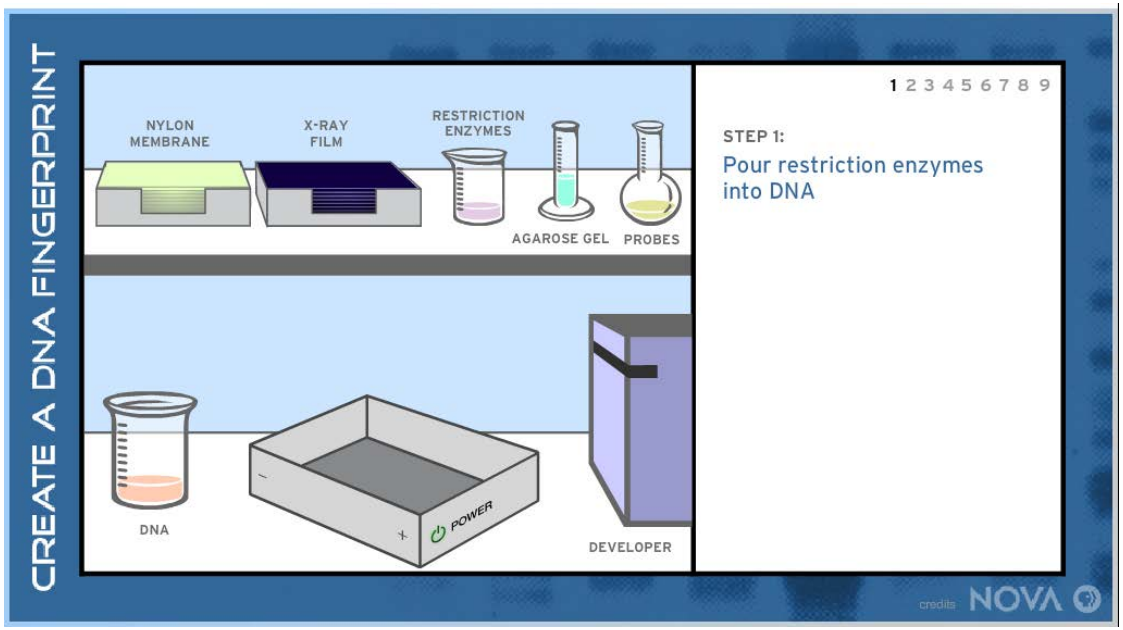
Activity 3

Engage
Explore
Explain
Extend
Evaluate



- Students would complete an web-based activity to investigate the process of gel electrophoresis and its application in DNA Analysis
- You can complete this portion on your own.

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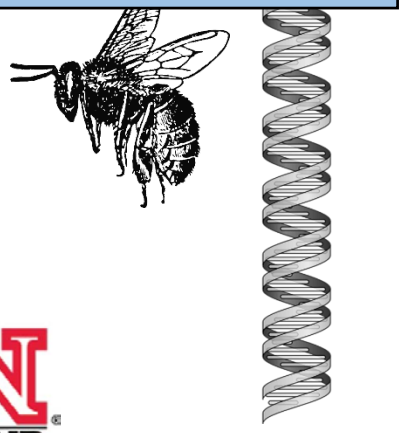
Activity 4

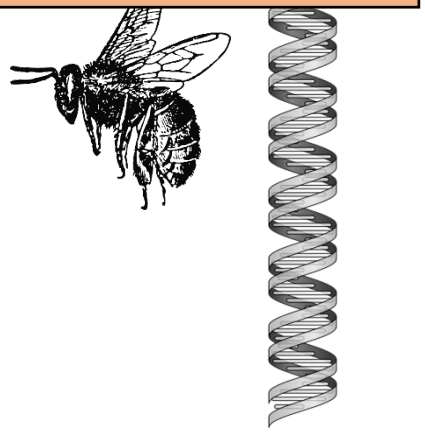
Engage
Explore
Explain
Extend
Evaluate

- Note: The genes responsible for pollen and nectar collecting are still being researched. One day, genetic experiments such as this one could be carried out.
- **Student Experiment**
  - The student compares and analyzes DNA from pollen collecting and nectar collecting bees.

Pollen Collectors



Nectar Collectors



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Activity 4

Engage
Explore
Explain
Extend
Evaluate

- DNA is extracted from pollen and nectar collecting bees
- A restriction enzyme is added which acts like scissors cutting the DNA at different locations. The cuts occur at different places depending on the DNA code and the enzyme's code.
- The enzyme, *Bam*HI, cuts whenever it encounters the sequence, GGATCC. The cut lengths of DNA will vary from bee to bee because of genetic variation within the honey bee population.

G	T	A	G	G	A	T	C	C	T
C	A	T	C	C	T	A	G	G	A

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Activity 4

Engage
Explore
Explain
Extend
Evaluate

- Determine where the restriction enzyme cuts.

G	T	A	G	G	A	T	C	C	T
C	A	T	C	C	T	A	G	G	A

Pollen Collector

T	C	C	T	A	G	G	C	T	C	C	T	A	G	G	A	A	T	C	C	T	A	G	G
A	G	G	A	T	C	C	G	A	G	G	A	T	C	C	T	T	A	G	G	A	T	C	C

Nectar Collector

T	T	C	T	A	G	T	C	T	C	C	T	A	G	G	A	A	T	G	C	T	A	G	T
A	A	G	A	T	C	A	G	A	G	G	A	T	C	C	T	T	A	C	G	A	T	C	A

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Activity 4

Engage
Explore
Explain
Extend
Evaluate

- Fill in the table based on the cuts made and segments formed.

	Pollen collector	Nectar collector
Number of cuts in DNA		
Number of segments of DNA		

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Activity 4

Engage
Explore
Explain
Extend
Evaluate

- How do the number of cuts in the pollen collector's DNA compare to the nectar collector's DNA?
- How will this affect the number of fragments formed on the gel electrophoresis?

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Activity 5

Engage
Explore
Explain
Extend
Evaluate

Gel Electrophoresis Simulation

- Get into groups of 3-4
- **Materials Needed:**
  - gel electrophoresis card
  - small bowl
  - water
  - 0.5 tsp washing soda
  - plastic spoon to stir
  - paper towel

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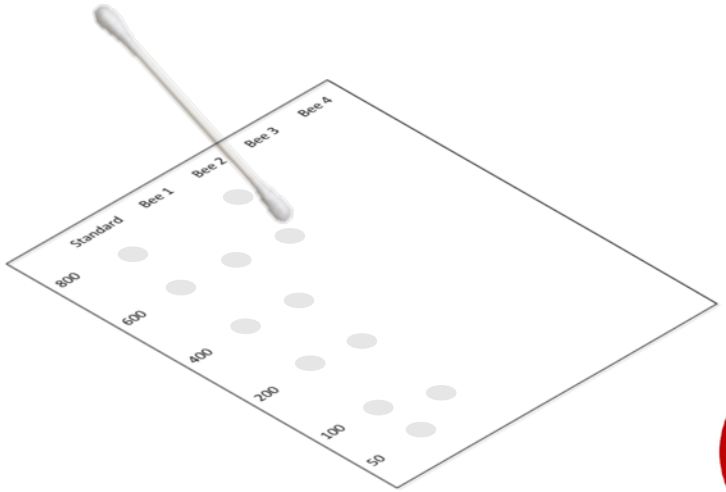
Activity 5

Engage
Explore
Explain
Extend
Evaluate

Making the Gel Electrophoresis Cards

- Copy the template onto typing paper and cut apart
- Place dots on card according to location in teacher notes



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Activity 5

Engage
Explore
Explain
Extend
Evaluate

Procedures

1. Fill bowl approximately 1/2 full with water, add 0.5 tsp of washing soda solution. Mix with spoon.
2. Dip card into solution until pink dots become visible and quickly remove it. Place on paper towel.
3. Briefly sketch your results into the data table.

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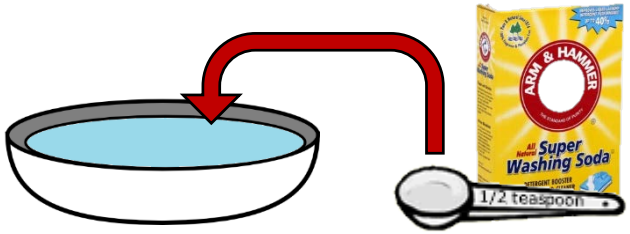
Activity 5

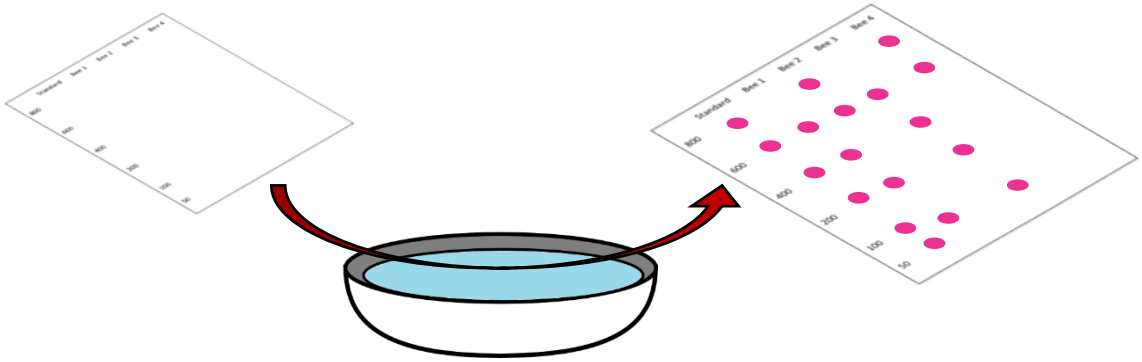
Engage
Explore
Explain
Extend
Evaluate

Procedures

- Step 1:



- Step 2:



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Activity 5

Engage
Explore
Explain
Extend
Evaluate

- What patterns did you observe?

	Standard	Bee 1	Bee 2	Bee 3	Bee 4
800	x		x		x
600	x	x	x	x	x
400	x	x		x	
200	x	x		x	
100	x				
50	x	x		x	

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Activity 5

Engage
Explore
Explain
Extend
Evaluate

- Using the known bees from Activity 4, identify which bees from your analysis would be…
  - Pollen collectors?
  - Nectar collectors?

	Standard	Bee 1	Bee 2	Bee 3	Bee 4
800	X		X		X
600	X	X	X	X	X
400	X	X		X	
200	X	X		X	
100	X				
50	X	X		X	

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Activity 5

Engage
Explore
Explain
Extend
Evaluate

- How might a bee's foraging behavior impact their pollination or honey production potential?
- Genetics are partially responsible for bees' foraging preference. How might the beekeeping industry use this to their advantage?

Evaluation and Assessment

Engage
Explore
Explain
Extend
Evaluate

- Student worksheets can be used as evidence of student understanding

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Summary

- Uploaded lesson plans will be available on the Curriculum Matrix at agclassroom.org
- The 5-E lesson plans are standardized to include
  - NGSS standards
  - Student Worksheet
  - Teacher Notes
  - Supplemental Materials (list of materials needed, PowerPoints, videos, audio, links)
  - Extending Activities

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Feedback

- Please contact us with your thoughts!
- Erin Ingram, eingram3@unl.edu