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EDUCATOR GUIDE

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Chemical Coaxes Locusts to Swarm

SOCIETY FOR SCIENCE & THE PUBLIC

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About this Guide

In this Guide, based on the online *Science News* "A single molecule may entice normally solitary locusts to form massive swarms," students will learn how a newly identified pheromone may influence species behavior, research a pheromone that interests them and discuss why scientists are interested in studying such chemicals.

This Guide includes:

Article-based Comprehension Q&A — Students will answer questions about the online *Science News* article "A single molecule may entice normally solitary locusts to form massive swarms," which describes a compound used in locust congregation that might also be used to control the pests. A version of the story, "Chemical coaxes locusts to swarm," can be found in the September 12, 2020 issue of *Science News*. Related standards include NGSS-DCI: HS-PS1; HS-LS1; HS-ETS1.

> **Student Comprehension Worksheet** — These questions are formatted so it's easy to print them out as a worksheet.

Cross-curricular Discussion Q&A — Students will explore the chemical makeup of pheromones, how the chemicals may cue species behavior and why it's important for scientists to study such information. Students will answer questions related to the pheromone discussed in the *Science News* article before applying the same questions to a pheromone of their choice. Related standards include NGSS-DCI: HS-PS1; HS-LS1; HS-LS2; HS-ETS1.

> **Student Discussion Worksheet** — These questions are formatted so it's easy to print them out as a worksheet.

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Article-based Comprehension, Q&A

Directions for teachers: After your students read the online *Science News* article "A single molecule may entice normally solitary locusts to form massive swarms," ask them to answer the following questions. A version of the story, "Chemical coaxes locusts to swarm," can be found in the September 12, 2020 issue of *Science News*. Students reading the print version should skip question No. 8.

1. What are locusts? Why does the author describe them as both harmless loners and plagues?

Locusts are insects that live a mostly solitary existence and are generally averse to socializing, which is why the author describes them as harmless loners. But locusts also can gather in large swarms. When they do, the insects can destroy crops. This is why the author also describes locusts as plagues.

2. How large can locust swarms get?

Swarms can be composed of potentially hundreds of millions of locusts.

3. What area of the world is currently plagued by locusts? Why do you think the author included this information in the article?

East Africa is currently experiencing its worst locust plague in decades. The author included this information because it is a current event that relates to the science and offers an example of real-world implications.

4. What do scientists suspect causes locusts to swarm? How might it work?

Scientists think aggregation pheromones cause solitary locusts to form large groups. Locusts may release these chemicals into the air to signal other locusts to join them.

5. Name the molecule that scientists identified as a potential locust aggregation pheromone. What effect does it have on locusts?

The molecule scientists pinpointed is called 4-vinylanisole, or 4VA. Researchers say 4VA could function to coax solitary locusts to a swarm and keep swarms together.

6. What evidence do the scientists present supporting the claim that the molecule is an aggregation pheromone?

In lab tests, the molecule attracted locusts of all sexes and ages, as well as solitary locusts and locusts already in swarms. Concentrations of the molecule also grew as swarms grew larger. In field tests, traps laced with 4VA attracted more locusts than control traps.

7. List three ways this discovery could be used to improve locust control measures.

Traps laced with 4VA could congregate locusts in one place and thus allow more selective spraying of insecticides, protecting livestock and the environment. Scientists could develop a compound that blocks locusts from sensing 4VA. Scientists could also genetically engineer locusts so that they cannot sense 4VA.

8. According to the online *Science News* article, what are potential drawbacks of some of the proposed measures?

Targeting 4VA might not stop swarms — factors including changes in behavior, metabolism and body size also are involved in swarm formation. The proposed measure to alter locusts' genetic makeup could have off-target effects. Such effects would need to be well understood before genetically engineered locusts could be released into the wild.

9. What does the expression "smoking gun" mean? It is an example of a literary device called an idiom. Based on the context of the article, explain what an idiom is.

A smoking gun is conclusive evidence or proof of something. Idioms are expressions or phrases that are used to describe something unrelated to the literal meaning of the words in the expression or phrase.

10. Is there evidence that the newly identified molecule is the smoking gun when it comes to locust swarm formation?

While 4VA might be *a* smoking gun, meaning it has a role in swarm formation, it may not be the only compound or the most important — there may be other factors involved.

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Student Comprehension Worksheet

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1. What are locusts? Why does the author describe them as both harmless loners and plagues?

2. How large can locust swarms get?

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4. What do scientists suspect causes locusts to swarm? How might it work?

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6. What evidence do the scientists present supporting the claim that the molecule is an aggregation pheromone?

7. List three ways this discovery could be used to improve locust control measures.

8. According to the online *Science News* article, what are potential drawbacks of some of the proposed measures?

9. What does the expression "smoking gun" mean? It is an example of a literary device called an idiom. Based on the context of the article, explain what an idiom is.

10. Is there evidence that the newly identified molecule is the smoking gun when it comes to locust swarm formation?

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Cross-curricular Discussion, Q&A

Directions for teachers:

Ask students to read the online *Science News* article "A single molecule may entice normally solitary locusts to form massive swarms" and answer the questions below about the chemical makeup of the pheromone described in the article. Then, in the section titled "Cued behaviors," students will select and research a pheromone that interests them and answer questions about the pheromone's role in species behavior. You may need to review concepts related to molecular formulas and structure before beginning the exercise. Have students partner up to discuss the last four prompts, which ask them to think about other factors that may influence behavior. Bring the class back together as a group and discuss questions of your choice.

Want to make it a virtual lesson? Post the online *Science News* article "A single molecule may entice normally solitary locusts to form massive swarms" to your virtual classroom. Ask students to answer the first set of prompts individually, and have them post the pheromone they chose to your online discussion board. When you're ready to pair students up, have them discuss the final prompts using a video-conferencing platform, or talking by phone. They can collaborate in a shared document during the conversation. After posting the answers to an online discussion board, have students give feedback on another pair's responses.

A pheromone's chemistry

1. What is the pheromone identified in the *Science News* article? Give both the common name and formal scientific name.

The locusts' aggregation pheromone identified by sciencetists has the common name of 4VA. It's formal scientific name is 4-vinylanisole, or 4-methoxystyrene.

2. Using PubChem, find and state the molecular formula of the pheromone. What elements does the molecule contain? How many atoms of each element does one molecule contain?

The molecular formula of 4VA is $C_9H_{10}O$. One molecule of it contains nine atoms of carbon, ten atoms of hydrogen and one atom of oxygen.

3. Use PubChem to list two additional properties given for your molecule. Are the properties physical or chemical? Explain.

4VA has a boiling point of 205.0 degrees Celsius and a molecular mass of 134.17 g/mol. Both of these properties are physical — they can be observed and measured without changing the chemical composition of the substance.

4. Using the "3D Conformer" section on PubChem along with the pheromone's molecular formula, draw the pheromone's molecular structure. Label each element within the molecule (make sure to use elemental symbols) and include all bonds. How many single bonds does the molecule contain? What about double bonds? Triple bonds?

See the 4-methoxystyrene page for the molecular structure of 4VA. The molecule contains 16 single bonds, four double bonds and no triple bonds.

5. What information does the molecular structure tell you that the molecular formula doesn't?

The molecular structure shows you the types of bonds that exist and which elements are bonded to other elements and how. The molecular formula tells you only how many atoms of each type of element exist in one molecule.

6. Optional extension question: What types of bonds exist within the molecule? If bonds are covalent, are they likely nonpolar covalent or polar covalent? Explain.

There are nonpolar covalent bonds between carbon atoms and between carbon and hydrogen atoms. The bonds between the oxygen atom and carbon atoms would likely be polar based on the relatively large electronegativity difference between the atoms.

Cued behaviors

7. What pheromone have you chosen to research? Why does it interest you?

Student answers will vary.

8. What organism releases the pheromone? What behavior does the pheromone appear to cue?

*Student answers will vary depending on the pheromone they choose. For 4VA, the pheromone appears to signal solitary migratory locusts (*Locusta migratoria*) to congregate into swarms.*

9. How might the behavior cued by the pheromone benefit the organism?

Student answers will vary depending on the pheromone they choose. In regards to 4VA, group formation can aid locusts in foraging, reproduction, migration and increased survival from predators.

10. What do scientists know about how the pheromone is produced or detected by individuals?

Student answers will vary depending on the pheromone they choose. For 4VA, scientists think that the protein that detects the pheromone sits on certain sensory hairs that extend from the locusts' antennae.

11. How might humans benefit from knowing about this pheromone? Explain.

Student answers will vary depending on the pheromone they choose. For 4VA, knowing more about the pheromone that may cue locust swarm formation could help determine ways to help control swarms and thus prevent them from destroying crops.

Final group prompts

12. Based on what you have learned from this exercise, how would you define a pheromone?

A pheromone is a chemical released by an individual organism that impacts the behavior of other individuals of the same species.

13. Why is it beneficial for scientists to know the structure of the pheromone molecule? Include the terms physical and chemical properties in your answer.

The chemical structure of the pheromone determines the chemical and physical properties of the pheromone. Physical properties such as boiling point and vapor pressure can explain how long the chemical will remain on a surface or in the air. Chemical properties such as its reactivity with other compounds could be used to create molecules that could consume or block the pheromone to prevent its spread.

14. List as many other examples of group and individual behavior as you can think of. Indicate which category (group or individual) each behavior belongs to. If a behavior could be categorized as group and individual, explain why.

Other group behaviors include: flocking, herding, migrating, swarming, etc.
Other individual behaviors include: mating, fleeing from a potential threat, eating, etc. Hunting and hibernating are examples of behaviors that could be group or individual behaviors, depending on the species exhibiting the behavior. For instance, arctic ground squirrels are solitary hibernators while some species of bats hibernate in groups.

15. What factors besides chemicals might influence behavior?

Environmental conditions such as climate or weather changes, the availability or lack of resources, the presence of other organisms (especially possible predators or threats) and the circadian rhythm of an animal may influence behavior.

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Student Discussion Worksheet

Directions: Use the article "A single molecule may entice normally solitary locuts to form massive swarms" and the PubChem chemistry database, run by the National Institutes of Health, to answer the first set of questions. Then, select and research a pheromone that interests you and answer questions about it in the section titled "Cued behaviors." Share your answers for your selected pheromone and discuss the final prompts with a partner.

A pheromone's chemistry

1. What is the pheromone identified in the *Science News* article? Give both the common name and formal scientific name.

2. Using PubChem, find and state the molecular formula of the pheromone. What elements does the molecule contain? How many atoms of each element does one molecule contain?

3. Use PubChem to list two additional properties given for your molecule. Are the properties physical or chemical? Explain.

4. Using the "3D Conformer" section on PubChem along with the pheromone's molecular formula, draw the pheromone's molecular structure. Label each element within the molecule (make sure to use elemental symbols) and include all bonds. How many single bonds does the molecule contain? What about double bonds? Triple bonds?

5. What information does the molecular structure tell you that the molecular formula doesn't?

6. Optional extension question: What types of bonds exist within the molecule? If bonds are covalent, are they likely nonpolar covalent or polar covalent? Explain.

Cued behaviors

7. What pheromone have you chosen to research? Why does it interest you?

8. What organism releases the pheromone? What behavior does the pheromone appear to cue?

9. How might the behavior cued by the pheromone benefit the organism?

10. What do scientists know about how the pheromone is produced or detected by individuals?

11. How might humans benefit from knowing about this pheromone? Explain.

Final group prompts

12. Based on what you have learned from this exercise, how would you define a pheromone?

13. Why is it beneficial for scientists to know the structure of the pheromone molecule? Include the terms physical and chemical properties in your answer.

14. List as many other examples of group and individual behavior as you can think of. Indicate which category (group or individual) each behavior belongs to. If a behavior could be categorized as group and individual, explain why.

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