ScienceNews

EDUCATOR GUIDE

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October 12, 2019 & October 26, 2019

The SN 10: Scientists to Watch

SOCIETY FOR SCIENCE & THE PUBLIC

SN EDUCATOR GUIDE

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About this Guide

This guide, based on the *Science News* special issue "The SN 10: Scientists to watch," asks students to explore the work of early- and mid-career researchers who are tackling some of science's biggest questions. The activity prompts students to draw inspiration from an SN 10 scientist and collaborate with classmates to develop an idea for a research project.

This Guide includes:

Article-Based Comprehension Q&A — These questions, based on the *Science News* article "The next champs of green chemistry," Readability: 12.9, ask students to explore the research of SN 10 scientist Michelle O'Malley. Related standards include NGSS-DCI: HS-LS1; HS-ESS3; 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 — These discussion prompts encourage students to discuss and compare the work and background of two SN 10 scientists to explore the varied paths to becoming a successful researcher. Related standards include NGSS-DCI: HS-LS1; HS-LS2; HS-ESS2; HS-ESS3; HS-ETS1.

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

Activity: Digital circuit design

> **Summary:** With inspiration from the SN 10 scientists, students will explore how their own interests combined with collaboration with a partner can lead to a specific science research question. Related standards include NGSS-DCI: HS-ETS1.
>
> **Approximate class time:** 2 class periods to complete the activity questions, present the oral reports and debrief as a class.

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Article-Based Comprehension, Q&A

Directions for teachers: After your students read "The next champs of green chemistry," ask them to answer the following questions.

1. Who is Michelle O'Malley? What organisms does she study and why?

Michelle O'Malley is a chemical and biological engineer at the University of California, Santa Barbara. She studies the anaerobic fungi that help animals such as goats and sheep digest plants. Enzymes made by these fungi might be useful for producing fuel and other chemicals from agricultural waste and inedible plant material.

2. What substance do the fungal enzymes break down? Why are researchers interested in this substance?

The fungal enzymes break down lignocellulose, which is the fibrous parts of plants. Researchers are interested in lignocellulose because it is rich in carbon, which is an important element in fuels, drugs and many other chemicals.

3. How is the substance described in question 2 currently broken down? Why is this not a great approach?

Typically, lignocellulose has been broken down through chemical and physical methods. But these approaches can be costly, toxic and wasteful.

4. According to the article, what personal characteristics have helped Michelle O'Malley as a scientist? What is the source of that insight into O'Malley's personality?

Michelle O'Malley is unafraid to tackle problems and can recognize interesting or unusual results, says her graduate school adviser, chemical engineer Anne Robinson.

5. How did Michelle O'Malley find a mentor in her field? How did her mentor support her research goals?

After graduate school, she reached out to more established scientists that could teach her how to grow and isolate the microbes she was interested in.

6. What two phrases does Michelle O'Malley use to describe the technique for growing anaerobic fungi? Why are these phrases appropriate for describing the technique?

Michelle O'Malley calls the method to grow the fungi a "very old-school technology" and "a lost art." It is "old-school" and "lost" because few people know how to do it anymore. It is an "art" because it takes care, coordination and experience, and it doesn't always work.

7. What did Michelle O'Malley's team find out about the phylum of fungi called Neocallimastigomycota? Why is that finding interesting?

The team found that the anaerobic fungi have genetic instructions for the largest number of biomass-degrading enzymes known in nature. All of those enzymes break down organic material and so might be options to explore for breaking down plant matter for use in biotechnology.

8. What STEM field(s) does Michelle O'Malley study? Describe how her research connects to each field?

Possible student response: Michelle O'Malley studies the science, technology, engineering and mathematics (STEM) fields of chemistry and microbiology. Her work connects to chemistry because she is interested in the composition and structure of agricultural leftovers and how they might be broken down. Because she is studying how microbial fungi break down those molecules, in particular using enzymes, her work is also squarely in the realm of microbiology.

9. What other types of careers could scientists in these fields pursue?

Possible student response: Chemists can work to develop new drugs and test new products. Microbiologists can work in hospitals and clinical laboratories, running various tests on patient samples for doctors and veterinarians, and helping public officials track outbreaks. Scientists in these fields can also work to shape regulations and public policy.

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Student Comprehension Worksheet

Directions: After reading "The next champs of green chemistry," answer the following questions.

1. Who is Michelle O'Malley? What organisms does she study and why?

2. What substance do the fungal enzymes break down? Why are researchers interested in this substance?

3. How is the substance described in question 2 currently broken down? Why is this not a great approach?

4. According to the article, what personal characteristics have helped Michelle O'Malley as a scientist? What is the source of that insight into O'Malley's personality?

5. How did Michelle O'Malley find a mentor in her field? How did her mentor support her research goals?

6. What two phrases does Michelle O'Malley use to describe the technique for growing anaerobic fungi? Why are these phrases appropriate for describing the technique?

7. What did Michelle O'Malley's team find out about the phylum of fungi called Neocallimastigomycota? Why is that finding interesting?

8. What STEM field(s) does Michelle O'Malley study? Describe how her research connects to each field?

9. What other types of careers could scientists in these fields pursue?

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Cross-curricular Discussion, Q&A

Directions for teachers: Have your students work with a partner to choose two articles about SN 10 scientists. They can pick articles from the October 12, 2019 & October 26, 2019 issue of *Science News* or use the *Science News* archive to find more choices. Students should decide who is reading which article and spend about 10 minutes reading the article thoroughly. Students will then share what they've learned with their partner so both have a strong understanding of the two scientists. Students will then answer the following comparison questions together.

Note to teachers: Possible answers are given for the articles about Michelle O'Malley, "The next green chemistry champs" (Readability: 12.9), and Malin Pinsky, "Understanding an ocean of changes" (Readability: 11.1). But questions can be used for any pair of SN 10 articles.

1. Do you think the two scientists could collaborate on a shared research topic or goal? How might their work connect?

Students should think about topics and techniques that are part of both scientists' research and discuss where there might be overlap. Students might suggest collaborating on a topic that is consistent with the research covered in the articles or suggest a new research question that aligns with both scientists' interests and skillsets.

Students might say that O'Malley and Pinsky could collaborate on research that informs new energy policies as a way to mitigate climate change and its effects. O'Malley's goal of finding greener sources of energy and Pinsky's data-driven approach to understanding the effects of climate change could meet to help shape these policies.

2. Describe what you know about each of your scientists' life paths. What experiences have helped each to become a successful science researcher? Do the two scientists share any experiences? Using the scientists' education, life and career experiences as a springboard, outline one possible path to success as a scientist.

Students should discuss and outline the path that each scientist took to becoming a researcher, and the factors and experiences that influenced the scientist's progress. Students may then decide to use experiences from one or both scientists in the response.

Students might highlight O'Malley's strategy of reaching out to scientists doing research in her field of interest as a good way to connect and learn. Or students might point to Pinsky's jobs as a research technician and an intern as valuable experiences to have before pursuing a graduate degree. Students' possible path might be: 1) Go to college. 2) Expose yourself to research experiences as an intern. 3) Reach

out to learn from current successful researchers in your area of interest. 4) Apply that knowledge to your own, unique research question that could make a meaningful impact on the world.

3. Compare the types of data discussed in each article and how the data were analyzed. Explain how data collection is key to achieving a goal in science research. Describe how a scientist determines what types of data to collect and analyze.

Students should compare examples of data collection and analysis from the two articles. Students should think about how the scientists had to decide what data to collect, how the scientists collected that data and how analyzing the data helped to determine the research outcome.

O'Malley collects animal poop and looks for anaerobic fungi. She then grows the fungi to analyze what enzymes the fungi possess and collects data on how those enzymes break down plant material. Pinsky collects data on clown fish and other marine populations. His data include population size and behaviors. Pinsky is analyzing that data to look for what factors might affect a population and how those factors might relate to climate change.

The scientists' research goals inform their data collection and analysis process. For example, O'Malley's goal is to re-create a method of breaking down plant material that exists in nature in the lab so that it can be used for green fuels and other chemicals. To achieve this, she collects data in the field and does tests to determine how to replicate a natural method. Pinsky's goal is to create a holistic picture of marine ecosystems to understand why oceans are changing and how those changes should inform related policy. He also collects data in the field and then puts it in context with existing data to answer his big-picture questions. To determine the types of data to collect and analyze, scientists need to work backward from their research goal, determine a testable research question and identify the information that is both possible to collect and could help answer that question.

4. Think about how the author of each article approached their topic. What factors might have affected what the author chose to include and what he or she chose to leave out? How would you go about writing a career profile of someone who's found success in science? Who would your audience be? What would be your goal? What aspects would you include and how much would you emphasize each?

Students should discuss how the journalists covered each scientist personally and professionally, and whether the approach and emphasis was effective. Students should think about the intended audience of the article and whether the author's background, including knowledge and own life experiences, could have affected the way he or she wrote the profile.

Some students might prefer to read about a scientist's passion and drive to achieve his or her goals, and would focus the profile on someone's personality. Other students might be interested in how professionals

get started in their industry and so might include more background information on early experiences. Students who are naturally interested in the field that their scientist studies might be inclined to write a more detailed description of the scientist's research.

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Student Discussion Worksheet

Directions: Working with a partner, choose two articles about SN 10 scientists. You can pick articles from the October 12, 2019 & October 26, 2019 issue of *Science News* or use the *Science News* archive to find more choices. Decide which partner is reading which article and spend about 10 minutes reading your article thoroughly. Once you feel you're an expert on the scientist you chose, tell your partner all you know about your scientist, including the scientist's life experiences and research findings. Your goal should be to make your partner an expert on the scientist you read about. Once you both feel knowledgeable about the two scientists you chose, answer the following comparison questions together.

1. Do you think the two scientists could collaborate on a shared research topic or goal? How might their work connect?

2. Describe what you know about each of your scientists' life paths. What experiences have helped each to become a successful science researcher? Do the two scientists share any experiences? Using the scientists' education, life and career experiences as a springboard, outline one possible path to success as a scientist.

3. Compare the types of data discussed in each article and how the data were analyzed. Explain how data collection is key to achieving a goal in science research. Describe how a scientist determines what types of data to collect and analyze.

4. Think about how the author of each article approached their topic. What factors might have affected what the author chose to include and what he or she chose to leave out? How would you go about writing a career profile of someone who's found success in science? Who would your audience be? What would be your goal? What aspects would you include and how much would you emphasize each?

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Activity Guide for Teachers: Collaborate with an SN 10 Scientist

Purpose: With inspiration from the SN 10 scientists, students will explore how their own interests combined with collaboration with a partner can lead to a specific science research question.

Procedural overview: Students will partner up, choose an SN 10 scientist and read the article about that scientist. After answering questions about the scientist and their own scientific interests, students will role-play with their partners to develop an idea for a collaborative research project with their chosen scientist.

Approximate class time: 2 class periods to complete the activity questions, present the oral reports and debrief as a class.

Supplies:
Internet access
The SN 10: Scientists to Watch list
Access to the *Science News* archive

Directions for teachers:

To explore concepts in science and understand how collaboration can help further scientific study, students will work in pairs to identify shared interests with an SN 10 scientist. They will then role-play with partners to develop a research question.

Explain to students that collaboration is a valuable way to explore interesting areas of science, develop research questions and figure out how to answer those questions. Often scientists can do more together than they can do on their own because they bring different perspectives to a topic and can share their knowledge, experiences and skillsets. Collaborators can brainstorm and push each other to scrutinize ideas and approaches.

1. Tell your students to partner up and, with their partner, identify one of the SN 10 scientists from 2019 or a previous year to read about. After reading the article, students should discuss the scientist's work and answer the questions provided. Encourage students to follow the links at the end of the SN 10 story to an original research paper to get more details on the scientist's research question or questions.

2. Next tell the students to think about their own interests. Use the prompts provided to have them explore what they are interested in and what area of scientific research they might be curious to pursue.

3. One student in each pair will first role-play as the SN 10 scientist, while the other students play themselves, using their own interests as a guide. Students should use the prompts provided to begin a conversation about overlapping interests. Students should then apply what they learn to develop a

research question and discuss some details of how they might carry out that research.

4. Tell the students to switch roles to give the other partner a chance to be the SN 10 scientist.

5. Each student will then give a two-minute oral presentation to the rest of the class describing the scientist they chose, the scientist's research, the student's research interests and what research question the student and scientist are going to investigate together. Students should describe why this research question is suited to the student and the scientist.

6. Following the presentations, students should discuss the final questions as a class.

Students' research questions need not be unique or novel. If students are concerned that they will not come up with a unique research project, assure them that the purpose of much of scientific research is to confirm and validate previous findings. Remind students that they can use the research conducted by the scientist as a springboard for a slightly modified scientific question. Collecting new data or using different methods to research the same question can also be as useful as asking a brand-new question.

Example collaboration:

To introduce students to the idea of the activity, consider discussing the example below about a student working with marine ecologist Malin Pinsky, whose work was described in "Malin Pinsky seeks to explain how climate change alters ocean life." In this example, the student is interested in music and wonders how research into sound could intersect with Pinsky's work.

In the *Science News* article "Malin Pinsky seeks to explain how climate change alters ocean life," marine scientist Malin Pinksy describes his "lightbulb moments." A lightbulb moment is a moment of sudden realization, as if you had turned on a light that illuminates a new vista of possibility. Such a moment can also be called an aha moment or an epiphany. Malin Pinksy's lightbulb moments were seeing whales in the Antarctic, and realizing how outdated ocean policies are. His lightbulb moments furthered his interest in marine ecosystems. Now Malin Pinsky studies how rising global temperatures are changing marine ecosystems and what we can do about it.

In this example, a student interested in music is wondering how to collaborate with Malin Pinsky. The student has had a lightbulb moment of her own. Her grandfather is hard of hearing and when she went to the pool with him, she noticed that he couldn't hear well on the pool deck, but he was able to hear better underwater. The student wondered how animals that live underwater might experience human-created sounds in their environment.

Malin Pinsky knows about a number of reports investigating how noise can affect marine life. Working together, the student and Pinsky decide to design experiments to explore how different sounds associated with energy harvesting — different pitches, rhythms and volumes — might affect fish populations.

Pinksy's understanding of aquatic ecosystems is useful because he brings experiences and skills studying animal behavior. In turn, the student could help explain the various properties of sounds that might

influence that behavior and find sample noises to play in underwater experiments. Additional collaborators could also be helpful to the project. For instance, a physicist could bring knowledge about how sound waves travel through water with various properties.

The pair's hypothesis is that if a sound is very loud and very deep, it will carry well underwater and is more likely to influence fish behavior.

Directions for students:

Your SN 10 scientist

With your partner, identify one of the SN 10: Scientists to Watch to read about. You can choose a scientist from the 2019 list or search the archive for another scientist. After reading the article, think about your scientist and the sorts of things he or she is studying and answer the following questions.

1. Which scientist's work did you choose to read about? Why?

2. Why is the scientist interested in his or her work? Did the scientist have any "lightbulb moments" or other life experiences that sparked interest in this work?

3. Based on the article, give an overview of the scientist's current research.

4. Find a primary research paper authored by the scientist. What is the research question posed in this paper? What is the hypothesis?

5. In what area(s) of science does the scientist specialize? Is the scientist's work cross-disciplinary?

6. How does the scientist take advantage of collaboration or expertise from other disciplines in his or her work?

Your interests

Consider your own interests and answer the following prompts.

7. What are you most interested in?

8. Is there a field of science or scientific topic that your interest connects to?

9. Is there something about that scientific topic that you'd like to know more about?

10. Is there a problem in your life, family, community that connects to the topic?

11. Have you had any lightbulb moments related to the problem or topic?

12. How could research in your area of interest be improved by collaboration?

Birth of collaboration

Now it's time to role-play. Either you or your partner should play the role of the SN 10 scientist and the other should be a student collaborator or mentee (playing yourself). Discuss the similarities and differences in your work to try to come up with a shared research question. Be sure to ask each other questions to go deeper into each other's interests. Share knowledge, and follow up on whatever sparks your curiosity. Use the prompts below if you get stuck. Be sure to switch roles so that you each have the experience of collaborating with the SN 10 scientist you chose.

Student: Can you tell me a little bit about your research?

Scientist: What aspects of this research sound interesting and resonate with you?

Student: How did you get inspired and involved in the project?

Scientist: What other areas of science generally interest you? Is there something in school that you've studied that you'd like to learn more about?

Student: What area of science do you specialize in? Would you consider your work to be cross-disciplinary, covering multiple areas of science?

Scientist: Are there local issues or problems that you're interested in solving?

Student: What are other scientific questions that you'd like to explore?

Scientist: Can you think of a scientific question that we could collaborate to answer?

Student: What data could we collect to investigate our question? Is there specialized equipment that we would have to use and have access to in order to collect the data?

Scientist: Based on the data collected, what could be our proposed hypothesis?

Present and debrief

Based on your role-playing, you and your partner should each prepare a two-minute presentation to explain the scientific question you might ask with your SN 10 scientist and your hypothesis. Discuss any methods you will use during your research and why the research project is of interest to you and your scientist. After the presentations, be prepared to answer the following questions as a class.

13. How did collaborating with a classmate help to clarify and/or expand your research interests?

14. What did you find helpful about working toward a research question with a collaborator?

15. What was hard about working with a collaborator? How did you overcome these obstacles?

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