READING A STUDENT-PUBLISHED JOURNAL ARTICLE

KEY TERMS
- Scientific journal article
- Scientific method

KEY SKILLS
- Active reading
- Reading primary scientific literature
- Summarizing text

GRADE LEVEL
Middle and high school

NGSS CONNECTIONS
Practices: obtaining, evaluating, and communicating information

ESTIMATED TIME
Two 45-minute class periods

MATERIALS
- Class set of one JEI article (print or upload to LMS)
- Class set of "Strategies for Reading" activity guide (print or upload to LMS)
- Student science notebooks (paper or digital)

For first activity:
- Two blank pieces of poster board/ bulletin paper or two large whiteboards, sticky notes, and markers OR digital bulletin boards (i.e., website or app)

SUMMARY

In this lesson, students will learn strategies for reading primary scientific literature using a journal article written by a middle or high school student for the *Journal of Emerging Investigators* (JEI). JEI publishes student research with the support of mentors (e.g., teachers or parents), and each article receives peer review by graduate-level scientists who are working on or have their Master's or PhD. By reading JEI articles, students gain exposure to primary scientific literature and the structure of scientific writing. They may even be inspired to publish their own research from science fairs, extracurricular activities (e.g., science camps), or home experiments!

LEARNING OBJECTIVES

By the end of this lesson, students will be able to:
1. Identify key text features of a scientific journal article
2. Use annotation strategies to support comprehension of primary scientific literature
3. Summarize a scientific journal article's experimental design and findings, using the scientific method as a framework

PRIOR KNOWLEDGE

This lesson introduces students to scientific journal articles and how to read them. Ideally, students will have previously learned about the components of scientific reports – such as an Introduction, Materials and Methods, Results, Discussion, etc. They should also have experience annotating text (e.g., highlighting, underlining, and adding margin notes).

BACKGROUND INFORMATION

Scientists communicate their work in different ways depending on their goals and audience. For formal communication with other scientists, researchers often publish their work in scientific journals. Scientific journals are periodical publications containing various types of **scientific journal articles** - such as commentaries, reviews, and original research that presents new findings. Together, these articles play an essential role in the scientific community by enabling scientists to share ideas, evaluate one another's work, and advance scientific knowledge.

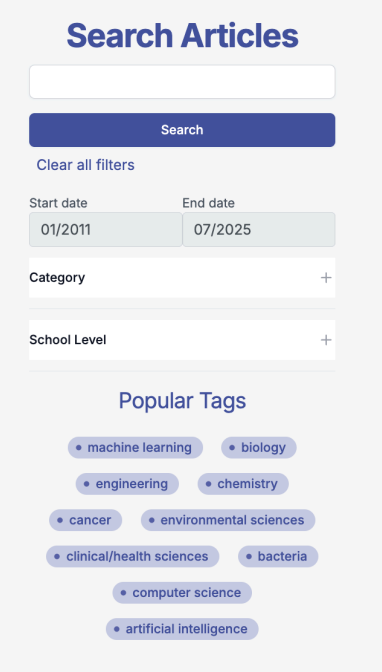
Most of these scientific journal articles are about new research that tests a hypothesis. In many ways, these articles organize information similarly to lab reports or science fair projects and include elements of the scientific method: the research question, hypothesis, materials and methods, data, analysis, results, and discussion. While science in practice doesn't always occur in a linear, step-by-step way, scientific journal articles often follow a consistent format that includes these elements in this order. This universal structure makes it easier to read the article and understand the experimental design.

MATERIAL PREPARATION

Finding a Student-Published Scientific Journal Article

To find an article, visit the *Journal of Emerging Investigators* website and choose from over 1200+ student-published articles:

- To narrow your search, you can filter by keyword, date, category (science field), school level (authored by middle or high school student), and popular tags (trending topics).
- Each article includes individual tags that identify key information or keywords related to the student's research. These tags and the Summary ("Abstract") can be used to connect the article to subject-specific NGSS standards.



CLASS ONE PROCEDURES

Think-Pair-Share (15 minutes)

1. Post the following two questions on two separate posters or whiteboards around the classroom *(alternative: use a digital bulletin board):*

- Think about science projects or experiments you've done as a student. How have you shared your work with your classmates, parents, teachers, or even the community?
- How do you think professional scientists at universities, research labs, or places like NASA share their studies with other scientists?

Scientists communicate information in different ways, from formal avenues like scientific journal articles to informal ones like podcasts or blogs. With recent calls for *open science* (i.e., making research more accessible), how scientists share their work with colleagues and the public is changing.

2. Give each student 3-4 sticky notes. Ask them to write one idea per note, and have them place their notes with the corresponding question.

3. Briefly scan the notes and read aloud recurring ideas (e.g., "posters" or "lab reports").

4. Ask students to pair up and discuss: "What's similar and what's different about how you and your classmates have shared science and how professional scientists share science?" Then, have each pair report either one similarity or one difference to the class.

5. Transition to the next activity by explaining that students will now learn five strategies for reading a scientific journal article, one way scientists communicate their research. Define a **scientific journal article**: *a report written by scientists to share their research that has been peer-reviewed by other expert scientists. It describes what they wanted to answer (i.e., research question), how they tested it (i.e., materials and methods), and what they found (i.e., results and conclusions).*

Strategies 1-3: Read the Abstract, Make Connections, and Skim the Article (25 minutes)

1. Give students a copy of the JEI article you chose. Explain to students that *this is a **student-published scientific journal article** written by a middle or high school student or group of students. The article describes research they performed with the support of a mentor, such as a teacher, parent, or other*

adult. Before being published, these articles undergo peer review: a process where they are read and evaluated by experts or other scientists in a similar field. Peer reviewers check that the experiment was done correctly, the results make sense, and the ideas are new. At the Journal of Emerging Investigators, peer reviewers are Master's or PhD-level volunteers with science backgrounds.

2. **Read** the Summary ("Abstract") together as a class. Then, have students create a three-column chart in their science notebook. Label the left column "Know, " the middle column "Wonder," and the right column "Learned." For a 2-minute quick write, ask students to **make connections** using the Summary ("Abstract") and the prompts below:

- *In the "Know" column, list scientific words or ideas you recognize or have background knowledge about.*
- *In the "Wonder" column, write questions about what you want to learn from the article or identify terms you don't know yet.*

3. Ask students to independently **skim the article** to identify its main sections. Then, as a class, go through the article and have students highlight the headers of the main sections: Introduction, Results, Discussion, Materials and Methods, and References. Have them highlight the titles of Tables and Figures as well.

Some scientific journal articles place the Materials and Methods section after the Discussion. The Methods section can be lengthy and technical, while some readers are primarily interested in the findings. Placing Materials and Methods at the end of the article can help streamline the main ideas.

Each journal establishes its own guidelines (such as the order of sections), and authors must structure their paper accordingly.

Quick Write (5 minutes)

1. Prompt students for another quick write in their science notebook: "How is this article similar to or different from the science papers you've written before? Explain using an example class assignment."

For a 45-minute class period, end the lesson here. If you have a 90-minute block, proceed to the next activity.

CLASS TWO PROCEDURES

Strategy 4: Annotate the Article (30 minutes)

1. As a class, read the article together, pausing after every 1-2 paragraphs for students to annotate the text by highlighting or underlining important concepts, essential vocabulary, and main ideas.

2. Encourage students to write brief comments in the margins about the experimental design. For example, they could:

- Look up and define technical terms
- Highlight or circle where parts of the scientific method are described (i.e., hypothesis)
- Make connections to their prior knowledge

Many text-to-speech apps will read JEI's articles.

Depending on your students and their experience reading primary scientific literature, consider alternative reading strategies such as independent, paired, or popcorn reading.

Strategy 5: Summarize the Article (15 minutes+)

1. Ask students to refer back to their three-column chart and briefly fill in the "Learned" column by responding to any comments or questions they had initially noted in the "Wonder" column. For example, were terms defined or parts of the experiment further described?

2. In class or for homework, have students write a one-paragraph summary of the article using their annotated notes. Students should use the main body of text from the article (not the article's Summary/Abstract) to synthesize the experimental design and findings. To address all parts of the scientific method, students should include 1-2 sentences for each of the following in their summary:

- Research question: what did the author(s) want to know?
- Hypothesis: what did the author(s) think would happen?
- Methods: what did the author(s) do to test their question?
- Results and conclusion: what did the author(s) find or discover?
- Bigger picture: why is the study important?
- Their impression: what do you think about the study or experiment?

Most scientific peer reviewers write their own editorial summary to show they read the article; this summary is different from the Summary ("Abstract") at the beginning of the published article. The reviewer's summary often includes an overall evaluation of the article's quality and its importance to the scientific community and/ or broader society.

EXTENSIONS

- Ask students to find another JEI article and read it using the five strategies in this lesson. Students can submit a new annotated article and summary as an assignment.
- Have students read and compare two different types of JEI articles on similar themes or topics (e.g., "bacteria" or "environmental sciences"), using article tags to find them. After students read the articles, ask them to compare and contrast the articles' structure and content.
- If students have conducted their own experimental research (e.g., a science fair or capstone project), encourage them to consider submitting their work to platforms like eiRxiv (a preprint server) or JEI (a student publication). Writing and submitting a formal scientific report can support students' understanding of how science works, including how scientists share their research with others.

ASSESSMENTS

The following prompts offer different ways for students to reflect on and apply what they have learned:

- To tell people about their research and why it matters, scientists will sometimes work with journalists to write a press release announcing their newly published scientific journal article. Using the article you read in class, create a one-page press release for the author(s). Describe their research and its importance to the scientific community and/or broader society, in a way that the average reader would understand and be excited by. You may include images or visuals from the article or other sources to describe the research. Make sure to cite the article in your press release.
- Think back to a time when you did an experiment and shared your results in writing (like a lab report in science class, or a poster for a science fair project). Compare and contrast your work to the article you read in class. What similarities or differences do you notice between their structures, goals, tones, and how the ideas are communicated (using words, graphs, or pictures)? Explain why communicating science in different formats may be helpful or necessary.

REFERENCES

This lesson plan draws on resources and information provided by the organizations listed below:

- Emerging Investigators Preprint Server (eiRxiv) - eirxiv.org
- Journal of Emerging Investigators (JEI) - emerginginvestigators.org

The following scientific journal article was also referenced:

- Fankhauser, S. C., & Lijek, R. S. (2016). Incorporating primary scientific literature in middle and high school education. Journal of Microbiology & Biology Education, 17(1), 120-124. https://doi.org/10.1128/jmbe.v17i1.1004

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At eiRxiv and JEI, we are committed to providing the tools, mentorship, and community necessary for any middle or high school student to publish and share their research with other students and the broader scientific community. Visit us at eiRxiv.org and emerginginvestigators.org.

STRATEGIES FOR READING SCIENTIFIC JOURNAL ARTICLES

The *Journal of Emerging Investigators* (JEI) publishes **scientific journal articles** written by middle or high school students about research they have done. They may have done the research for science fairs, independent study projects, class assignments, or as part of an independent exploration at home. All of these projects are overseen by a mentor like a teacher, parent, or other adult. Before being published, these articles undergo peer review: a process where a scientific report is read and evaluated by experts in the same scientific field. Peer reviewers check that the experiment was done correctly, the results make sense, and the ideas are new. At JEI, peer reviewers are Master's or PhD-level volunteers with science backgrounds.

STRATEGY 1: Read the Summary ("Abstract")

The Summary (sometimes called an "Abstract") is a brief description of the study from start to finish. The Summary often includes information such as:

- Research question: what did the author(s) want to know?
- Hypothesis: what did the author(s) think would happen?
- Methods: what did the author(s) do to test their question?
- Results and conclusion: what did the author(s) find or discover?
- Bigger picture: why is the study important?

1. Read the Summary, looking for the information above.

STRATEGY 2: Make Connections

Reading **scientific journal articles** gets easier with practice, especially once you are familiar with common scientific terms and the scientific process.

1. In your science notebook, create a three-column chart like the one shown to the right. Label column titles: Know, Wonder, Learned.

KNOW	*WONDER*	*LEARNED*

2. Using the Summary (Abstract) section of the article only:

- In the "Know" column, list scientific words or ideas you recognize or understand.
- In the "Wonder" column, write questions about what you want to learn from the article or identify terms you didn't know yet.
- Leave the "Learned" column blank for now.

STRATEGY 3: Skim the Article

Skimming an article means quickly scanning the text to determine its overall structure and layout. When you skim, don't read every word. Instead, focus on section headings and visuals like tables or figures. This will help you get a sense of what information is included in the article.

1. Skim through the article to become familiar with its structure.

2. Highlight the section headings (titles), which are usually in bold or placed above the main body of text.

3. Highlight the titles of any Tables and Figures you see (hint: sometimes these titles are in a caption *under* the table or figure, not above it).

STRATEGY 4: Annotate the Article

Annotating (making notes on) an article makes reading more active, which can help you better understand and remember what you read. While reading the article, pause every 1-2 paragraphs to:

1. Highlight or underline important concepts, essential vocabulary, and main ideas.

2. Write brief comments in the margins:
   - Look up and define words you don't know.
   - Identify parts of the **scientific method** (hypothesis, research question, methods, materials, results, discussion) by writing them next to where you find them in the text.
   - Make connections to what you already know.

STRATEGY 5: Summarize the Article

Now that you've read and annotated the article, you will summarize it using the **scientific method** to help you structure your summary.

1. Review the three-column chart you made earlier in your notebook. In the "Learned" column, respond to any comments or questions you wrote in the "Wonder" column. For example, did you learn the definitions of any words you didn't know at first? Can you answer the questions you had?

2. Write a one-paragraph summary of the article in your own words, using your annotated notes to help you. Using your notes and the text of the article (not the Summary included in the article), your paragraph should include 1-2 sentences for each of the following:

- Research question (paragraph introduction): what did the author(s) want to know?
- Hypothesis: what did the author(s) think would happen?
- Methods: what did the author(s) do to test their question?
- Results and conclusion: what did the author(s) find or discover?
- Bigger picture: why is the study important?
- Your impression (paragraph conclusion): what do you think about the study or experiment?