

**Teacher’s Guide**

**From Pond Scum to Product**

***April 2023***

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Activate students’ prior knowledge and engage them before they read the article.

[***Reading Comprehension Questions***](#_Student_Reading_Comprehension) ***3***

These questions are designed to help students read the article (and graphics) carefully. They can help the teacher assess how well students understand the content and help direct the need for follow-up discussions and/or activities. You’ll find the questions ordered in increasing difficulty.

[***Graphic Organizer***](#_Graphic_Organizer) ***5***

Thishelps students locate and analyze information from the article. Students should use their own words and not copy entire sentences from the article. Encourage the use of bullet points.

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Access the answers to reading comprehension questions and a rubric to assess the graphic organizer.

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Here you will find additional labs, simulations, lessons, and project ideas that you can use with your students alongside this article.

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# Anticipation Guide

**Directions: *Before reading the article*,** in the first column, write “A” or “D,” indicating your **A**greement or **D**isagreement with each statement. Complete the activity in the box.

As you read, compare your opinions with information from the article. In the space under each statement, cite information from the article that supports or refutes your original ideas.

|  |  |  |
| --- | --- | --- |
| **Me** | **Text** | **Statement** |
|  |  | 1. Algae photosynthesize more efficiently than plants, so they capture more CO2 from the atmosphere than plants. |
|  |  | 2. The carbon cycle includes carbon found in living things but not nonliving things. |
|  |  | 3. The oldest algal fossils are more than a billion years old. |
|  |  | 4. Alginates are copolymers found in food thickeners, cosmetics, and other products. |
|  |  | 5. The taste of umami comes from a common amino acid. |
|  |  | 6. Most chemically reactive nitrogen is found in the atmosphere. |
|  |  | 7. Jet fuel can be made from algae. |
|  |  | 8. Algal oils are very similar to palm oil. |
|  |  | 9. Most of the world’s plastic comes from algae. |
|  |  | 10. Algae has the potential to produce medicines to combat viruses, bacteria, and cancer. |

# Student ReadingComprehension Questions

**Directions**: Use the article to answer the questions below.

1. State some similarities and differences between algae and other types of plants.
2. What are the five basic tastes? Which is the one discovered last?
3. What is the definition of “umami”? What is the main chemical that produces the umami taste?
4. State some reasons why nitrogen is such an important element in our lives.
5. Why do some scientists define algae as a kind of Neosporin?
6. Explain how scientists can more effectively print 3D cells using algae versus plastics.
7. What is the difference between a polymer and a copolymer? Give and describe an example of a common polymer. How would this be different from a copolymer?
8. What are some ways algae can lower excess CO2 levels? What are some other ways algae can help the environment?
9. Why is nitrogen in the air not chemically reactive? (Hint: look at the structure of the N2 molecule).

**Student Reading Comprehension Questions, cont.**

**Questions for Further Learning**

***Write your answers on another piece of paper if needed.***

1. Research and explain what happens to CO2 when it is dissolved in water. How would an increase in acidity affect the dissolved CO2?
2. Research MSG (Monosodium glutamate). What is it used for? Why was MSG considered bad for your health?

# Graphic Organizer

**Directions**: As you read, complete the graphic organizer below to describe current and future products made from algae, and the people working on the projects. Try to list at least 4 products for each component of algae. Add horizontal lines as needed.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Component** | **Products** | **Advantages** | **Chemistry involved** | **Person(s) or group(s) involved** *(if mentioned)* |
| **Alginate** |  |   |   |   |
| **Algal Protein** |   |   |   |   |
| **Algal Oil** |   |   |   |   |

**Summary:** On the back of this sheet, write a short email (3-4 sentences) to a friend describing what you learned about the importance of developing products from algae.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. State some similarities and differences between algae and other types of plants.
Algae are similar to plants because they conduct photosynthesis to get their energy. However, algae do not have roots or stems, so photosynthesis is much more efficient.
2. What are the five basic tastes? Which is the one discovered last?
The five basic tastes are salt, sour, sweet, bitter, and umami (Umami was discovered last).
3. What is the definition of “umami”? What is the main chemical that produces the umami taste?
Umami is a Japanese word translated to “deliciousness”. The taste has a rich and savory feel to it. The main chemical that contributes to umami was glutamic acid (an amino acid).
4. State some reasons why nitrogen is such an important element in our lives.
One of the main reasons why nitrogen is so important is that the element is in amino acids, which we need to create protein to survive. (“amine = NH3+ group on the molecular chain).
5. Why do some scientists define algae as a kind of Neosporin?
Neosporin is used on cuts and scratches to prevent bacteria from getting into the bloodstream. Studies have shown that compounds from algae have similar properties needed to kill the bacteria.
6. Explain how scientists can more effectively print 3D cells using algae versus plastics.
Scientists want to create human tissue, but it needs to be in 3D. 3D printing is typically done at high temperatures. However, the human tissue cells can also grow on the compound alginate at much lower, and more favorable temperatures.
7. What is the difference between a polymer and a copolymer? Give and describe an example of a common polymer. How would this be different from a copolymer?
Polymers and copolymers are both long chains of bonded monomers. A polymer is a long chain that consists of many of the same monomer. An example of this is your basic plastics found around your home and school. A copolymer consists of 2 different monomers bonded together in a long chain. Alginate, from algae (as seen in the article) is a common copolymer. These types of compounds create a gummy type of compound, which in some cases can be edible.
8. What are some ways algae can lower excess CO2 levels? What are some other ways algae can help the environment?
There are a few ways algae can help in the reduction (or “capture”) of CO2. First, the structure of algae is great in absorbing large amounts of the CO2. This is because Algae does not have roots or trunks/branches like other plants. Thus, the algae does not have areas where CO2 cannot be absorbed. Also, algae oils can replace palm oils, which would lead to less deforestation. Also, the algae can be converted into more environmentally friendly plastics, which captures permanently the CO2, thus minimizing the amount that goes into the atmosphere.
9. Why is nitrogen in the air not chemically reactive? (Hint: look at the structure of the N2 molecule).
If you look at a picture of the structure of the N2 molecule, you will see that the two N atoms are connected by a triple bond. A very large amount of energy is needed to break these triple bonds, which means the N2 molecule is very non-reactive. The nitrogen we use in our lives are part of nitrogen-based compounds or ions.
10. Research and explain what happens to CO2 when it is dissolved in water. How would an increase in acidity affect the dissolved CO2?
When CO2 is dissolved in water, it reacts with water to make the weak carbonic acid, which breaks down into hydrogen ions and bicarbonate ions. (see reactions below).

CO2 + H2O –> H2CO3

H2CO3 → H+ + HCO3-1

If the acidity of the oceans/lakes increases, this means more hydrogen ions are present, thus not as much CO2 can dissolve in the water. The excess CO2 remains in the atmosphere, causing the greenhouse gas effect, and disrupts the natural carbon cycle. (Good resource: <https://www.ucsusa.org/resources/co2-and-ocean-acidification>).

1. Research MSG (Monosodium glutamate). What is it used for? Why was MSG considered bad for your health?
Monosodium glutamate (MSG) is a flavor enhancer that is added to foods to make them more tasty and appealing. MSG is commonly added to certain foods (like canned or processed foods) that may need some extra flavor. For a time, there were claims that MSG had adverse health effects, such as headaches and nausea, as well as other symptoms. However, there was very little evidence of this being true, and the FDA still considers MSG to be safe. (<https://www.mayoclinic.org/healthy-lifestyle/nutrition-and-healthy-eating/expert-answers/monosodium-glutamate/faq-20058196>).

**Graphic Organizer Rubric**

If you use the Graphic Organizer to evaluate student performance, you may want to develop a grading rubric such as the one below.

|  |  |  |
| --- | --- | --- |
| **Score** | **Description** | **Evidence** |
| 4 | Excellent | Complete; details provided; demonstrates deep understanding. |
| 3 | Good | Complete; few details provided; demonstrates some understanding. |
| 2 | Fair | Incomplete; few details provided; some misconceptions evident. |
| 1 | Poor | Very incomplete; no details provided; many misconceptions evident. |
| 0 | Not acceptable | So incomplete that no judgment can be made about student understanding |

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# Additional Resources and Teaching Strategies

**Additional Resources**

* **Labs and demos**
	+ [The Algae-in-a-Bottle Experiment: A High-Impact Learning Activity (carleton.edu)](https://serc.carleton.edu/sp/activities/124605.html)
	+ <https://teachchemistry.org/periodical/issues/march-2023/algae-trivia>
	+ <https://teachchemistry.org/classroom-resources/ingenious-is-the-answer-to-overfishing-algae-video-questions>
	+ <https://teachchemistry.org/classroom-resources/ideal-gas-law-using-carbon-dioxide>
	+ <https://teachchemistry.org/classroom-resources/clean-air-chemistry>
* **Lessons and lesson plans**
	+ [Ocean Acidification: “The Other Carbon Dioxide Problem” – Compound Interest (compoundchem.com)](https://www.compoundchem.com/2017/01/18/ocean-acidification-co2/)
	+ [RealTimeChem Week: Turning Carbon Dioxide into Useful Plastics – Compound Interest (compoundchem.com)](https://www.compoundchem.com/2016/11/04/rtcw-co2-plastics/)
	+ [The Secrets of the Coke and Mentos Fountain – Compound Interest (compoundchem.com)](https://www.compoundchem.com/2017/05/02/coke-mentos/)
	+ [A Brief Guide to Atmospheric Pollutants – Compound Interest (compoundchem.com)](https://www.compoundchem.com/2015/05/05/atmospheric-pollutants/)

**Teaching Strategies**

Consider the following tips and strategies for incorporating this article into your classroom:

* **Alternative to Anticipation Guide:** Before reading, ask students where algae might be found and what products are made from algae. Ask them why algae may become more important in the future. Their initial ideas can be collected electronically via Jamboard, Padlet, or similar technology.
	+ As they read, students can find information to confirm or refute their original ideas.
	+ After they read, ask students what they learned about the importance of developing products from algae.
* This article fits well with the theme for Chemists Celebrate Earth Week: The Curious Chemistry of Amazing Algae (April 16-22, 2023). Go to<https://www.acs.org/education/outreach/ccew.html> to find more information about integrating the chemistry of algae into your curriculum.
* Beth Zotter, one of the people featured in this article, is profiled in the Chemistry in Person column on page 19. Students can find out more about how she became interested in developing the products made by her company.

# Chemistry Concepts and Standards

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Polymers
* Molecular structure

**Correlations to Next Generation Science Standards**

This article relates to the following performance expectations and dimensions of the NGSS:

**HS-LS2-7.** Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.

**HS-ETS1-2.** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

**Disciplinary Core Ideas:**

* PS.1.A: Structure and Properties of Matter
* LS2.C: Ecosystem Dynamics, Functioning, and Resilience
* ETS1.B: Developing Possible Solutions

**Crosscutting Concepts:**

* Scale, proportion, and quantity
* Systems and system models
* Energy and matter

**Science and Engineering Practices:**

* Constructing explanations (for science) and designing solutions (for engineering)

**Nature of Science:**

* Science is a human endeavor.

See how *ChemMatters* correlates to the[**Common Core State Standards** online](https://www.acs.org/content/acs/en/education/resources/highschool/chemmatters/teachers-guide.html).