

**Teacher’s Guide**

**The Search for Hidden Plastics**

***October 2020***

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

[Reading Comprehension Questions](#_Student_Reading_Comprehension_1) 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 5](#_Graphic_Organizer_1)

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.

[Answers 6](#_Answers_to_Reading)

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

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**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. Worldwide, there are five ocean gyres where plastic trash accumulates. |
|  |  | 1. Ocean gyres are caused by pollution. |
|  |  | 1. Almost all of the plastic pollution that enters the oceans remains floating on the surface of the oceans. |
|  |  | 1. Microplastics are defined as plastic pieces smaller than 5 mm. |
|  |  | 1. Microplastics have been found all over the world, including in the air and drinking water. |
|  |  | 1. Scientists do not yet know the effects of microplastics in humans. |
|  |  | 1. Nanoplastics are small enough to enter living cells. |
|  |  | 1. Most lab equipment is made of plastic, increasing the possibility of contamination of experiments to research the effects of nanoplastics. |
|  |  | 1. Unlike plastics, natural debris becomes waterlogged and sinks in water. |
|  |  | 1. Plastics reflect infrared light in the water differently than ocean sediments. |

# Student Reading Comprehension Questions

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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

1. What is a garbage patch?
2. According to the article, what item makes up a large portion of the plastics found in the ocean?
3. List the five ocean gyres in the world.
4. Name two ways that microplastics can travel in the environment.
5. Many fishing nets are made of polyethylene. Write the chemical formula for an ethylene monomer.
6. Compare and contrast microplastics and nanoplastics.
7. What makes nanoplastics difficult to locate in the environment?
8. Explain how Anna Du’s underwater remote-operated vehicle uses patterns to locate microplastics.
9. Describe a method that scientists have used to study the impact of microplastics on humans without deliberately exposing humans to microplastics.
10. Explain how and where garbage patches form.
11. Microplastics have been found in honey and table salt. Explain how this could happen.

**Student Reading Comprehension Questions, cont.**

**Questions for Further Learning**

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

1. After reading about Aivazian’s idea for separating out microplastics, what is a method you would recommend for separating microplastics? Use scientific principles to support your idea.
2. Use the information you learned about microplastics and nanoplastics to draft a PSA explaining what they are and steps that could be taken to reduce them.

# 

# Graphic Organizer

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Directions**: As you read, complete the graphic organizer below to describe issues related to describe the issues related to microplastics discussed in the article.

|  |  |  |
| --- | --- | --- |
| **Sources of microplastics  (list at least four)** |  | |
| **Where microplastics have been found (list at least four places other than the ocean)** |  | |
| **Ongoing research related to microplastics** | **Albert Koelmans:** | **Ter Halle:** |
| **Possible solutions to microplastic pollution** | **Ray Aivasian:** | **Anna Du:** |

**Summary:** Write one thing you can do to reduce the amount of plastic in the environment, and explain why your choice would help.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. **What is a garbage patch?**

*An area of the ocean where trash is found in a high concentration.*

1. **According to the article, what item makes up a large portion of the plastics found in the ocean?**

*Fishing nets account for a large portion of plastics in the ocean.*

1. **What type of plastic is most frequently used to make fishing nets?**

*Most fishing nets are made of polyethylene.*

1. **List the five ocean gyres in the world.**

*The five ocean gyres are the North Pacific Gyre, South Pacific Gyre, North Atlantic Gyre, South Atlantic Gyre, and Indian Ocean Gyre.*

1. **Name two ways that microplastics can travel in the environment.**

*Microplastics can travel through water and air.*

1. **Many fishing nets are made of polyethylene. Write the chemical formula for an ethylene monomer.**

*The formula for an ethylene monomer is C2H4.*

1. **Compare and contrast microplastics and nanoplastics.**

*Both are small pieces of plastic. A microplastic is a piece of plastic smaller than 5 mm. A nanoplastic is a piece of plastic smaller than 1 micrometer. Nanoplastics are small enough to cross barriers and enter cells.*

1. **What makes nanoplastics difficult to locate in the environment?**

*Nanoplastics are difficult to locate because they are too small to measure with the instruments and protocols that are typically used for detecting microplastics.*

1. **Explain how Anna Du’s underwater remote-operated vehicle uses patterns to locate microplastics.**

*Anna Du’s ROV uses infrared LEDs to shine light onto its surroundings and the uses the wavelength patterns in the light that bounces back to distinguish between sediment and plastic.*

1. **Describe a method that scientists have used to study the impact of microplastics on humans without deliberately exposing humans to microplastics.**

*Scientists can use human cells outside of the human body, such as in Lehner’s experiment, to study the impact of plastics on humans. Lehner grew a layer of intestinal cells and immune cells to mimic the intestinal wall. Additionally, Koelman utilized artificial intestinal juices to research the impact of microplastics in the digestive system.*

1. **Explain how and where garbage patches form.**

*Garbage patches form at an ocean gyre. A gyre is an area of the ocean where currents meet and swirl in a circle. Plastics that enter the ocean move through the currents and then become trapped in the gyre, creating a patch of garbage.*

1. **Microplastics have been found in honey and table salt. Explain how this could happen.**

*Because they are so small, microplastics move through natural systems through both the air and water. These modes of travel can allow them to come into contact with living organisms and food sources.*

**Questions for Further Learning**

1. **After reading about Aivazian’s idea for separating out microplastics, what is a method you would recommend for separating microplastics? Use scientific principles to support your idea.**

*Student answers will vary and may include ideas that involve mass, density, and/or wavelength of reflected light.*

1. **Use the information you learned about microplastics and nanoplastics to draft a PSA explaining what they are and steps that could be taken to reduce them.**

*Student responses should define microplastics and nanoplastics as well as including at least one possible method for mitigation.*

**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 |

# Additional Resources

**Labs and demos**

Sampling for Microplastics in Beach Sand: This lab provides students with an opportunity to examine samples of beach sand for microplastics.

<http://sfyl.ifas.ufl.edu/media/sfylifasufledu/flagler/sea-grant/pdf-files/microplastics/Sampling-for-Microplastics-in-Beach-Sand.pdf>

Activity: Identifying Plastics with Density Data <https://teachchemistry.org/classroom-resources/identifying-plastics-with-density-data>

Lab: The Six Big Plastics <https://teachchemistry.org/classroom-resources/the-big-six-plastics>

**Simulations**

Garbage Patch Visualization Experiment: This NASA visualization utilizes NOAA buoy data to demonstrate currents and gyres. <https://svs.gsfc.nasa.gov/4174>

**Lessons and lesson plans**

Microplastics: It All Comes Out in the Wash: In this lesson students learn about the various sources of microplastics as well as analyze citizen science data.

<http://masweb.vims.edu/bridge/datatip.cfm?Bridge_Location=archive1019.html>

Mitigating Microplastics – Teacher Lesson Plans: This curriculum unit includes lessons to help students identify and mitigate microplastics from a variety of sources.

<https://seagrant.oregonstate.edu/sites/seagrant.oregonstate.edu/files/e-16-001_kowalski_conway_m-a-02.pdf>

The Great Pacific Garbage Patch: In this lesson students learn about how the Great Pacific Garbage Patch developed and explore how environmental engineers are working to help mitigate the problem.

<https://www.teachengineering.org/lessons/view/uoh_dig_mapping_less3>

# Chemistry Concepts, Standards, and Teaching Strategies

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Physical properties and physical change
* Density
* Separating mixtures
* Polymers
* Measurement

**Correlations to Next Generation Science Standards**

This article can be used to achieve the following performance expectations of NGSS:

**HS-ESS3-4**

Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.

**HS-ETS1-3**

Evaluate a solution to a complex real-world problem based on prioritized criteria and tradeoffs that account for a range of constraint, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

**Disciplinary Core Ideas:**

* ESS3.c: Human Impacts on Earth Systems
* ETS1.B: Developing Possible Solutions

**Crosscutting Concepts:**

* Cause and Effect: Mechanism and explanation.
* Scale, Proportion, and Quantity
* Systems and System Models
* Stability and Change

**Science and Engineering Practices:**

* Analyzing and interpreting data
* Constructing explanations and designing solutions

**Nature of Science:**

* Scientific investigations use a variety of methods.

**Correlations to Common Core State Standards**

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

**Teaching Strategies**

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

* **Alternative to Anticipation Guide:** Before reading, ask students if they have heard of the huge garbage patches in the ocean, and what they might be made of. Ask where they think microplastics have been found in the environment. As they read, students can find information to confirm or refute their original ideas. *Do not tell students the answers prior to reading.*
* As an alternative to the graphic organizer summary, have students write a letter to their community or to their major identifying one thing that the community can do to reduce the amount of plastic in the environment, and explain why their choice would help.
* After they read, ask students what surprised them about the article. Ask them what ideas they have about removing microplastics from the environment.
* If students want to know more about what is being done to solve the plastics pollution problem, you can show the ACS Reactions Video: “Can Plastic Be Composted?” URL: <https://youtu.be/Q02Xi7S5PTM>
  + Ask students what problems must be overcome to compost plastics.
* Do the “Hidden Plastics” puzzle with your students for a fun activity. See the printable version and accompanying answer key in the next pages.

**Hidden plastics**

Hidden in the sea of letters below are 11 polymers found in plastic waste and 13 everyday items that use them. After you find all of those, the remaining letters, when read from left to right and top to bottom, may or may not spell out a joke.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| I | H | A | T | O | O | T | H | P | A | S | T | E | V | P | C | P |
| S | G | A | B | Y | R | E | C | O | R | G | E | A | J | O | O | O |
| P | K | E | C | A | W | B | O | L | U | T | T | E | F | L | O | N |
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| C | E | G | E | I | R | T | C | H | L | N | L | J | U | E | R | E |
| A | W | N | T | S | B | T | S | Y | Y | S | G | Y | S | T | E | O |
| R | I | I | E | O | O | E | E | L | P | P | S | O | N | H | T | P |
| B | N | H | N | R | T | S | C | E | O | U | A | N | A | A | T | R |
| O | G | T | D | O | T | H | A | N | R | C | N | A | C | N | I | E |
| N | G | O | N | E | L | S | F | E | P | R | D | I | A | E | L | N |
| A | U | L | R | O | E | A | Y | M | Y | E | N | O | D | T | G | E |
| T | M | C | R | T | O | T | A | L | L | P | L | L | O | Y | S | U |
| E | C | I | R | C | U | I | T | B | O | A | R | D | S | R | E | W |
| H | D | R | E | B | B | U | R | E | P | P | R | E | I | T | E | N |
| E | D | S | S | G | A | B | P | I | H | C | O | T | A | T | O | P |

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| --- | --- | --- | --- | --- |
| **Products Containing Polymers** | | | **Polymers** | |
| 1) |  | 8) | 1) | 8) |
| 2) |  | 9) | 2) | 9) |
| 3) |  | 10) | 3) | 10) |
| 4) |  | 11) | 4) | 11) |
| 5) |  | 12) | 5) |  |
| 6) |  | 13) | 6) |  |
| 7) |  |  | 7) |  |

**Remaining letters**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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**Hidden plastics – ANSWER KEY**

Hidden in the sea of letters below are 11 polymers found in plastic waste and 13 everyday items that use them. After you find all of those, the remaining letters, when read from left to right and top to bottom, may or may not spell out a joke.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| I | H | A | T | O | O | T | H | P | A | S | T | E | V | P | C | P |
| S | G | A | B | Y | R | E | C | O | R | G | E | A | J | O | O | O |
| P | K | E | C | A | W | B | O | L | U | T | T | E | F | L | O | N |
| O | P | O | A | L | A | Y | B | Y | E | M | E | R | Y | Y | K | C |
| L | C | H | R | E | T | M | U | E | N | I | P | V | S | U | W | T |
| Y | H | R | P | Y | E | B | R | T | E | O | I | U | T | R | A | N |
| C | E | G | E | I | R | T | C | H | L | N | L | J | U | E | R | E |
| A | W | N | T | S | B | T | S | Y | Y | S | G | Y | S | T | E | O |
| R | I | I | E | O | O | E | E | L | P | P | S | O | N | H | T | P |
| B | N | H | N | R | T | S | C | E | O | U | A | N | A | A | T | R |
| O | G | T | D | O | T | H | A | N | R | C | N | A | C | N | I | E |
| N | G | O | N | E | L | S | F | E | P | R | D | I | A | E | L | N |
| A | U | L | R | O | E | A | Y | M | Y | E | N | O | D | T | G | E |
| T | M | C | R | T | O | T | A | L | L | P | L | L | O | Y | S | U |
| E | C | I | R | C | U | I | T | B | O | A | R | D | S | R | E | W |
| H | D | R | E | B | B | U | R | E | P | P | R | E | I | T | E | N |
| E | D | S | S | G | A | B | P | I | H | C | O | T | A | T | O | P |

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **Products Containing Polymers** | | | | **Polymers** | | | |
| 1) | CARPET | 8) | GROCERY BAGS | 1) | NEOPRENE | 8) | POLYURETHANE |
| 2) | CHEWING GUM | 9) | PAPER CUPS | 2) | NYLON | 9) | POLYVINYL CHLORIDE |
| 3) | CIRCUIT BOARDS | 10) | POTATO CHIP BAGS | 3) | POLYCARBONATE | 10) | RUBBER |
| 4) | CLOTHING | 11) | SODACANS | 4) | POLYESTER | 11) | TEFLON |
| 5) | COOKWARE | 12) | TOOTHPASTE | 5) | POLYETHYLENE |  |  |
| 6) | FACE SCRUB | 13) | WATER BOTTLE | 6) | POLYPROPYLENE |  |  |
| 7) | GLITTER |  |  | 7) | POLYSTRENE |  |  |

**Remaining letters**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| U | T |  | P | O | L | Y | M | E | R |  | C | H | E | M | I | S |
| T | R | Y |  | B | U | T |  | I | T |  | J | U | S | T |  | G |
| O | E | S |  | O | N |  | A | N | D |  | O | N |  | A | N | D |
|  | I |  | A | M |  | N | O | T |  | T | O | T | A | L | L | Y |
| S | S | U | R | E |  | W | H | E | R | E |  | I | T |  | E | N |
| D | S | . |  |  |  |  |  |  |  |  |  |  |  |  |  |  |