

**Teacher’s Guide**

**How to Make Fashion Sustainable**

***April 2021***

**Table of Contents**

[Anticipation Guide](#_Anticipation_Guide) 2

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 5](#_Graphic_Organizer)

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.

[Additional Resources](#_Additional_Resources) 8

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

[Chemistry Concepts, Standards, and Teaching Strategies 9](#_Chemistry_Concepts,_Standards,)

# 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. Polyester fabrics are made of polymers derived from fossil fuels. |
|  |  | 1. Each year, commercial flights produce more carbon dioxide than the textile industry. |
|  |  | 1. Unwanted clothing made from natural fibers release methane when put in landfills. |
|  |  | 1. Most textiles are made from cotton. |
|  |  | 1. Making one pair of denim jeans requires 20,000 liters of water. |
|  |  | 1. Some natural fibers are made from wood scraps. |
|  |  | 1. As clothing is used, the polymers lengthen. |
|  |  | 1. Ionic liquids have been developed to dissolve cellulose. |
|  |  | 1. The same chemical process that works to recycle cotton works for other fabrics. |
|  |  | 1. Spandex is easy to recycle. |

# Student Reading Comprehension Questions

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

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

1. Which polymer is the most naturally abundant polymer on Earth?
2. Name the greenhouse gas that is produced when the natural fibers in clothing degrade in landfills.
3. What is a polymer?
4. What is lyocell?
5. Describe ionic liquids.
6. How is NuCycl different from other textiles?
7. Explain the impact of the clothing industry on land, air, and water resources.
8. Describe two drawbacks of using cotton for clothing.
9. What are two benefits of using lyocell rather than cotton to make textiles?
10. Describe the process of depolymerization.
11. Why don’t denim jeans dissolve in the washing machine?
12. Create a pie chart to represent the percentage of textiles that are made of polyester, cotton, and other fibers.

**Student Reading Comprehension Questions, cont.**

**Questions for Further Learning**

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

1. Explain how solvent-based recycling works.
2. Finding the correct solvent for dissolving specific types of polymers in clothing depends on what type of relationship between the polymer and the solvent?
3. Why is it difficult to use solvent-based recycling on textiles that are made of different types of polymers?
4. Research textile recycling in your area. Where is the closest recycling site? What method do they use to recycle textiles? Use the information you find to create a blog post informing readers about the benefits of recycling textiles and how they can help with recycling efforts.
5. Select one of the options from the “5 Ways to Reduce Your Fashion Footprint” section of the article and create an infographic to help others better understand how they can reduce their fashion footprint.

# Graphic Organizer

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

**Directions**: As you read, complete the graphic organizer below to describe problems with fabric manufacturing for clothing and possible solutions.

|  |  |  |
| --- | --- | --- |
|  | **Polyester** | **Cellulose** |
| **Raw materials** |  |  |
| **Structural formula** |  |  |
| **Type of clothing** |  |  |
| **Environmental drawbacks** |  |  |
| **Recycling challenges** |  |  |

**Summary:** Write a tweet (280 characters or less) about the importance of recycling clothing.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. **Which polymer is the most naturally abundant polymer on Earth?**

*Cellulose is the most naturally abundant polymer.*

1. **Name the greenhouse gas that is produced when the natural fibers in clothing degrade in landfills.**

*Methane is produced when natural fibers in clothing degrade in landfills.*

1. **What is a polymer?**

*A polymer is a long chain of chemically linked molecules or monomers.*

1. **What is lyocell?**

*Lyocell is a human made natural fiber produced from wood scraps.*

1. **Describe ionic liquids.**

*Ionic liquids are conductive salts that are composed of a large organic cation and either an organic or an inorganic anion.*

1. **How is NuCycl different from other textiles?**

*NuCycl is a fiber made from 100% post-consumer cotton.*

1. **Explain the impact of the clothing industry on land, air, and water resources.**

*The clothing industry is problematic because it produces 1.2 billion metric tons of carbon dioxide, 90% of clothes end up in landfills, and the process of clothing manufacture uses 93 billion metric tons of water each year.*

1. **Describe two drawbacks of using cotton for clothing.**

*Growing cotton requires a lot of water and the land used to grow cotton could be used to grow food.*

1. **What are two benefits of using lyocell rather than cotton to make textiles?**

*Lyocell does not require as much water and can be grown without pesticides.*

1. **Describe the process of depolymerization.**

*Depolymerization is a process that breaks a polymer down into its constituent monomers.*

1. **Why don’t denim jeans dissolve in the washing machine?**

*Denim does not dissolve in water because the intermolecular forces between polymer strands help keep them together.*

1. **Create a pie chart to represent the percentage of textiles that are made of polyester, cotton, and other fibers.**

*Polyester is found in 55% of textiles. Cotton fibers make up 27% of all textiles. Human-made cellulose fibers, such as lyocell, make up 5%.*

**Questions for Further Learning**

1. **Explain how solvent-based recycling works.**

*Solvent-based recycling is when used textiles are collected, their polymers are dissolved using solvents and then the fibers are turned into yarn.*

1. **Finding the correct solvent for dissolving specific types of polymers in clothing depends on what type of relationship between the polymer and the solvent?**

*The key to finding the best solvent for dissolving polymers is to make sure that the polymer-solvent intermolecular attraction outweighs the polymer-polymer forces.*

1. **Why is it difficult to use solvent-based recycling on textiles that are made of different types of polymers?**

*Solvents that work with one type of polymer may not be effective in dissolving a different polymer.*

1. **Research textile recycling in your area. Where is the closest recycling site? What method do they use to recycle textiles? Use the information you find to create a blog post informing readers about the benefits of recycling textiles and how they can help with recycling efforts.**

*Student responses will vary but should include at least two benefits of recycling textiles and provide information on textile recycling in the region.*

1. **Select one of the options from the “5 Ways to Reduce Your Fashion Footprint” section of the article and create an infographic to help others better understand how they can reduce their fashion footprint.**

*Student responses will vary. Students should select one method for reducing their fashion footprint and include pictures and a meaningful description of the environmental impact of the option.*

**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**

**Focus on Fabrics: Putting Materials to Good Use**: This hands-on lab encourages students to investigate various properties of different natural and synthetic fibers found in textiles. <https://www.teachengineering.org/activities/view/focus_on_fabrics>

**Bond Strength of Ionic Salts**: During this lab students will use models to demonstrate the bonds of ionic salts and will investigate the temperature changes that result when different salts are dissolved. <https://teachchemistry.org/classroom-resources/bond-strength-of-ionic-salts>

**Polymerization of Nylon**: This activity can be conducted as a demonstration or a lab, when following proper safety guidelines, to help students understand the polymerization of nylon. <https://uakron.edu/polymer/agpa-k12outreach/lesson-plans/polymerization-of-nylon>

**Lessons and lesson plans**

**Man and Materials through History:** In this lesson plan students learn identify polymers, learn how they are made, and create a timeline of polymer history. <https://www.acs.org/content/acs/en/education/whatischemistry/landmarks/lesson-plans/man-and-materials-through-history.html>

**Everyday Polymers**: In this lesson plan students will explore the varied uses of polymers and their structures. <https://www.teachengineering.org/lessons/view/csu_polymer_lesson01>

# Chemistry Concepts, Standards, and Teaching Strategies

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Molecular structure
* Polymers
* Solutions
* Intermolecular forces

**Correlations to Next Generation Science Standards**

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

**HS-PS1-3**

Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles.

**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:**

* PS1.A: Structure and Properties of Matter
* ETS1.C: Optimizing the Design Solution

**Crosscutting Concepts:**

* Structure and function
* Scale, proportion, and quantity
* Energy and matter

**Science and Engineering Practices:**

* Planning and carrying out investigations

**Nature of Science:**

* Scientific knowledge assumes an order and consistency in natural systems.

**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 clothing can be recycled, and how.
  + As they read, students can find information to confirm or refute their original ideas.
  + After they read, ask students what they learned about energy use in producing textiles, and the problems with recycling clothing.
* The ACS Reactions Video “The dark side of synthetic fleece” (<https://youtu.be/o6qnwV7ep-M>) has information about environmental problems caused from washing synthetic fibers. Consider sharing this video with students after they have discussed how they could reduce their fashion footprint.