

**Teacher’s Guide**

 **What is Ice Cream and Why Do We Scream for It?**

***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. By definition, ice cream must contain at least 10% milk fat by weight according to the U.S. Food & Drug Administration.
 |
|  |  | 1. Ice cream is 20-50% air by volume.
 |
|  |  | 1. Sugars increase the freezing point of ice cream.
 |
|  |  | 1. Ice cream can be scooped even at -20 °C.
 |
|  |  | 1. Thawing and refreezing ice cream creates small ice crystals.
 |
|  |  | 1. Ice cream with small ice crystals has a creamier texture than ice cream with large ice crystals.
 |
|  |  | 1. Ice cream made with liquid nitrogen has larger ice crystals.
 |
|  |  | 1. Gelato has a higher fat content than ice cream.
 |
|  |  | 1. Fat droplets help stabilize the air bubbles formed when ice cream is churned.
 |
|  |  | 1. Sorbet does not contain any dairy products.
 |

# Student ReadingComprehension Questions

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

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

1. What is the purpose of adding emulsifiers in the ice cream making process?
2. What components of ice cream help create the creamy, smooth texture? How does varying the amount of these components affect the nature of the ice cream?
3. The article states that 75% of the water in ice cream becomes frozen once the ice cream is made. The remaining 25% combines with other ingredients in the ice cream’s liquid phase. Why is maintaining the liquid phase critical to creating high quality ice cream?
4. Explain the role stabilizing gum plays in improving the shelf life of ice cream.
5. List and explain two natural ingredients that food scientists are experimenting with to develop enhanced ice cream properties in the future.
6. How has low temperature extrusion, or “slow churn,” improved the ice cream making process?
7. Discuss how the ingredients in ice cream can be altered to create a low-calorie version of the famous treat.
8. The article mentions freezing point depression and how the dissolved solutes in the liquid phase of the ice cream help lower the freezing point of water. This helps prevent ice cream from developing a gritty, coarse texture. Explain the freezing point depression on the molecular level and find a real-world application of freezing point depression other than ice cream.
9. Emulsifiers are used to prevent ingredients that normally would not mix from separating in the ice cream making process. Give an example of a polar compound and a non-polar compound and give a brief explanation of why polar and non-polar molecule do not mix.

**Student Reading Comprehension Questions, cont.**

1. The article states that U.S. dairies produce nearly 5.2 billion liters of ice cream each year. Based on that production rate, how many years would it take for the U.S. to produce enough ice cream to fill the moon (if the moon were theoretically hallow)?

Volume of the moon = 2.19 x 1010 km3

1 L = 1 x 103 cm3

1 m3 = 1 x 106 cm3

1 km3 = 1 x 109 m3

**Questions for Further Learning**

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

1. An estimated 6.1 million Americans are allergic to milk and other dairy products. Research and discuss alterations that can be made to the ingredients to make ice cream accessible and safe to individuals with a milk or dairy allergy.
2. The number of flavors and varieties of ice cream has increased dramatically over the years. Select your three favorite flavors of ice cream and research and list the ingredients used to make your favorite flavors.

# Graphic Organizer

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

**Directions**: As you read, complete the graphic organizer below to describe the ingredients in ice cream and why they are needed.

|  |  |  |
| --- | --- | --- |
| **Ingredient** | **Example or source** | **Importance in making ice cream** |
| **Water** |  |  |
| **Fat** |  |  |
| **Emulsifiers** |  |  |
| **Air** |  |  |
| **Stabilizers** |  |  |
| **Sweeteners** |  |  |

**Summary:** Write a one-sentence summary (20 words or less) about what you learned about making ice cream.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. **What is the purpose of adding emulsifiers in the ice cream making process?**

*Emulsifiers prevent substances that normally do not blend well (such as polar water and non-polar fat) from separating once the ice cream is formed.*

1. **What components of ice cream help create the creamy, smooth texture? How does varying the amount of these components affect the nature of the ice cream?**

*Fat, proteins, emulsifiers, and air bubbles all contribute the texture of ice cream. The quantities of these ingredients can be altered to create different variations of ice cream such as soft served, gelato, and frozen yogurt, which all differ in texture, fat content, melting time, and taste.*

1. **The article states that 75% of the water in ice cream becomes frozen once the ice cream is made. The remaining 25% combines with other ingredients in the ice cream’s liquid phase. Why is maintaining the liquid phase critical to creating high quality ice cream?**

*The liquid phase contains dissolved sugars and other ingredients that help lower the freezing point of the water in the ice cream and keep the ice cream soft and scoopable at very low temperatures.*

1. **Explain the role stabilizing gum plays in improving the shelf life of ice cream.**

*Stabilizers prevent the water molecules from joining together in the liquid phase which would cause larger crystals to form and give the ice cream an undesirable coarse and gritty texture.*

1. **List and explain two natural ingredients that food scientists are experimenting with to develop enhanced ice cream properties in the future.**

*Polyphenol from strawberries helps ice cream keep its shape and prevent dripping during melting.*

*Cellulose nanofibers from banana plants reduce melting, enhance creaminess, and prolong shelf life.*

1. **How has low temperature extrusion, or “slow churn,” improved the ice cream making process?**

*The ice cream freezes more rapidly and uniformly during the process. Therefore, only small ice crystals have a chance to form and stay small. The slow churn kneading motion reduces the air bubbles size and distributes fat more efficiently for enhanced smoothness and texture.*

1. **Discuss how the ingredients in ice cream can be altered to create a low-calorie version of the famous treat.**

*The fat content can be reduced to 2%-3%. The use of non-caloric stabilizer gums can be used to offset the texture loss. Air content can be increased to add volume due to the fat loss. Low-calorie sweeteners can also be used to create a low-calorie version.*

1. **The article mentions freezing point depression and how the dissolved solutes in the liquid phase of the ice cream help lower the freezing point of water. This helps prevent ice cream from developing a gritty, coarse texture. Explain the freezing point depression on the molecular level and find a real-world application of freezing point depression other than ice cream.**

*When a solute is dissolved in a solvent such as water, the particles interfere with the water molecule’s ability to form hydrogen bonds between adjacent molecules and disrupt the freezing process.*

*Another real-world application of freezing point depression adding salt (NaCl) and other compounds to snow and ice covered roads, driveways, and sidewalks. The dissolved Na+ and Cl– ions interact the partial positive and negative charges on the polar water molecule and interfere with the hydrogen bonds and the freezing process.*

1. **Emulsifiers are used to prevent ingredients that normally would not mix from separating in the ice cream making process. Give an example of a polar compound and a non-polar compound and give a brief explanation of why polar and non-polar molecule do not mix.**

*Answers may vary for the compounds. Example: Water-Polar and Oil-Non-polar*

*Non-polar compounds only contain weak London dispersion forces. Therefore, a non-polar solute when placed in a polar solvent the weak dispersion forces of the non-polar solute are not strong enough to disrupt the dipole-dipole or hydrogen bonds present in the polar molecule. Strong intermolecular forces are required to form an attraction, i.e. mix or dissolve, with a polar compound which is simply not present in a non-polar molecule.*

1. **The article states that U.S. dairies produce nearly 5.2 billion liters of ice cream each year. Based on that production rate, how many years would it take for the U.S. to produce enough ice cream to fill the moon (if the moon were theoretically hallow)?**

Volume of the moon = 2.19 x 1010 km3

1 L = 1 x 103 cm3

1 m3 = 1 x 106 cm3

1 km3 = 1 x 109 m3

 *2.19 x 1010 km3 x 1 x 109 m3 x 1 x 106 cm3 x \_1 L\_\_\_\_\_ = 2.2 x 1022 L*

 *1 km3 1 m3 1 x 103 cm3*

*Liters of ice cream per year: 5.2 x 109 L\_*

 *1 year*

*Volume of the moon in liters 2.2 x 1022 L x 1 year\_\_\_ = 4.2 Years*

 *5.2 x 109 L*

**Questions for Further Learning**

1. **An estimated 6.1 million Americans are allergic to milk and other dairy products. Research and discuss alterations that can be made to the ingredients to make ice cream accessible and safe to individuals with a milk or dairy allergy.**

*Milk/dairy free ice cream can be created using dairy milk alternatives such as soy milk, coconut milk, and almond milk. Non-dairy emulsifiers and stabilizers also exist to create non-dairy ice cream.*

1. **The number of flavors and varieties of ice cream has increased dramatically over the years. Select your 3 favorite flavors of ice cream and research and list the ingredients used to make your favorite flavors.**

*Answers will vary*

**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

**Lessons and lesson plans**

**Polarity Activity:** In this activity, the students model the pull of electrons in a bond between two elements, demonstrating covalent bonding. In a second activity, the students apply the information they developed in the first activity to a molecule. <https://teachchemistry.org/periodical/issues/may-2019/modeling-polarity>

**Labs and demos**

**Freezing Ice Cream**: In this lab, students will investigate changing states of matter, chemical reactions, and the properties of ice and salt while creating their own ice cream. <https://teachchemistry.org/classroom-resources/freezing-ice-cream>

**Coffee Creamer Ice Cream:** In this lab, students will investigate how dissolving salt (sodium chloride) in water changes the freezing point of the solution. While investigating this, they will make ice cream from small coffee creamer cups. <https://teachchemistry.org/classroom-resources/coffee-creamer-ice-cream>

**Salad Dressing Science: Emulsions:** In this lab, students mix polar and nonpolar substances and then add various emulsifiers to encourage the mixing of the two substances. They use ingredients in salad dressing to relate science to real life scenarios. <https://teachchemistry.org/classroom-resources/salad-dressing-science-emulsions>

**Homemade Ice Cream:** Use science know-how to create a tasty vanilla treat! Follow along with vides to create your own ice cream. <https://www.stevespanglerscience.com/lab/experiments/homemade-ice-cream-sick-science/>

**Emulsion Experiments:** To illustrate the properties of an emulsion, a well-constructed experiment for students (with notes for teacher support) can be found at <http://www.juliantrubin.com/encyclopedia/chemistry/emulsion_experiments.html>.

**Simulations and animations**

**Salty Roads (Freezing Point Depression):** This simulation from the CK-12 Foundation explores how solutes can keep roads clear of ice in the winter. Students will learn how different types and concentrations of solute affect the freezing point of a solution. <https://interactives.ck12.org/simulations/chemistry/freezing-point/app/index.html>

**Other Resources**

**The Chemistry of Frozen Desserts:** Find the infographic referenced in the article: <https://cen.acs.org/articles/95/i29/Periodic-graphics-chemistry-frozen-desserts.html>

# Chemistry Concepts, Standards, and Teaching Strategies

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Solutions
* Freezing point depression
* Mixtures
* Freezing point

**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:**

* Cause and effect: Mechanism and explanation
* Structure and Function

**Science and Engineering Practices:**

* Planning and carrying out investigations

**Nature of Science:**

* Science addresses questions about the natural and material world.

**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 made ice cream, and what they know about the chemistry involved.
	+ As they read, students can find information to confirm or refute their original ideas.
	+ After they read, ask students what they learned about making ice cream. Ask what is important to create ice cream with a creamy, smooth texture.
* Students may find this ACS Reactions Video about ice cream interesting to watch after they read the article: “How Science Affects Your Ice Cream” <https://youtu.be/-rlapUkWCSM>

The video compares three different ways to make ice cream, including making ice cream in a baggie.