

**Teacher’s Guide**

**Sugar: ‘White Gold,’ Transforming America**

***December 2022***

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

[***Reading Comprehension Questions***](#_heading=h.3znysh7) ***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***](#_heading=h.9f8azrtnp6p5) ***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.

[***Answers***](#_heading=h.djipzn7z1r1b) ***6***

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

[***Additional Resources***](#_heading=h.8qbtv1wio6jt) ***9***

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

***[Chemistry Concepts and Standards](#_heading=h.gy1yjx1c39og) 11***



# 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. Excessive sugar consumption is linked to increased risk of heart attack and stroke. |
|  |  | 2. Sugar cane was growing in America when the Europeans arrived. |
|  |  | 3. The boiling point of water on top of a mountain is greater than the boiling point of water in a pressure cooker. |
|  |  | 4. Two hundred years ago, sugar was concentrated and refined by using a series of increasingly smaller kettles called a sugar train. |
|  |  | 5. Norbert Rillieux, the inventor of the multiple effect evaporator, was educated in the United States. |
|  |  | 6. Sugar is a hydrocarbon. |
|  |  | 7. Glucose and sucrose are monosaccharides. |
|  |  | 8. Water can boil at room temperature if the pressure is low enough. |
|  |  | 9. Rillieux’s invention saved fuel in the process of sugar cane refining. |
|  |  | 10. The laws of thermodynamics were understood prior to the invention of the multiple effect evaporator. |

# Student Reading Comprehension Questions

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

1. List some of the effects of consuming too much sugar.
2. What are some of the ideal conditions needed to grow sugar cane?
3. Describe the relationship between the boiling point of a liquid and the air pressure.
4. Assuming air pressure remains constant, what can also cause a liquid to boil at a higher boiling point?
5. What is the 1st law of thermodynamics?
6. List the steps Rillieux used to conserve energy in the sugar making process.
7. Even though outer space has a temperature near zero Kelvin (absolute zero, or about -273°C), water would exist only as a gas, and not a solid. Explain in terms of air pressure and boiling points.
8. Would it take longer to cook a pot of pasta in Denver, Colorado, or Lincoln Nebraska (or neither)? Explain.
9. Explain how pressure cookers are used to increase the speed of cooking foods.
10. Why does the concentration of sugar make the boiling point of the liquid higher?

**Student Reading Comprehension Questions, cont.**

**Questions for Further Learning**

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

1. Colligative properties are physical properties of a liquid that change with the amount of solute (a dissolved substance) in it. Boiling point elevation is one example of a colligative property. Find some other examples, and explain how they work.
2. Research other minority scientists and write a brief biography on their discoveries as well as the challenges they had to face in their scientific pursuits.

# Graphic Organizer

**Directions**: As you read, complete the graphic organizer below to describe the history of sugar refining, the chemistry of sugar refining, and how sugar affects health.

|  |  |  |
| --- | --- | --- |
|  | **Historical Significance** | **Chemistry Involved** |
| **Sugar cane** |  |  |
| **Sugar train** |  |  |
| **Multiple Effect Evaporator** |  |  |
| **Sources of sugar prior to sugar refining process** |  |  |

|  |  |  |
| --- | --- | --- |
|  | **How are they related?** | **Examples** |
| **Boiling point & Vapor pressure** |  |  |
| **Sugar & Carbohydrates** |  |  |
| **Sugar & Health** |  |  |

**Summary:** On the back of this sheet, write three things you learned about the history of sugar refining from the article.

# Answers to Reading Comprehension Questions & Graphic Organizer Rubric

1. List some of the effects of consuming too much sugar.

Some of the effects of consuming too much sugar are high blood pressure, inflammation, weight gain, and diabetes.

1. What are some of the ideal conditions needed to grow sugar cane?

Rich, fertile soil and consistently warm temperatures are needed to grow sugar cane. This makes the Caribbean and southern states the most common areas for growing sugar cane.

1. Describe the relationship between the boiling point of a liquid and the air pressure.

The boiling point of a liquid is when the liquid molecules have enough energy to overcome the competing air pressure and break away from the surface of the liquid. The lower the air pressure, the lower the boiling point, because the liquid needs less energy to break through the lower air pressure.

1. Assuming air pressure remains constant, what can also cause a liquid to boil at a higher boiling point?

Another way to increase the boiling point is to add a dissolved substance (a “solute”). This solute causes the liquid to keep from boiling at its regular temperature.

1. What is the 1st law of thermodynamics?

The first law of thermodynamics states that energy is neither created nor destroyed. It is just converted into different forms.

1. List the steps Rillieux used to conserve energy in the sugar making process.

Rillieux used steam instead of wood fire to heat and power his machine. The hot steam was passed through closed tubes throughout the apparatus to provide constant heat during the entire process. He was also able to trap any heat escaping the machine, and diverted it to other areas. This eliminated the need to create more fires for additional sources of energy. He also lowered the pressure inside the apparatus, which allowed the liquid to boil off at a lower temperature.

1. Even though outer space has a temperature near zero Kelvin (absolute zero, or about -273 °C), water would exist only as a gas, and not a solid. Explain in terms of air pressure and boiling points.

Even though space is very cold, the pressure is almost zero (no air pressure). With no air pressure to keep a substance together in the liquid phase, the liquid molecules will easily separate into gaseous vapor particles and scatter throughout space.

1. Would it take longer to cook a pot of pasta in Denver, Colorado, or Lincoln Nebraska (or neither)? Explain.

Pasta takes longer to cook in Denver, because of the higher altitudes. In these higher altitudes, the air pressure is much lower, so the water to cook the pasta boils at a temperature below 100 oC. Because of the lower cooking temperature, the pasta needs longer to become fully cooked.

1. Explain how pressure cookers are used to increase the speed of cooking foods.

A pressure cooker is a sealed cooking vessel that increases the pressure inside as the food is heated. The high pressure keeps the water the food is cooking in at a much higher temperature (a temperature typically higher than the boiling point of water). This high temperature allows the food to cook faster.

1. Why does the concentration of sugar make the boiling point of the liquid higher?

Sugar (or any dissolved substances) causes the boiling point of a liquid to increase. This is because of the attraction of the sugar molecules to the water molecules. The sugar molecules attracted to the water molecules hold them in the liquid phase, thus preventing them from releasing as a gas. More energy is needed to break these attractions and allow the water to convert to gas.

**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**
  + Changing the Boiling Point of Water

<https://teachchemistry.org/classroom-resources/changing-water-s-boiling-point>

* + Changing the Freezing Point of Water

<https://teachchemistry.org/classroom-resources/sweet-salty-and-cold-as-ice>

* **Simulations**
  + Effects of Solutes on Boiling and Freezing Points

<https://teachchemistry.org/classroom-resources/simulation-activity-the-effect-of-solutes-on-boiling-and-freezing-point>

* **Lessons and lesson plans**
  + Boiling Point Infographic

<https://www.compoundchem.com/2016/03/22/boiling-point/>

* + Candy Making Infographic

<https://www.compoundchem.com/2014/10/21/chemistryofcandy/>

* + Natural Sweeteners Infographic

<https://cen.acs.org/food/Periodic-Graphics-Natural-sweeteners/98/i32>

* + History of Norbert Rillieux

<https://teachchemistry.org/classroom-resources/norbert-rillieux-thermodynamics-and-chemical-engineering>

* **Projects and extension activities**
  + Designing an Effective Respiratory Mask: <https://teachchemistry.org/classroom-resources/designing-an-effective-respiratory-cloth-mask>
  + Tie Dye: <https://teachchemistry.org/classroom-resources/tie-dye>
  + Video- Layered Fabrics in Heat Resistance: <https://teachchemistry.org/classroom-resources/ingenious-this-sandwich-will-save-your-life-in-an-arc-flash-video-questions>

**Teaching Strategies**

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

* **Alternative to Anticipation Guide:** Before reading, ask students where sugar is found in their diet, and how white table sugar is produced. 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 sugar refining and how sugar relates to good health.
* More lesson planning resources about Norbert Rillieux’s life and his invention of the multiple effect evaporator can be found at<https://teachchemistry.org/classroom-resources/norbert-rillieux-thermodynamics-and-chemical-engineering>

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# Chemistry Concepts and Standards

**Connections to Chemistry Concepts**

The following chemistry concepts are highlighted in this article:

* Separating mixtures
* Intermolecular forces
* Molecular structure
* Boiling 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 constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

**Disciplinary Core Ideas:**

* PS.1.A: Structure and Properties of Matter
* ETS1.C: Optimizing the Design Solution

**Crosscutting Concepts:**

* Cause and effect
* Energy and matter
* Systems and system models

**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).