



**Reading Supports**

**Teacher’s Guide:**

**“Feeding the World:   
A Story of Guano,   
War, and Invention”**

*October/November 2018*

<http://www.acs.org/chemmatters>



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Guano, War, and Invention”***

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# Reading Supports

The pages that follow include reading supports in the form of an Anticipation Guide, a Graphic Organizer, and Student Reading Comprehension Questions. These resources are designed to help students prepare to read the article, and then locate and analyze information from the article.

* **Anticipation Guide (p. 5):** The Anticipation Guide helps to engage students by activating prior knowledge and stimulating student interest before reading. If class time permits, discuss students’ responses to each statement before reading each article. As they read, students should look for evidence supporting or refuting their initial responses.

**Or** consider the following ideas to engage your students in reading:

**Feeding the World: A Story of Guano, War, and Invention**

* If you have already taught Le Chatelier’s principle, this article will be an excellent review.
* Before reading, ask students why fertilizer is so important to help feed the world’s people.
* As they read, ask students to look for different ways plants can obtain the nitrogen needed for growth.
* **Graphic Organizer (p. 6):** The Graphic Organizer is provided to help students locate and analyze information from the article. Student understanding will be enhanced when they explore and evaluate the information themselves, with input from the teacher, if students are struggling. Encourage students to use their own words and avoid copying entire sentences from the article. The use of bullets helps them do this.

If you use the aforementioned organizers 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 |

* **Student Reading Comprehension Questions (p. 7):** The Student Reading Comprehension Questions are designed to encourage students to read the article (and graphics) for comprehension and attention to detail, to provide the teacher with a mechanism for assessing how well students understand the article and/or whether they have read the assignment, and, possibly, to help direct follow-up, in-class discussion, or additional, deeper assignments.

Some of the articles in this issue provide opportunities, references, and suggestions for students to do further research on their own about topics that interest them.

To help students engage with the text, ask students which article **engaged** them most and why, or what **questions** they still have about the articles. The “Web Resources for More Information” section of the Teacher’s Guide: Tools and Resources provides sources for additional information that might help you answer these questions.

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

## Anticipation Guide

**Directions:**  ***Before reading the article*,** in the first column, write “A” or “D,” indicating your agreement or disagreement with each statement. 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. Seabird poop (guano) is an excellent natural fertilizer because of its nitrogen content. |
|  |  | 1. Fertilizers supply nitrogen, phosphorus, and potassium to plants. |
|  |  | 1. Nitrogen in the air is readily available to plants. |
|  |  | 1. Proteins cannot be made without nitrogen. |
|  |  | 1. The world’s population needs fertilizers made from ammonia for food production. |
|  |  | 1. In a system at equilibrium, decreasing pressure will cause the reaction to continue in the direction that decreases pressure. |
|  |  | 1. Cooling a system at equilibrium will encourage the production of more heat. |
|  |  | 1. Removing one of the chemicals in a system at equilibrium will cause the reaction to shift to produce more of that chemical. |
|  |  | 1. Using a catalyst increases the amount of energy required for a chemical reaction to occur. |
|  |  | 1. Only about one-tenth of all the world’s food production is thrown away. |

## Graphic Organizer

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

**Directions**: As you read the article, complete the graphic organizer below to describe the different ways to make nitrogen available in plant fertilizer.

|  |  |  |
| --- | --- | --- |
|  | What is it? | How does it provide nitrogen? |
| **Guano** |  |  |
| **Nitrogen-fixing bacteria** |  |  |
| **Haber-Bosch process** |  |  |

**Summary:** On the back of this paper, write a tweet (280 characters or less) about the importance of nitrogen in food production, based on what you learned from reading the article.

## Student Reading Comprehension Questions

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

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

* 1. (a) What is guano, and (b) why is it important?
  2. (a) What are the three macronutrients crucial for plant growth, and (b) which one is essential for producing plant proteins?
  3. (a) Why is atmospheric nitrogen not directly useable for plant growth, and (b) what happens to atmospheric nitrogen in the process of biological nitrogen fixation?
  4. What three factors did Fritz Haber and Carl Bosch optimize for their process of producing ammonia from nitrogen and hydrogen?
  5. Why is Fritz Haber considered to be a controversial figure in the history of chemistry?
  6. Why do scientists consider the industrial-scale production of ammonia by Haber and Bosch to be one of the most important chemical engineering innovations in the history of the world?

**Student Reading Comprehension Questions, cont.**

* 1. When is a chemical system considered to be at equilibrium?
  2. According to Le Châtelier’s principle, what happens to a system at equilibrium when it is subjected to a change?
  3. If a reaction has a negative ΔH, (a) what is happening to the energy in the reaction, and (b) what is the name for this type of reaction?
  4. What is used in the Haber-Bosch process to keep the temperature of ammonia manufacturing below 500 °C?

**Critical-Thinking Question**

***Write your answer on another piece of paper, if needed.***

* 1. Explain why high temperatures can be both an advantage and a disadvantage in the chemical reaction for producing large quantities of ammonia by the Haber-Bosch process.

## Answers to Reading Comprehension Questions

1. **(a) What is guano, and (b) why is it important?**
2. Guano is bird poop, or, more specifically, seabird excrement.
3. It is important because it contains nitrogen, a key ingredient in plant fertilizer.
4. **(a) What are the three macronutrients crucial for plant growth, and (b) which one is essential for producing plant proteins?**
5. The three macronutrients crucial for plant growth are
   1. nitrogen,
   2. phosphorous, and
   3. potassium; and
6. the one that is essential for producing plant proteins is nitrogen.
7. **(a) Why is atmospheric nitrogen not directly useable for plant growth, and (b) what happens to atmospheric nitrogen in the process of biological nitrogen fixation?**
8. Atmospheric nitrogen is not directly useable for plant growth because it contains an incredibly strong triple covalent bond, which makes it almost unreactive and useless to plants.
9. In biological nitrogen fixation, atmospheric nitrogen is converted by microorganisms into ammonia (NH3) and ammonium (NH4+), with the use of an enzyme.
10. **What three factors did Fritz Haber and Carl Bosch optimize for their process of producing ammonia from nitrogen and hydrogen?**

To produce the greatest yields of ammonia from nitrogen and hydrogen, Haber and Bosch optimized these three factors:

1. temperature,
2. pressure, and
3. a catalyst.
4. **Why is Fritz Haber considered to be a controversial figure in the history of chemistry?**

Fritz Haber is considered to be a controversial figure in the history of chemistry because of his work on both the life-saving production of ammonia and for his work in the development of deadly chemical weapons initially used in World War I.

1. **Why do scientists consider the industrial-scale production of ammonia by Haber and Bosch to be one of the most important chemical engineering innovations in the history of the world?**

The industrial-scale production of ammonia by Haber and Bosch is one of the most important chemical engineering innovations in the world because fertilizers made from ammonia help sustain food production for billions of people.

1. **When is a chemical system considered to be at equilibrium?**

A chemical system is considered to be at equilibrium when “the rates of the forward and reverse reactions are equal, and the concentrations of the reactants and products are constant.”

1. **According to Le Châtelier’s principle, what happens to a system at equilibrium when it is subjected to a change?**

Le Châtelier’s principle states that “a system at equilibrium that is subjected to a change will react with a shift in equilibrium that opposes the direction of the change in establishing a new equilibrium.”

1. **If a reaction has a negative ΔH, (a) what is happening to the energy in the reaction, and (b) what is the name for this type of reaction?**

In a reaction with a negative ΔH,

1. energy is released from the chemical reaction into the surroundings, and
2. the reaction is called exothermic.
3. **What is used in the Haber-Bosch process to keep the temperature of ammonia manufacturing below 500 °C?**

To keep the temperature of the Haber-Bosch process of ammonia manufacturing below   
500 °C, a catalyst (iron) is used.

**Critical-Thinking Question**

1. **Explain why high temperatures can be both an advantage and a disadvantage in the chemical reaction for producing large quantities of ammonia by the Haber-Bosch process.**

High temperatures can be both a chemical reaction advantage and disadvantage in the Haber-Bosch synthesis of ammonia, because high temperatures are needed to make the reaction happen quickly (producing more ammonia faster), but the high temperatures also favor the reverse reaction, the decomposition of ammonia, resulting in less ammonia, in this exothermic reaction.