

Food, Fertilizers and Chemistry: A Knowles Teacher Initiative Social Justice Unit

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Discipline / Grade Band	Chemistry / Grade 10
Phenomenon	Food Fertilizer
Description	This unit uses the phenomenon of the food industry and the driving question "How does nitrogen fertilizer for blueberry crops impact life on Earth?" As students interrogate the stakeholders and impacts of using food crop fertilizers, they will also learn about stoichiometry and the basics of chemical reactions.

Jump to:

[NGSS STANDARDS](#)

[PHENOMENON & BRIEF EXPLANATION](#)

[DRIVING QUESTION](#)

[CONTEXT](#)

[SOCIAL JUSTICE CONNECTIONS](#)

[BACKGROUND STUDENTS KNOWLEDGE](#)

[NOT INCLUDED IN THIS UNIT](#)

[LEARNING TARGETS](#)

[ACTIVITIES & ASSESSMENTS](#)

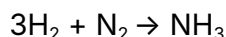
[CITATIONS](#)

NGSS STANDARDS

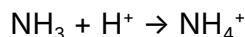
- **HS-PS1-7:** Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction
- **HS-ESS3-1.** Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
- **HS-ESS3-2.** Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*
- **HS-ESS3-3.** Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.
- **HS-ESS3-6.** Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

PHENOMENON & BRIEF EXPLANATION

Farmers in the United States use nitrogen fertilizer to improve their crop yield. The process by which this nitrogen fertilizer is made is called the Haber-Bosch process. This reaction is as follows:



Students will interrogate stoichiometric analysis necessary for the production of nitrogen fertilizer. In plants, that NH_3 is converted to NH_4^+ so that it can be taken in by plants. This reaction is as follows:



Once the nitrogen enters the plant, the plant uses it for several different processes like the construction of amino acids, proteins, and chlorophyll. Students will analyze this assimilation reaction, which prepares nitrogen to be taken in by plants, utilizing the chemistry practice of stoichiometry. Students will be asked if it is reasonable to apply a chemical level of stoichiometric thinking to this situation, or if it is instead more important to utilize the skills of dimensional analysis applied to data relating crop growth and fertilizer usage. Purdue University provides this [data for blueberry crops](#)¹: "For mature plants, the application should consist of 60-80 pounds of actual nitrogen per acre before growth starts each spring." Students will use this data to determine the appropriate amount of fertilizer to use in the plot of blueberry crops owned by the school district.

We will then consider other issues related to the policies, practices, and consequences of utilizing fertilizer in agriculture. Students will read several different articles that connect fertilizer to the world, and engage in a socratic seminar to debate the usage of fertilizer on our crops. Students will then reflect on how the skill of dimensional analysis tells only a part of the story, while removing nuance and outside impacts that go into decision making. Students will be asked to think about who is impacted if the nuance isn't addressed in the different scenarios.

- The Haber-Bosch process is very energy intensive and requires a lot of [energy usage](#)²
- Nitrogen is a limiting factor for plant growth, farmers often apply [more fertilizer than necessary](#)³ to ensure that there is plenty for the plants.
- Greenhouse gas emissions do not just come from the energy used to produce the fertilizer, a lot of it comes from when the nitrogen is [in the soil](#)⁴.
- A significant amount of soil applied to crop farms is lost to the environment. This can lead to pollution of water; in bodies of water this can lead to a phenomenon called [eutrophication](#)⁵.
- Nitrogen pollution can get into drinking water and be harmful to [those drinking it](#)⁶.

DRIVING QUESTION

In what ways is dimensional analysis useful and not useful for analyzing nitrogen fertilizer for blueberry crops' impact on life on Earth?

CONTEXT

The school that this was created for is a suburban high school in western Michigan. The district is located directly on lake Michigan, making the soil rich for the dominant agricultural industry that makes up much of the local economy. Most of the student population either lives on farms, lives near farms, or knows someone else who does. This means that fertilizer is being used in the local area for farms, and students are exposed to the byproducts and runoff associated with such agricultural practices. Additionally, the proximal location to Lake Michigan means that there is a large, important body of fresh water near that fertilizer usage, so the impacts of runoff are dangerous for fresh water ecosystems too.

SOCIAL JUSTICE CONNECTIONS

When students analyze the impacts of fertilizer usage in the agricultural industry, they will engage with several social justice connections. First, in framing the unit around the industry of agriculture, it helps to build student understanding of social processes as systems that make decisions that impact people's lives, an important step in developing critically literate learners. Second, as students analyze the energy needed to produce, use, and transport fertilizer and the breakdown of nitrogen in soil, they will simultaneously consider how these processes are connected, and contribute to, the ongoing climate crisis. Finally, there are many homes in the local community that utilize well water, which is also impacted by agricultural runoff. As students learn about the impacts of runoff, they will write a letter to local policy makers about the dangers of runoff on local well water, fishing, tourism (another significant dimension of the local economy), etc..

BACKGROUND STUDENTS KNOWLEDGE

- Balancing equations
- Ionic bonding
- Covalent bonding
- Units
- Math (multiplication, division, fractions)

NOT INCLUDED IN THIS UNIT

- Limiting reactants

<ul style="list-style-type: none"> • Molecular structure 	
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LEARNING TARGETS
<ul style="list-style-type: none"> • LT1: I can utilize stoichiometry to calculate the outcome of a reaction. • LT2: I can critique local fertilizer practices through dimensional analysis.

ACTIVITIES & ASSESSMENTS			
Day	LT#	Activity Description & Resources	Formative Assessment(s)
1	LT2	<p>Name: Stoich with sandwiches⁷</p> <p>Description: Students will utilize the linked PhET simulation as an introduction to dimensional analysis. Students will configure variables to arrive at a specific type of sandwich.</p> <p>Learning Goal: Students are introduced to the concept of dimensional analysis through this sandwich-based activity.</p>	
2	LT2	<p>Name: Unpacking Stoichiometry through Recipes</p> <p>Description: Students bring to class their favorite recipe from home. Students begin class by engaging with the "Ratio and Recipes"⁸ text and digest the text using reading strategy (think-pair-share). Then, students create a stoichiometry equation using the recipes they brought.</p> <p>Learning Goal: Students transfer understanding of Dimensional Analysis to family recipes.</p>	
3	LT2	<p>Name: Stoich with recipes, day 2</p> <p>Description: This is a continuation of the previous day's activity. Students will look at other student's recipes and assess if their peer's stoichiometry equation is accurate and accounts for all ingredients. The end of class is a whole class discussion to solidify takeaways from the lesson. The teacher creates an anchor chart that summarizes student ideas as a point of evidence for future lessons.</p>	<p>Exit Slip: How does our recipes activity help us think about our driving question?</p>
4	LT2	<p>Name: What is a mole?</p> <p>Description: Students engage with a worksheet⁹ that</p>	<p>Informal, Small Group Check-ins: check in for conceptual and</p>

		<p>introduces Avogadro's number and the concept of a mole. As students work in small group work time, the teacher circulates to help, as needed, and check on conceptual and mathematical understanding.</p> <p>Learning Goal: Students are introduced to the concept of a mole.</p>	<p>mathematical understanding on worksheet</p>
5	LT2	<p>Name: Stoich Introduction Lecture</p> <p>Description: Students begin by revisiting findings from Recipe lesson (Day 2/3). This will act as a segway into an introduction for Stoichiometry lecture.</p> <p>Lesson Goal: Students will develop their understanding of Stoichiometry and practice using stoichiometry to solve a problem.</p>	<p>Exit Ticket: If you had 100 dollars saved, how many 3 tender meals from [local store] could you buy? SHOW WORK (1 meal = 9.50 dollars)</p>
6	LT2	<p>Name: Stoichiometry Practice Worksheet</p> <p>Description: Students will practice stoichiometry using the worksheets attached. The teacher circulates to check for understanding and to push student thinking. Helpful backpacket questions include:</p> <ul style="list-style-type: none"> • How did you arrive at that answer? • Can you walk me through your process? • How are you keeping track of the units while you do this practice? <p>#33 - Stoichiometry and % Comp Practice ¹⁰</p> <p>#33b - Stoichiometry Guide ¹¹</p> <p>Learning Goal: Students will practice stoichiometry calculations.</p>	<p>Informal, Small Group Check-ins: check for understanding on worksheets</p>
7	LT1	<p>Name: Interrogate the context of stoich</p> <p>Description: Students do a community map activity to identify areas where stoichiometry may be present in the community. As this school is located in a farming community, the teacher will connect student asset maps to the Haber-Bosch process, a process which generates ammonia, often used to produce farm fertilizer from atmospheric nitrogen reacting with hydrogen. The mapping activity will take the majority of class, and students will generate connections to stoichiometry on their maps.</p> <p>Learning Goals: Students will identify the areas where stoichiometry is used for production in our community;</p>	

		Students become familiar with local applications of stoichiometry, such as the Haber-Bosch process.	
8	LT1	<p>Name: Bloom game</p> <p>Description: In the Bloom game¹², students use their understanding of chemistry to play a person responsible for monitoring and keeping agricultural businesses intact. Students will write observations as they play. The teacher will move around the room asking probing questions to deepen student connections between chemistry and agriculture.</p> <p>Learning Goal: Students will engage in observation as a part of a Science and Engineering practice for this unit.</p>	<p>Exit slip: What did you learn today from the bloom game? What is one question that you have?</p>
9	LT1	<p>Name: Bloom game, day 2</p>	
10	LT1	<p>Name: Jigsaw</p> <p>Description: Students will break off into groups and become the experts on a particular connection between agricultural runoff and the byproducts associated with the run off. Students will share their expertise in a full class setting once they have mastered the content and classmates will take notes on their peers' findings.</p> <p>Driving questions:</p> <ul style="list-style-type: none"> ● <i>What is the process that you have researched?</i> ● <i>How does the process use dimensional analysis?</i> ● <i>Is this a safe process for people who live close to the production facility?</i> ● <i>For safety purposes, are there any measures that we can take as a community?</i> <ul style="list-style-type: none"> ○ Energy consumption for haber-bosch¹³ ○ Excess fertilizer¹⁴ ○ Greenhouse gas of nitrogen in soil¹⁵ ○ Eutrophication¹⁶ ○ Nitrogen in drinking water¹⁷ <p>Learning Goal: Students situate stoichiometry in a specific, local scientific practice prevalent in our community.</p>	
11	LT1 & LT2	<p>Name: Jigsaw Presentations and Unit Review</p> <p>Description: Students report on their findings from the</p>	

		previous day in a whole-group setting. Peers take notes and ask critical questions. Then, students engage in a summative assessment review.	
12	LT1 & LT2	Name: Summative Assessment – Part 1 Note: I used a common assessment (test) as created and required by my school's Chemistry PLC	
13	LT1 & LT2	Name: Summative Assessment – Part 2 Description: Students apply their stoichiometry understanding to a new phenomenon around airbag inflation and safety. Airbag lab individual assessment ¹⁸	

CITATIONS

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