WASTE NOT WANT NOT

Illinois Mathematics & Science Academy

PBL

Problem-Based Learning

Notes

Unit Overview

Title: Waste Not, Want Not: Using Agricultural Plant Waste
Focus: Chemistry

Embedded Problem: Determine the best use of agricultural plant waste
Overarching questions:

- What is agricultural plant waste?
- How can agricultural plant waste be used?
- Can agricultural plant waste be reduced?

Role and Situation: The students are asked by Eckert's Orchards to come up with a plan for utilizing their plant waste.

Grade Level/s and Content Area/s: Grades 6-8
Science: Chemistry, Physical Science, Biology
Math: Data collection and analysis
Language Arts: Research, writing, presentation skills
Additional Possible Resources:

People and Places:

- Farm/Orchard
- Farm Bureau
- University of Illinois Extension
- Sewage Treatment Plant (biogas)
- Ethanol Plant
- Chemist/Chemical Manufacturer
- Farmer/Farm worker
- Botanical Garden
- Science Center
- Chamber of Commerce
- Universities

Materials and Technology:

- Internet access
- Apples/Peaches
- Samples of bioplastic
- General lab equipment, such as safety goggles, glassware, balances, etc.

Curriculum Outcomes: Throughout this PBL experience, learners are actively engaged in learning the content, developing self-directed learning dispositions and applying thinking and reasoning skills.

Notes

Standards

Next Generation Science Standards:

MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.
MS-PS1-2. Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.
MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
MS-PS1-4. Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
MS-PS1-5. Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.
MS-LS1-6. Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
MS-LS2-3. Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.
MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.
MS-ETS1-2. Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms.
HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.
HS-LS1-5. Use a model to illustrate how photosynthesis transforms light energy into stored chemical energy.
HS-LS2-4. Use a mathematical representation to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
HS-LS2-5. Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.
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.

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HS-ESS3-4. Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

Science and Engineering Practices in the NGSS:

SEP1. Asking questions and defining problems.
SEP2. Developing and using models.
SEP3. Planning and carrying out investigations.
SEP4. Analyzing and interpreting data.
SEP5. Using mathematics and computational thinking.
SEP6. Constructing explanations and designing solutions.
SEP7. Engaging in argument from evidence.
SEP8. Obtaining, evaluating, and communicating information.

Common Core State Standards
English Language Arts:

6.RI.7. Integrate and evaluate multiple sources of information presented in different media or formats (e.g., visually, quantitatively) as well as in words in order to address a question or solve a problem.
8.RI.1. Cite the textual evidence that most strongly supports an analysis of what the text says explicitly as well as inferences drawn from the text.
8.RI.2. Determine a central idea of a text and analyze its development over the course of the text, including its relationship to supporting ideas; provide an objective summary of the text.
8.RI.3. Analyze how a text makes connections among and distinctions between individuals, ideas, or events.
8.RI.6. Determine an author's point of view or purpose in a text and analyze how the author acknowledges and responds to conflicting evidence or viewpoints.
8.RI.7. Evaluate the advantages and disadvantages of using different mediums to present a particular topic or idea.
8.RI.8. Delineate and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient; recognize when irrelevant evidence is introduced.
8.W.1. Write arguments to support claims with clear reasoning and relevant evidence.
8.W.1a. Introduce claim(s), acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.
8.W.8. Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.
8W.9. Draw evidence form literary or informational texts to support analysis, reflection, and research.
8.SL.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade appropriate topics, texts, and issues, building on others' ideas and expressing their own clearly.

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8.SL.1a. Come to discussions prepared, having read or researched material under study; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion.
8.SL.1b. Follow rules for collegial discussions and decision-making, track progress toward specific goals and deadlines, and define individual roles as needed.
8.SL.1c. Pose questions that connect the ideas of several speakers and respond to others' questions and comments with relevant evidence, observations, and ideas.
8.SL.1d. Acknowledge new information expressed by others, and, when warranted, qualify or justify their own views in light of the evidence presented.
8.SL.2. Analyse the purpose of information presented in diverse formats and media (e.g., visually, quantitatively, orally) and evaluate the motives behind its presentation.
8.SL.3. Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and relevance and sufficiency of the evidenc and identifying when irrelevant evidence is introduced.
8SL.4. Present claims and findings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.
8.SL.5 Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.
8.SL.6. Adapt speech to a variety of contexts and tasks, demonstrating a command of formal English when indicated or appropriate.
8.L.1. Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
8.L.3. Use knowledge of language and its conventions when writing, speaking, reading, or listening.
6-8.WHST.1b. Support claim(s) with logical reasoning and relevant, accurate data and evidence that demonstrate an understanding of the topic or text, using credible sources.
6-8.RST.1. Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
6-8.RST.2. Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.
6-8.RST.3. Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
6-8.RST.4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grade level texts and topics.
6-8.RST.5. Analyze the structure an author used to organize a text, including how the major sections contribute to the whole and to an understanding of the topic.
6-8.RST.6. Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.
6-8.RST.7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually.
6-8.RST.8. Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.
6-8.RST.9. Compare and contrast the information gained from experiments, simulations, video or multimedia sources with that gained from reading a text on the same topic.

Notes

6-8.RST.10. By the end of the year, read and comprehend science/technical texts in the appropriate CCR text complexity band independently and proficiently.

Mathematics:

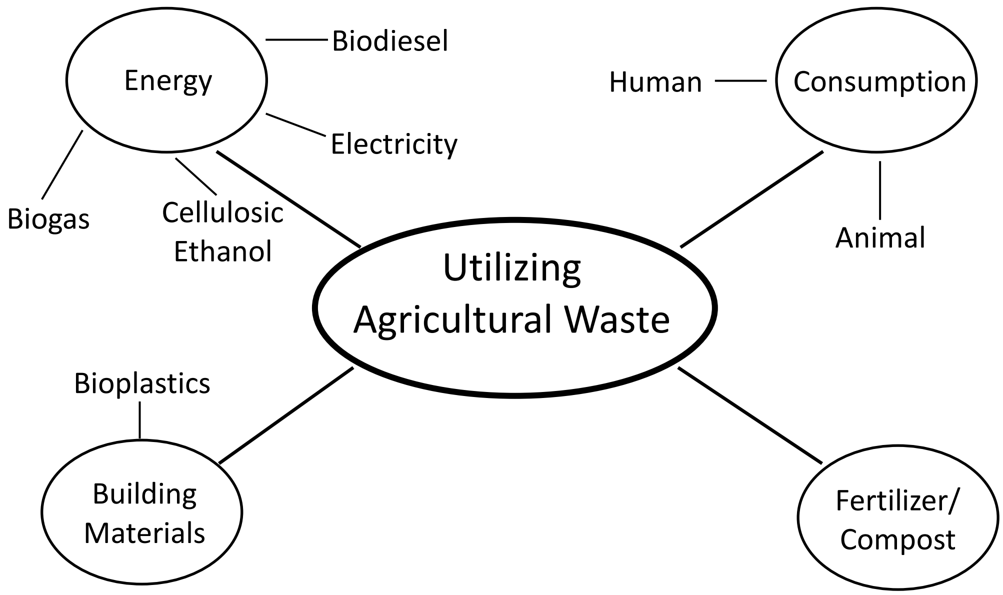
6.RP.1. Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities.
6.RP.3. Use ratio and rate reasoning to solve real-world and mathematical problems.
9-12.S-IC.3. Make inferences and justify conclusions from sample surveys, experiments, and observational studies. Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.
9-12.S-IC.6. Make inferences and justify conclusions from sample surveys, experiments, and observational studies. Evaluate reports based on data.
9-12.S-MD.5. Use probability to evaluate outcomes of decisions. Weigh the possible outcomes of a decision by assigning probabilities to payoff values and finding expected values.
9-12.S-MD.6. Use probability to evaluate outcomes of decisions. Use probabilities to make fair decisions (e.g., drawing by lots, using a random number generator).
9-12.S-MD.7. Use probability to evaluate outcomes of decisions. Analyze decisions and strategies using probability concepts (e.g., product testing, medical testing, pulling a hockey goalie at the end of a game).

Standards for Mathematical Practice:

MP.1. Make sense of problems and persevere in solving them.
MP.2. Reason abstractly and quantitatively.
MP.3. Construct viable arguments and critique the reasoning of others.
MP.4. Model with mathematics.
MP.5. Use appropriate tools strategically.
MP.6. Attend to precision.
MP.7. Look for and make use of structure
MP.8. Look for and express regularity in repeated reasoning.

Notes

Map of the Problem



Notes

Meet the Problem

Logistics

Class age/size: 6-8th grade/whole group

Materials:
- Meet the Problem artifact(s)

Time: 15 minutes

Location: Classroom

Objectives/Standards:

- *Students are introduced to the problem and begin to make sense of it.*
  - **NGSS: SEP.1,8**
  - **Math: MP.1**
  - **ELA: 6.RI.7; 8.SL.2,3; 8.RI.2,3,6; 8.L.3**

Introduction:

The students will meet the problem through a letter from Eckert's Orchards. In order to "hook" the students, make the situation and role as authentic and believable as possible, using the letter and/or video, guest speakers, field trips, etc. However, be sure to avoid information overload, and "giving away" the whole problem. After sharing the letter with the whole group, it can be helpful to have the students individually or in small groups highlight or underline key information.

Coaching Questions:
- What problem factors do we need to consider?
- What issues connect to this problem?

Assessment:
- Are the students aware that the situation is problematic, did they get "hooked?"
- Can learners participate in a team discussion of the problem situation?

Notes

Dear Students,

Poser of the problem shares their background.

Poser needs to set up how much waste is generated by them in apples.

Since a certain amount of waste is unavoidable, and we cannot sell this produce for human consumption, we are wondering if there are other possible uses for the fruit. I have heard about corn and soybeans being used to generate energy, such as biogas, biodiesel, and ethanol, as well as being used to make building materials and plastic. I am wondering if there are any possibilities for using our wasted fruit for these purposes. I am also interested in finding out if there are any options for converting the fruit to fertilizer or compost, or salvaging it for human or animal consumption.

Here at poser's location we are interested in finding practical solutions to the problem of managing our waste. In our waste management plan, we want to be good stewards of the environment, but we also understand that our solutions need to workable and cost-effective.

I look forward to hearing your ideas for solving this problem,
Sincerely,

Notes

Know/Need to Know

Logistics

Class age/size: 6-8th grade/whole class

Materials:

- Chart Paper
- Markers
- K/NK

Time: 45 minutes

Location: Classroom

Safety: No known issues

Objectives/Standards:

- *Students will list their prior knowledge and questions they have whose answers will help them solve the problem.*
    - **NGSS: SEP.3,8**
    - **Math: MP.1**
    - **ELA: 8.W.1a,8; 8.SL.1,1c,1d**

Introduction:

In this lesson students will develop a list of Know and Need to Know items relating to the problem. The purpose of the activity is to have students think deeply about what they will need to know in order to solve the problem, and to provide a guide for their investigations. Student engagement is increased when they can see the connections between learning activities and questions they have about the problem. The list should be posted in the classroom, and as the questions are addressed, they can be crossed off of the Need to Know list and added to the Know list. Need to Know items can be added to the list as they arise, and the students should refer to the list before and after learning activities. It may be necessary to coach students to particular Need to Know items relating to learning activities.

Notes

Activity/Activities:

1) Using the handout, the students will individually fill out Know and Need to Know items. Reminds students that it is all right if there are more items on the Need to Know list than the Know list.
2) Pairs of students will compare their lists and add as needed.
3) Small groups (4-6) of students will compare their lists. The groups will come to a consensus as to which items are the top 3 on each list.
4) As a whole class, generate a master K/NK list on chart paper that will be posted in the classroom.
5) As an extension, or as an initial activity, students could draw concept maps of the problem, individually or in small groups.

Coaching Questions:

- What do you know about the problem? How do you know that information?
- What questions do you still have? Why do you need to know?
- Are there other areas that you should consider? Why do you think so?

Assessment:

- Can learners identify key elements from the Meet the Problem artifacts and situation? Can they identify key areas of investigation?
- Concept maps and K/NK lists—for breadth and depth of understanding
- Do the students validate and respect the contributions of all individuals?

Notes

Anticipated Needs to Know items addressed by unit:

- What are the uses for apple waste?
- What are the uses for peach waste?
- What are the uses for other waste generated at the orchard?
- How can agricultural waste be used to make fertilizer?
- What happens when agricultural waste is composted?
- Where could such fertilizer or compost be used?
- How can agricultural waste be used to make plastic?
- What types of waste would be best for making plastic?
- What types of plastic could be made?
- How can agricultural waste be used to make alternative forms of energy?
- What is biogas, and how is it made?
- What is biodiesel, and how it is made?
- What are the types of ethanol made from agricultural waste and how are they made?
- What are the uses for other waste generated at the orchard?
- How can ideas for other types of waste be used by the apple orchard?
- What do the letters and numbers in the chemical reactions mean?
- How much gas is produced by a single apple or peach?
- What makes up the apples and peaches?
- How can apples and peaches be used for consumption?
- Why do the elements combine the way that they do?
- What are the proper terms to describe the components of a chemical reaction?
- How do the physical and chemical make ups of apples and peaches affect how we can use their waste?
- Why can the parts of apples and peaches be used for the same things?
- How does the apple and peach waste cycle through nature?
- How will the changing cycles affect the environment?
- What are the different types of reactions?
- What are the safety concerns with different chemical reactions that may need to be done to repurpose the waste?
- What are the possible outcomes of performing the reactions to repurpose the agricultural waste?
- What happens to the mass of a fruit as it ripens?
- How much gas can be produced by Eckert's orchard?
- How much energy can that gas provide?
- What is polymer?
- What is a bioplastic?
- What is material science?
- What is tensile strength?
- Does bioplastic serve as an effective replacement to commercial plastics?
- What are environmental costs of the different solutions?
- What are the other costs involved with the possible solutions?

Notes

Problem Statement

Logistics

Class age/size: 6-8th grade/whole group

Materials:
- Chart Paper
- Markers
- Problem Statement handouts

Time: 45 minutes

Location: Classroom

Objectives/Standards:

- *Students will define the problem that will guide their investigation.*
  - **NGSS: SEP.1**
  - **Math: MP.1**
  - **ELA: 8.SL.1,1b; 8.L.1**

Introduction:

The Problem Statement is the key document that will guide the students through the problem. It consists of an overall task, and the factors to be considered in successful completion of the task. The students should carefully consider the information given in the Meet the Problem documents when writing their Problem Statement. Having the students draw concept maps, with the problem in the middle and the factors around it, can help the student clarify their thinking. The Problem Statement should be posted, and can be changed if the need arises.

Activity/Activities:

1. The students will draw a concept map of the problem.
2. Distribute the Problem Statement handouts.
3. The students will fill in the columns individually, then with a partner, and then with a small group of 4-6 students.
4. Each group of students will present their proposed Problem Statement to the class. The teacher will then work with the class to develop a whole class Problem Statement.
5. The Problem Statement will be revisited on a daily basis to guide the class' investigations.

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The stem for the Problem Statement is:

"How can we as (role) [overall task], in such a way that we consider [factors]

Coaching Questions:

- What have we been asked to do? (overall task)
- Are there other areas to consider? (factors)
- Who else could be affected by this problem?
- Are there other problem conditions to consider?

Assessment:

- Does the problem statement identify most of the key issues of the problem? (individual and group)
- Do they have a working problem statement?
- Do the students validate and respect the contribution of all individuals?
- The Problem Statement worksheet can be used to assess the learners' overall understanding of the "big picture" of the problem and key factors for solutions.

Final Anticipated Problem Statement:

How can we, as middle school students, develop a plan for utilization of agricultural plant waste…

… in such a way that we consider:

- Environmental impact
- Cost
- Space
- Feasibility

Notes

Plan for Information Gathering

Logistics

Class age/size: 6-8th grade/whole class

Materials:
- Chart Paper
- Markers
- K/NK handouts, Problem Statement Handouts from previous sessions

Time: 15 minutes

Location: Classroom

Objectives/Standards:

- *Students will design a plan for answering their need to know items and solving the problem.*
  - **NGSS: SEP.3,8**
  - **Math: MP.1**
  - **ELA: 8.SL.1b**

Introduction:

In this lesson students will develop a plan for gathering information. The students will usually come up with the Internet as the first option. They key understanding is that there are other sources of information, such as experts, lab activities, books, surveys, etc. that can be used. The students may need some coaching to get to these ideas.

Activity/Activities:

6) The students will brainstorm ideas for gathering information to address the Need to Know items and the Problem Statement. The teacher will capture the ideas on chart paper.
7) The students will develop a plan for gathering information at the teacher's discretion. Options include assigning individual students or groups of students to address particular items, investigating as a whole class, etc.
8) The Need to Know list and the Problem Statement will be revisited on a daily basis, with completed items being checked off, and new items added as needed.

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Coaching Questions:

- Is the information important? Why?
- Where can you obtain the information?
- Is the information relevant to the problem? How do you know?

Assessment:

- Are students able to identify information critical to the problem?
- Can learners find, evaluate, and use information effectively?
- Do learners make valid connections between needed information and possible resources?
- Do learners work collaboratively and share resources?

Notes

What to do with the waste?

Logistics

Class age/size: middle school/in 4 or 8 groups

Materials:
- Devices with Internet access

Time: 60 Minutes

Location: Classroom where students can access the Internet

Safety: None

Objectives/Standards
- *Students will research the uses of agricultural waste and how to apply them to apples and peaches*
  - **NGSS: MS-PS1-3; SEP.8**
  - **ELA: 6.RI.7; 8.RI.1,6,8; 8.W.8; 8.SL.2; 6-8.RST.1,2,4,5,6,7,8,9,10**
- *Students will share their findings with their classmates.*
  - **NGSS: MS-PS1-3; SEP.7,8**
  - **Math: MP.3**
  - **ELA: 6.RI.7; 8.SL.1,3,4; 6-8.RST.1,2,7,8,9,10**

Need to Know Items Addressed
- How do the solutions for other types of waste work?
- What are the uses for apple waste?
- What are the uses for peach waste?
- What are the uses for other waste generated at the orchard?
- How can agricultural waste be used to make fertilizer?
- What happens when agricultural waste is composted?
- Where could such fertilizer or compost be used?
- How can agricultural waste be used to make plastic?
- What types of waste would be best for making plastic?
- What types of plastic could be made?
- How can agricultural waste be used to make alternative forms of energy?
- What is biogas, and how is it made?
- What is biodiesel, and how it is made?
- What are the types of ethanol made from agricultural waste and how are they made?
- How can ideas for other types of waste be used by the apple orchard?

Notes

Introduction

From the meet the problem letter, the students have learned about the different types of waste generated by the orchard and uses for other types of agricultural waste. These uses will include consumption by animals and/or humans; energy production through the production of biogas, biodiesel, and cellulosic ethanol; generation of fertilizer; and production of building materials, including bioplastics. The students will research these different types of solutions to learn more about them and possibly get ideas as to how they can be used for apples and peaches. Understanding these solutions will be the basis for the rest of the curriculum.

Activity/Activities

Activity 1: Online research
Estimated Time: 35
Minutes

Materials:

- Devices with internet access

Objective/Standard:
Students will research the uses of agricultural waste and how to apply them to apples and peaches

- **NGSS: MS-PS1-3; SEP.8**
- **ELA: 6.RI.7; 8.RI.1,6,8; 8.W.8; 8.SL.2; 6-8.RST.1,2,4,5,6,7,8,9,10**

Teacher note:
If you want a place for students to get a head start on research, they can go to http://trackstar.4teachers.org/trackstar/index.jsp. They will type in 455185 in the space next to "View Track #". These sites can give them some places to start their research.

Instruction:

1) Students will work in groups to find out more information about one of the solutions. They can also look for ways to adapt them for peaches and apples. Finally, they can also start to find out some of the pluses and minuses of the different possible solutions.
2) They will then design a way to present their information to their classmates. They can put together a visual using any means available, PowerPoint or drawn visual.

Notes

Activity 2: Sharing of information
Estimated Time: 20 Minutes

Materials:

- Student generated information

Objective/Standard:
Students will share their findings with their classmates. .

- **NGSS: MS-PS1-3; SEP.7,8**
- **Math: MP.3**
- **ELA: 6.RI.7; 8.SL.1,3,4; 6-8.RST.1,2,7,8,9,10**

Instruction:

1) Students will share their information with the rest of the class. Each group should get a short period of time to share. They will find out more information about the different solutions as they progress through the curriculum.

Conclusion:
Estimated Time: 5 Minutes

Revisit the Know/Need to Know list and answer any Needs to Know and add any new ones that may have arisen from this activity.

Notes

What does all of this mean?

Logistics

Class age/size: middle school/whole class (activities 1, 2) and small groups (activity 3)

Materials:
- 3 apples or peaches per group
- Plastic baggie per group
- Balance
- Copies of periodic table

Time: 60 Minutes

Location: Classroom where apples and peaches can be stored

Safety: Students should not eat food items.

Objectives/Standards

- *Students will be exposed to the parts of a chemical reaction, using cellular respiration as an example.*
  - **NGSS: MS-PS1-1; SEP.2, 6**
  - **ELA: 6.RI.7**
- *Students will hear the Law of Conservation of Mass and see why reactions must be balanced.*
  - **NGSS: MS-PS1-5; SEP.5**
  - **Math: MP.2**
  - **ELA: 6.RI.7**
- *Students will set up and start an experiment to test the Law of Conservation of Mass*
  - **NGSS: MS-PS1-5; SEP.1,3,8**
  - **Math: MP.1,3,5,6**
  - **ELA: 6-8.RST.3; 8.SL.1**

Need to Know Items Addressed

- What do the letters and numbers in the chemical reactions mean?
- How much gas is produced by a single apple or peach?
- What makes up the apples and peaches?
- How can apples and peaches be used for consumption?

Notes

Introduction
Each of the solutions for using the waste will involve some type of chemical reaction, changing the waste into a useful material. The students may not know what the letters and numbers mean in the chemical reactions. The students will start with the reaction for cellular respiration, the reaction for converting food into energy. Any organism consuming the waste will use this reaction to utilize the waste. From this, the students will learn about the Law of Conservation of Mass and how to simply balance a reaction. They will then design and set up an experiment to test the Law of Conservation of Mass.

Activity/Activities

Activity 1: Parts of a Chemical Reaction
Estimated Time: 20 Minutes

Materials:
- Copies of the periodic table

Objective/Standard:
Students will be exposed to the parts of a chemical reaction, using cellular respiration as an example.
- **NGSS: MS-PS1-1; SEP.2, 6**
- **ELA: 6.RI.7**

Instruction:

3) Ask the students, "What is the goal of eating?"
    - To get energy
4) Ask, "What is the reaction to get energy?"
    - Depending on their experience, they may know it, they may not. You can use hints like it occurs in the mitochondria or it happens in every cell in your body.
    - $C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$
    - Glucose + oxygen → carbon dioxide + water
5) Go over the parts of the reaction. To the left of the arrow are the products and to the right are the products.
6) Use the periodic tables to have the students list all of the individual elements in the reaction.
7) Go over what the lowercase numbers mean.

Notes

Activity 2: Law of Conservation of Mass
Estimated Time: 15 Minutes

Materials:
- None

Objective/Standard:
Students will hear the Law of Conservation of Mass and see why reactions must be balanced.
- **NGSS: MS-PS1-5; SEP.5**
- **Math: MP.2**
- **ELA: 6.RI.7**

Instruction:

2) Tell students the Law of Conservation of Mass
   - Matter is neither created nor destroyed during a chemical reaction, just changed
3) Ask the students, does the reaction as written shown.
   - No, it is not. How can we balance it? Help work towards the reaction below.
   - $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

Activity 3: Testing the Law of Conservation of Mass
Estimated Time: 20 Minutes

Materials:
- 3 apples or peaches per group
- Plastic baggie per group
- Balance

Objective/Standard:
Students will set up and start an experiment to test the Law of Conservation of Mass
- **NGSS: MS-PS1-5; SEP.1,3,8**
- **Math: MP.1,3,5,6**
- **ELA: 6-8.RST.3; 8.SL.1**

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Instruction:

1) Show students reaction for methionine being converted into ethylene gas and ask them how easy would it be to balance these reactions? The Law of Conservation of Mass still applies to these reactions.
2) How can we use the Law of Conservation of Mass to determine how much ethylene gas is released by each apple or peach?
3) Coach the students to take an initial mass of the fruit and then let it sit for several days in an unsealed plastic baggie and then take the mass again. The students should cut their fruit in half to help speed up the process. Any mass that they lose, will be to the release of ethylene gas.
4) Students can check the masses at the start of classes each day.

Conclusion:
Estimated Time: 5 Minutes

Revisit the Know/Need to Know list and answer any Needs to Know and add any new ones that may have arisen from this activity.

Notes

What is everything called?

Logistics

Class age/size: middle school/small groups (activities 1, 2) and whole class (activity 3)

Materials:

- Samples of water, sand, salt, salt water, sand/salt mixture, and aluminum foil (or galvanized nail or pencil lead)
- Copies of periodic table

Time: 60 Minutes

Location: Classroom

Safety: Students should not eat food items and any spills should be cleaned up immediately to prevent slips.

Objectives/Standards

- *Students will use the meaning of atom, molecule, compound, solution, element, and mixture to label different examples.*
  - **NGSS: MS-PS1-1; SEP.7**
  - **Math: MP.7,8**
  - **ELA: 8.SL.1,3,4**
- *Students will use the periodic table to combine different elements.*
  - **NGSS: MS-PS1-1; HS-PS1-1,2; SEP.2**
  - **Math: MP.7,8**
  - **ELA: 6.RI.7**

Need to Know Items Addressed

- What do the letters and numbers in the chemical reactions mean?
- What makes up the apples and peaches?
- How can apples and peaches be used for consumption?
- Why do the elements combine the way that they do?
- What are the proper terms to describe the components of a chemical reaction?

Introduction

The students now know the parts of a chemical reaction, but they do not have a working knowledge of the basic terms used in chemistry. The first two activities will give them a working knowledge of basic terms that will help them understand the rest of the lessons. Finally the students will use the Periodic Table to combine elements and understand why they come together in the ratios they do in nature.

Notes

Activity/Activities

Activity 1: Let's learn some vocabulary
Estimated Time: 20 Minutes

Materials:

- None

Objective/Standard:
Students will use the meaning of atom, molecule, compound, solution, element, and mixture to label different examples.

- **NGSS: MS-PS1-1; SEP.7**
- **Math: MP.7,8**
- **ELA: 8.SL.1,3,4**

Instruction:

1) On the board, have the following terms and definitions in a random order:
    - Atom: the smallest component of an element having the chemical properties of the element
    - Molecule: simplest unit of a chemical compound that can exist, consisting of 2 or more atoms held together by chemical bonds
    - Compound: a pure substance composed of 2 or more elements whose composition is constant
    - Solution: gas, liquid, or solid that is dispersed homogenously in a gas, liquid, or solid with no chemical change
    - Element: a substance that cannot be separated into simpler substances by chemical means
    - Mixture: an aggregate of two or more substances that are not chemically united and that exist in no fixed proportion to each other
2) Have the students determine which definition goes with which term in their groups.
3) Have the groups come to a consensus.
4) Go over the correct definitions.

Activity 2: What are we looking at?
Estimated Time: 20 Minutes

Materials:
Samples of water, sand, salt, salt water, sand/salt mixture, and aluminum foil (or galvanized nail or pencil lead)

Notes

Objective/Standard:
Students will use the meaning of atom, molecule, compound, solution, element, and mixture to label different examples.

- **NGSS: MS-PS1-1; SEP.7**
- **Math: MP.7,8**
- **ELA: 8.SL.1,3,4**

Instruction:

1) Have samples of the following out for students with them labeled using their full names and not their chemical formulas.
   - Water
   - Sand
   - Salt
   - Aluminum foil (or un galvanized nail)
   - Salt water
   - Sandy salt (just some sand and salt mixed together)
2) Have the groups decide what each of the samples are based on the definitions from the previous activity.
3) Have the groups share and let the class come to a consensus for any disagreements.
4) Give the chemical formulas for each of the samples.
   - H_2O
   - SiO_2
   - $NaCl$
   - Al
   - $NaCl + H_2O$
   - $SiO_2 + NaCl$
5) Have the groups label each sample again, see if there are any changes.
6) Ask why they made any changes?
7) Give the correct answers
   - Compound
   - Compound
   - Compound
   - Element
   - Solution
   - Mixture
8) Explain to the students that any of the compounds they see are made up of billions and billions of individual molecules. The same is true of the element, but it is made up of individual atoms.
9) Ask the students if a solution is a type of compound or mixture?
   - Answer: Mixture because the sample of saltwater is the same throughout, not all salt waters are the same, so the composition is not constant.

Notes

Activity 3: How to find a partner
Estimated Time: 15 Minutes

Materials:

- Copies of the periodic table

Objective/Standard:
Students will use the periodic table to combine different elements.

- **NGSS: MS-PS1-1; HS-PS1,2; SEP.2**
- **Math: MP.7,8**
- **ELA: 6.RI.7**

1) Ask the students what they notice about the chemical formulas of water and sand.
   - They both have oxygen, but water has 1 and sand has 2.
2) The properties of each element determine how they combine with other elements.
3) The Periodic Table lets us predict how the different elements will combine. Each column is called a group and elements in the same period have similar chemical properties.
   - Group 1: +1
   - Group 2: +2
   - Group 13: +3
   - Group 14: +/- 4
   - Group 15: -3
   - Group 16: -2
   - Group 17: -1
   - Group 18: 0
   - Groups 3-12: more complicated.
4) The goal of a compound is to be neutral. That is why 2 hydrogens combine with 1 oxygen, but 1 silicon (or carbon) will combine with 2 oxygens.
5) Group 18 is called the Noble Gases because they do not need to combine with other elements to be neutral, so they do not react with other elements.
6) Have the students practice making some compounds.

Conclusion:
Estimated Time: 5 Minutes

Revisit the Know/Need to Know list and answer any Needs to Know and add any new ones that may have arisen from this activity.

Notes

What is the difference?

Logistics

Class age/size: middle school/small groups

Materials:

- Sample of activated charcoal and sample of graphite for each group
- Diamond (or CZ) for class
- Graduated cylinder for each group (10 mL)
- Nail for each group
- Wire, light bulb, and batter for testing conductivity
- Several pre-1982 and post-1982 pennies for each group
- Balance

Time: 60 Minutes

Location: Laboratory

Safety: Any spills should be cleaned up to prevent slips. Students should be taught how to safely set up a circuit to test conductivity.

Objectives/Standards

- *Students will differentiate between physical and chemical properties of elements.*
  - **NGSS:MS-PS1-4; SEP.3,4,6,7,8**
  - **Math: MP.3,5,6,7**
  - **ELA: 6-8.RST.3,7,9; 8.SL.1,4**

Need to Know Items Addressed

- How do the physical and chemical makeups of apples and peaches affect how we can use their waste?
- Why can't the parts of apples and peaches be used for the same things?

Introduction

The repurposing of the agricultural waste from the orchard will affect both the carbon and nitrogen cycles for the orchard. Depending on the solution, the effects will be different on each cycle. To fully understand the effects, the students need to understand how the carbon and nitrogen change as they move through the cycles. The students will start by learning about chemical and physical properties and how the two are not always connected.

Notes

Activity/Activities

Activity 1: Same element different looks
Estimated Time: 35 Minutes

Materials:
- Sample of activated charcoal and sample of graphite for each group
- Diamond (or CZ) for class
- Wire, battery, light bulb to test conductivity of samples for each group
- Nail
- Pre-1982 penny
- Graduated cylinder for each group (10 mL)
- Balance

Objective/Standard:
Students will differentiate between physical and chemical properties of elements.
- **NGSS:MS-PS1-4; SEP.3,4,6,7,8**
- **Math: MP.3,5,6,7**
- **ELA: 6-8.RST.3,7,9; 8.SL.1,4**

Instruction:
Physical Characteristics:
1) Give each group a sample of charcoal and graphite (can use mechanical pencil lead).
2) Have them write down all of the physical properties that they can determine.
3) Have each group come up, one at a time, and make observations of the diamond as well.

Conductivity:
4) Show the students how to set up their circuits to test the conductivity of the charcoal and graphite. (Graphite should conduct electricity)
5) Show that the diamond is not conductive.

Hardness:
6) Have the students determine the hardness of each sample using the Moh's Hardness Scale.
   - Have the students first see if the sample flakes off in their hands. If it does, then it has a hardness of 1.
   - If it does not flake off, then have them try to scratch the sample with their fingernail. If it is scratched, then it has a hardness of 2.
   - If it does not scratch, then have them try to scratch it with a penny. If it scratches, then it has a hardness of 3.
   - Finally, if it has not been scratched yet, then try with the nail. If it is scratched, then it has a hardness of 4.
   - Tell them that the diamond is the hardest substance and has a value of 10 on the scale.

Notes

Density:

7) Have the students determine the density of the charcoal and graphite.
   - The students should first take the mass of the sample (the sample should fit in the graduated cylinder)
   - They should then add some water to the graduated cylinder and determine the volume.
   - Now, add their sample and record the change in volume.
   - To calculate the density, divide the mass by the volume.
   - Density of diamond: 3.52g/mL

Debrief:

1) Share with the students that all 3 samples are made of carbon.
2) Ask the following questions:
   - Why were the physical characteristics different between the three samples if they are all the same element?
   - Show them the structures of diamond and graphite
   - Ask, why do these different structures cause the different physical characteristics?
   - Diamond is made of stronger bonds that make it difficult to conduct electricity and make it a much harder and denser compound then graphite.

Activity 2: Same look, different elements
Estimated Time: 20 Minutes

Materials:

- Graduated cylinder for each group (10 mL)
- Several pre-1982 and post-1982 pennies for each group
- Balance

Objective/Standard:
Students will differentiate between physical and chemical properties of elements.

- **NGSS:MS-PS1-4; SEP.3,4,6,7,8**
- **Math: MP.3,5,6,7**
- **ELA: 6-8.RST.3,7,9; 8.SL.1,4.**

Notes

Instruction:

1) Give each group several of the pre and post-1982 pennies.
2) Have them record the physical properties of type of penny and perform the same tests that they did on the carbon samples.
3) Ask the students what differences they observe between the two types of pennies?
4) What do you think is causing the differences?
- Pre-1982: 95% copper and 5% zinc
- Post-1092: 97.5% zinc and 2.5% copper

5) Are all of the properties we tested chemical or physical? Why?
- They are physical properties because the material is not being changed in any of the tests. A chemical property is one that will change its chemical identity.

6) Can you think of any chemical properties?
- Examples include heat of combustion, reactivity with water, pH, electromotive force, and flammability.
- What are chemical and physical properties of apples and peaches?

Conclusion:
Estimated Time: 5 Minutes

Revisit the Know/Need to Know list and answer any Needs to Know and add any new ones that may have arisen from this activity.

Notes

What is the change?

Logistics

Class age/size: middle school/small groups

Materials:
- Broken Eggshell, enough for each group
- Water (in containers for 3 stations)
- Vinegar
- Piece of paper for each group
- Table Salt
- Rubbing alcohol
- Matches
- Empty beaker
- 3 test tubes per group
- Sink
- Copies of carbon and nitrogen cycles

Time: 60 Minutes

Location: Laboratory with at least 1 sink

Safety: Students should only taste salt water and none of the other chemicals used. Make sure to go over basic fire safety and have the station with the matches and rubbing alcohol by the sink.

Objectives/Standards

- *Students will differentiate between physical and chemical changes.*
  - **NGSS:MS-PS1-4; SEP.3,4,6,7,8**
  - **Math: MP.3,5,6,7**
  - **ELA: 6-8.RST.3,7,9; 8.SL.1,4**
- *Students will determine the types of changes nitrogen and carbon go through as they cycle in nature.*
  - **NGSS: MS-PS1-4, LS1-6, LS2-3; HS-LS1-5, LS2-4, 5; SEP.2,4,6,7**
  - **Math: MP.3**
  - **ELA: 6-8.RST.7,8,9; 6.RI.7, 8.SL.3,4**

Need to Know Items Addressed

- Why can’t the parts of apples and peaches be used for the same things?
- How does the apple and peach waste cycle through nature?
- How will changing the cycles affect the environment?

Notes

Introduction

The students have looked at physical and chemical properties and these properties will help determine how different elements and compounds will act in nature. In these activities, they will look at examples of chemical and physical changes and be able to understand the difference between the two. They will use this information to understand how carbon and nitrogen change and what the effect of their solution may have on the cycle.

Activity/Activities

Activity 1: Physical or Chemical Change
Estimated Time: 25 Minutes

Materials:

- Broken Eggshell, enough for each group
- Water (in containers for 3 stations)
- Vinegar
- Piece of paper for each group
- Table Salt
- Rubbing alcohol
- Matches
- Empty beaker
- 3 test tubes per group
- Sink
- Matches

Objective/Standard:
Students will differentiate between physical and chemical changes.

- **NGSS:MS-PS1-4; SEP.3,4,6,7,8**
- **Math: MP.3,5,6,7**
- **ELA: 6-8.RST.3,7,9; 8.SL.1,4**

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Instruction:

1) Set up the 3 stations, if you can have 6 groups of students, then have 2 set ups for each station. The students will follow the directions at each station.
2) **Station 1: The Eggshell**
   - The egg was broken. Write down the appearance of the eggshell pieces.
   - Put a couple of pieces of the shell into 2 test tubes.
   - Into one tube, add some water to cover the shells. Into the other tube, add vinegar to cover the shells.
   - Write down what happens to the shells in each test tube.
   - Clean out your test tubes.

Notes

5) **Station 2: Paper**
   - Take a piece of paper and rip it in half. Write about the appearance before and after being ripped.
   - Take one of the pieces of paper and light it on fire. Write your observations before and after the fire.
   - Take the other piece of paper, put it in a test tube, and add water. Write your observations of the paper before and after.
   - Clean up your station.
6) **Station 3: Sodium Chloride**
   - Add some sodium chloride to a baggie. Write your observations of the sodium chloride.
   - Add water to the bag and mix it to dissolve the salt. Taste the water and write your observations.
   - Repeat steps 1 and 2, but this time add rubbing alcohol. Write your observations. DO NOT TASTE THIS SAMPLE.
   - Add the liquid to the beaker and drop in a lit match. Write your observations.
   - Clean up your station
7) Based on the definitions yesterday of physical and chemical properties, what is a physical and chemical change?
   - A physical change is a change that is usually reversible, can change the appearance of the sample but does not change its identity. A chemical change is a change in the chemical composition of the sample and is not reversible.
8) Have the students label the different experiments as physical or chemical changes. Go over their answers.

Activity 2: Changes in the Cycles
Estimated Time: 30 Minutes

Materials:
- Copies of the Carbon and Nitrogen Cycles

Objective/Standard:
Students will determine the types of changes nitrogen and carbon go through as they cycle in nature.
- **NGSS: MS-PS1-4, LS1-6, LS2-3; HS-LS1-5, LS2-4, 5; SEP.2,4,6,7**
- **Math: MP.3**
- **ELA: 6-8.RST.7,8,9; 6.RI.7, 8.SL.3,4**

Notes

Instruction:

1) Give half of the groups copies of the Carbon cycle and the other half copies of the Nitrogen cycle.
2) Give the groups 10 minutes to follow their element though the cycle labeling if each step is a physical or chemical change for the element and labeling where the different solutions come into play.
3) Have the groups with the carbon cycle and the groups with the nitrogen cycle meet as a larger group and give them 10 minutes to reach a consensus on their labeling. They should also be prepared to show their final decisions with the other group.
4) Give each group no more than 5 minutes to share their cycle with the other group.
5) Ask the following questions:
    a. Which solutions would be physical changes from the waste and which would be chemical ones?
    b. How do you think an influx of carbon or nitrogen would affect each cycle?

Conclusion:
Estimated Time: 5 Minutes

Revisit the Know/Need to Know list and answer any Needs to Know and add any new ones that may have arisen from this activity.

Notes

Reaction, what reaction?

Logistics

Class age/size: middle school/small groups

Materials:

- See individual activities for materials.

Time: Total of 110 minutes if each activity is done separately and all activities are done. Activities can be jigsawed and students do not need to do all activities, but they should do activity 1 and at least one of the exothermic and at least one endothermic reaction.

Location: Laboratory. If doing activity 7, then demonstration needs to be done in a hood.

Safety: Students should wear goggles for all activities and not taste any chemical. MSDS sheets for potassium permanganate, calcium chloride, ammonium chloride, hydrochloric acid, and barium hydroxide octahydrate should be consulted for storage and how to handle any accidents.

Objectives/Standards

- *Students will perform and observe different types of chemical reactions.*
    - **NGSS: MS-PS1-2,4,5; SEP.4,7,8**
    - **Math: MP.3,6,7**
    - **ELA: 6-8.RST.3,7,8,9; 6.RI.7; 8.SL.1,4**

Need to Know Items Addressed

- What are the different types of reactions?
- What are the safety concerns with different chemical reactions that may need to be done to repurpose the waste?
- What are the possible outcomes of performing the reactions to repurpose the agricultural waste?

Introduction

The repurposing of the agricultural waste will require chemical changes, and thus chemical reactions. Different types of reactions have different consequences. The reaction of an acid and base will generate carbon dioxide gas, which can negatively affect the environment. Also, some chemical reactions require extra heat to be added to them (endothermic) for the reaction to occur. This could lead to extra costs for the orchard and safety concerns about where and how the reactions can be performed. Other chemical reactions release heat (exothermic) and this can lead to safety concerns and difficulty in containing the reaction. In these activities, the students will perform different chemical reactions and experience at least one of each of the three types of chemical reactions.

Notes

Activity/Activities

Activity 1: Hungry Chemicals (Acid/Base)
Estimated Time: 15 Minutes

Materials: for each group

- Test tube
- Test tube rack (or beaker)
- Small piece of chalk
- Vinegar

Objective/Standard:
Students will perform and observe different types of chemical reactions.

- **NGSS: MS-PS1-2,4,5; SEP: 4,7,8**
- **Math: MP.3,6,7**
- **ELA: 6-8.RST.3,7,8,9; 6.RI.7; 8.SL.1,4**

Instruction:

1) Put the test tube on the rack
2) Put the small piece of chalk in the test tube.
3) Pour enough vinegar in the test tube to cover the chalk.
4) Let it sit for 10 minutes and record your observations during the 10 minutes.
5) Wash the test tube well and throw away the chalk.
6) Ask the students the following questions:
   - What happened immediately after adding the vinegar?
   - What happened over time?
   - What gas was produced by the reaction?
   - Which do think was the acid? The base?

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Activity 2: Quick Fire (exothermic)
Estimated Time: 5 Minutes

Materials: for each group

- Paper towel
- Tart pan
- Glycerin
- Potassium permanganate
- Spoon
- Stop watch

Objective/Standard:

Notes

Students will perform and observe different types of chemical reactions.

- **NGSS: MS-PS1-2,4,5; SEP: 4,7,8**
- **Math: MP.3,6,7**
- **ELA: 6-8.RST.3,7,8,9; 6.RI.7; 8.SL.1,4**

Instruction:

1) Wet the paper towel and place the tart pan upside down on the center of it.
2) Put a small pile, just slightly larger than a quarter, of potassium permanganate on the tart pan.
3) Use the spoon to make a small volcano of the pile.
4) Fill the top of the volcano with glycerin, start the stopwatch, and step back.
5) Record your observations
6) Ask the students the following questions:
- What happened to the tart pan?
- How fast did it happen?

Activity 3: Homemade Handwarmer (exothermic)
Estimated Time: 20 Minutes

Materials: for each group

- Thermometer
- Calcium Chloride
- Resealable baggie
- Warm water

Objective/Standard:
Students will perform and observe different types of chemical reactions.

- **NGSS: MS-PS1-2,4,5; SEP: 4,7,8**
- **Math: MP.3,6,7**
- **ELA: 6-8.RST.3,7,8,9; 6.RI.7; 8.SL.1,4**

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Instruction:

1) Add 150 mL of warm water to baggie.
2) Take an initial reading of the temperature.
3) Add a scoop of calcium chloride to water.
4) Record the temperature every minute for 10 minutes. Try to keep the baggies as closed as possible.
5) Have the students graph their data
6) Ask the students the following questions:
- What is the rate of temperature change?
- What would happen if you used colder or warmer water?

Objective/Standard:
Students will perform and observe different types of chemical reactions.

Notes

- **NGSS: MS-PS1-2,4,5; SEP: 4,7,8**
- **Math: MP.3,6,7**
- **ELA: 6-8.RST.3,7,8,9; 6.RI.7; 8.SL.1,4**

Instruction:

1) Add 30 mL of water to s Styrofoam cup and measure its temperature.
2) Add 6-12 grams of ammonium chloride and mix.
3) Record the temperature every minute for 10 minutes.
4) Dispose down the sink with running water.
5) Have the students graph their data.
6) Ask the students the following questions:

- What happened to the temperature?
- How fast did it happen?
- Does the initial temperature affect the results?

Activity 4: Slow fire (exothermic)
Estimated Time: 30 Minutes

Materials: for each group

- Glass jar (about 12 oz.) with screw-top lid
- Thermometer
- Vinegar
- Steel wool
- Beaker

Objective/Standard:
Students will perform and observe different types of chemical reactions.

- **NGSS: MS-PS1-2,4,5; SEP: 4,7,8**
- **Math: MP.3,6,7**
- **ELA: 6-8.RST.3,7,8,9; 6.RI.7; 8.SL.1,4**

Instruction:

1. Put the thermometer in the jar and close the lid.
2. Wait 10 minutes and record the temperature
3. Put the steel wool in the beaker and cover with the vinegar. Soak for 1 minute.
4. Wrap the steel wool around the bulb at the base of the thermometer, put them in the jar and close the lid.
5. Wait 10 minutes and record the temperature.
6. Record your observations about the steel wool.
7. Ask the students the following questions:

- What happened when the vinegar was added?
- What color was the steel wool at the end?
- What do we normally call this reaction?

Activity 5: Putting in the chill (endothermic)
Estimated Time: 20 Minutes

Notes

Materials: for each group

- Ammonium chloride (6-12 g)
- Water (30 mL)
- Styrofoam cup
- Stir rod
- Thermometer
- 100 mL graduated cylinder
- Balance

Objective/Standard:
Students will perform and observe different types of chemical reactions.

- **NGSS: MS-PS1-2,4,5; SEP: 4,7,8**
- **Math: MP.3,6,7**
- **ELA: 6-8.RST.3,7,8,9; 6.RI.7; 8.SL.1,4**

Instruction:

1) Add 30 mL of water to s Styrofoam cup and measure its temperature.
2) Add 6-12 grams of ammonium chloride and mix.
3) Record the temperature every minute for 10 minutes.
4) Dispose down the sink with running water.
5) Have the students graph their data.
6) Ask the students the following questions:

- What happened to the temperature?
- How fast did it happen?
- Does the initial temperature affect the results?

Activity 6: Chilling with acid (endothermic)
Estimated Time: 15 Minutes

Materials: for each group

- Sodium bicarbonate (6-12 g)
- 1M HCl (30 mL)
- Styrofoam cup
- Stir rod
- Thermometer
- 100 mL graduated cylinder
- Balance

Notes

Objective/Standard:
Students will perform and observe different types of chemical reactions.

- **NGSS: MS-PS1-2,4,5; SEP: 4,7,8**
- **Math: MP.3,6,7**
- **ELA: 6-8.RST.3,7,8,9; 6.RI.7; 8.SL.1,4**

Instruction:

1) Add 30 mL of 1M HCl to a Styrofoam cup and record its temperature.
2) Add 6-12 grams of sodium bicarbonate and mix.
3) Record the temperature every minute for 10 minutes.
4) Dispose down the sink with running water.
5) Graph the data.
6) Ask the students the following questions:
   - What happened to the temperature?
   - How fast was the change?
   - Is this like another reaction already performed?

Activity 7:Quick freeze (endothermic)
Estimated Time: 5 Minutes

Safety: Needs to be done in a hood.

Materials: for each group

- Barium hydroxide octahydrate (32 g)
- Ammonium chloride (10 g)
- Water
- Watch glass
- Beaker
- Stir rod
- 100 mL graduated cylinder

Objective/Standard:
Students will perform and observe different types of chemical reactions.

- **NGSS: MS-PS1-2,4,5; SEP: 4,7,8**
- **Math: MP.3,6,7**
- **ELA: 6-8.RST.3,7,8,9; 6.RI.7; 8.SL.1,4**

Notes

Instruction:

1) Put a small amount of water onto a watch glass.
2) Set the beaker onto the water in the watch glass.
3) Add 32g of barium hydroxide octahydrate and 10g of ammonium chloride to the beaker and stir.
4) Let stand for 30-45 second.
5) Lift the beaker. The watch glass should be attached to the beaker. Beaker can be passed around for the students to feel.
6) Ask the students the following questions:
   - What happened to the temperature?
   - How fast was the change?

Conclusion

Estimated Time: 10 Minutes

1) Ask the students the following questions:

- Which experiments gave off heat? (exothermic)
- Which experiments absorbed it? (endothermic)
- Which experiment was the fastest?
- Which was the slowest?
- How would these reactions affect the solution for the orchard?

Revisit the Know/Need to Know list and answer and Needs to Know and add any new ones that may have arisen from this activity.

Notes

Do I smell gas?

Logistics

Class age/size: 6th-8th grade/students working independently

Materials:
- Digital Scale(s)
- Bagged fruit from earlier in the week
- Biofuel student pages
- Calculators

Time: 60 Minutes

Location: Classroom
Safety: No major safety concerns with this lesson.

Objectives/Standards

- *Students will determine the amount of ethylene gas produced from a single piece of fruit.*
  - **NGSS: SEP.4,5**
  - **Math: 6.RP.1; MP.4,6,7**
  - **ELA: 6-8.RST.3,9; 8.SL.1**
- *Students will calculate the ethylene gas production of an entire acre of fruit trees.*
  - **NGSS: SEP.4,5**
  - **Math: 6.RP.3; MP.4,6,7**
  - **ELA: 6-8.RST.3,9; 8.SL.1**
- *Students will calculate the Joules obtained from an acre's worth of ethylene gas.*
  - **NGSS: SEP.4,5**
  - **Math: 6.RP.3; MP.4,6,7**
  - **ELA: 6-8.RST.3,9; 8.SL.1**

Need to Know Item Addressed

- What happens to the mass of a fruit as it ripens?
- How much gas is produced by a single fruit?
- How much gas can be produced by Eckert's orchard?
- How much energy can that gas provide?

Notes

Introduction

As a fruit ripens, or decays, it naturally produces ethylene gas. The chemical formula for ethylene gas is simple, C_2H_4. If this gas could be trapped, or harnessed, it could act as a potential recycled fuel source, commonly known as biogas. The focus of this lesson will be taken data collected from the ripening of one piece of fruit and mathematically determining the amount of biogas and therefore, energy that could be harnessed from an entire fruit orchard.

Activity/Activities

Activity 1: Ethylene Gas Production from 1 fruit
Estimated Time: 20 Minutes

Materials:
- Digital Scale(s)
- Bagged fruit from earlier in the week
- Biofuel student pages
- Calculators

Objective/Standard:
Students will determine the amount of ethylene gas produced from a single piece of fruit.
- **NGSS: SEP.4,5**
- **Math: 6.RP.1; MP.4,6,7**
- **ELA: 6-8.RST.3,9; 8.SL.1**

Instruction:
1) Today we are going to record the mass of the fruit again, what do you think happened to this fruit's mass since we started the experiment?
    a. Do you think it increased, decreased, or stayed the same?
2) We know now that as a fruit ripens, it produces ethylene gas.
    a. If this gas could be trapped, or harnessed, it could act as a potential recycled fuel source.
3) Place digital scale(s) throughout the classroom and have students record their fruit's mass.
    a. Call on a collection of students and have them share what their initial and second mass readings were.
        i. The mass readings should have gone down.
4) Continue to call on different students to share their hypothesis about the fruits mass.
    a. What does the Law of Conservation of Mass say?
    b. Why did the mass go down even though it should be the same?
5) By taking the difference from our initial mass and our final mass reading, this is the amount of ethylene gas produced.
    a. Call on five different students to collect five different masses, have the students determine the average and use this value for the entire class. Make sure and determine separate averages for apples and peaches.

Notes

6) In order for this number to mean much of anything to us, we need to determine a ratio. This ratio will help us to determine much larger values in for the rest of today's class.
7) Have the students start working through the first chart. Depending on the skill level of your students, you may need to use this as an example problem as a class to work through a proportion.
    a. This value will give you the grams of ethylene gas produced by a pound of fruit.
    b. 1 pound = 454 grams

Activity 2: Extrapolation to an Orchard
Estimated Time: 20 Minutes

Materials:
- Biofuel Student Pages
- Calculators

Objective/Standard:
Students will calculate the ethylene gas production of an entire acre of fruit trees.
- **NGSS: SEP.4,5**
- **Math: 6.RP.3; MP.4,6,7**
- **ELA: 6-8.RST.3,9; 8.SL.1**

Instruction:
1) Activity 2 focuses on proportions obtained from statistics derived from the actual fruit orchard this program is based on.
    a. Students may work in partners to progress through their student pages.
2) Students will be expected to explore more proportions and experimentally determine the amount of ethylene gas produced by an entire acre of trees.
    a. Inform students that not all the proportions for a piece of fruit will necessarily need to be used.
3) Make sure and set a time limit for students.
    a. You may also want to monitor individual student progress throughout the class to determine if they are succeeding or struggling with the concept.
    b. Ideally the students will be expected to determine this value themselves.
4) Have the students work on the questions at the bottom of the first page before moving onto to Activity 3.
    a. Make sure they are applying the proportions from their respective fruit.

Activity 3: Ethylene Gas Energy Production
Estimated Time: 15 Minutes

Materials:
- Biofuel Student Pages – 20
- Calculators - 20

Notes

Objective/Standard:
Students will calculate the Joules obtained from an acre's worth of ethylene gas.

- **NGSS: SEP.4,5**
- **Math: 6.RP.3; MP.4,6,7**
- **ELA: 6-8.RST.3,9; 8.SL.1**

Instruction:

1) Students will again be able to work in pairs.
2) Activity 3 is going to have the students calculating the amount of energy (in Joules) obtained from the ethylene gas produced in an entire acre.
   a. The kilojoules per gram was obtained from the standard enthalpy of combustion of ethylene gas.
3) They will progress through the proportions on the second page converting the ethylene gas production of an acre into megajoules.
4) It may be beneficial to check-in with the class before starting Activity 3.
   a. The entirety of Activity 2 could be worked out on the board to ensure everyone is at the same pace.
5) The students will calculate a large number of megajoules of energy.
   a. For comparison,
   b. 1 cubic foot of natural gas = 37 Megajoules of energy
   c. 43,560 foot long cubes of natural gas can fit into 1 acre
   d. 43,560 x 37 = **1.6 million Megajoules of energy**

Conclusion

Estimated Time: 5 Minutes

Revisit the Know/Need to Know list and answer any Needs to Know and add any new ones that may have arisen from this activity.

Sources

http://hypertextbook.com/facts/2002/JanyTran.shtml

Notes

What is this large molecule?

Logistics

Class age/size: 6^{th}-8^{th} grade/groups of 4

Materials:

- Plastic Cup – 1
- Polyurethane Foam A – 10 mL
- Polyurethane Foam B – 10 mL
- Popsicle Stick – 1 per student and 1 for teacher
- Microwave – 1
- Paper Bowl – 1 per student
- Corn Starch – 591.5 g
- Water – 887 mL
- Goggles – 1 pair per student

Time: 50 Minutes

Location: Laboratory

Safety: Be careful when handling materials removed from the microwave. Only the teacher should handle materials going in and out of the microwave. Once polyurethane foam A and B are mixed together do NOT touch to your skin. As the reaction takes place the foam will harden to any surface, skin, nails, desktop. Students should wear eye protection during this lesson.

Objectives/Standards

- *Students will be introduced to polymers*
    - **NGSS: MS-PS1-1; SEP.7**
    - **Math: MP.7,8**
    - **ELA: 8.SL.1,3,4**
- *Students will observe the chemical formation of polyurethane foam.*
    - **NGSS: MS-PS1-2.**
- *Students will create a polymer using food-based materials.*
    - **NGSS: MS-PS1-3.**

Need to Know Items Addressed:

- What is a polymer?
- What is a bioplastic?

Notes

Introduction

Prior to the 1920's the existence of molecules with molar masses greater than 1000g seem very unlikely to scientists. Before that, scientists believed that polymers were clusters of small molecules (called colloids), without definite molecular weights, held together by an unknown force, a concept known as association theory. In 1922, Hermann Staudinger proposed that polymers consisted of long chains of atoms held together by covalent bonds, an idea that did not gain wide acceptance for over a decade, and for which Staudinger was ultimately awarded the Nobel Prize. Modern Americans encounter polymers extremely frequently. Some worth examples of polymers are as follows: rubber (a natural polymer), polyethylene (two types: HPDE and LPDE, high an low density, respectively. They are used in bottles, toys, plastic wrap, and plastic bags), polypropylene (carpeting, upholstery), and polyvinyl chloride (PVC, pipes, siding).

Activity/Activities

Activity 1: Definitions
Estimated Time: 5 Minutes

Objective/Standard:
Students will be introduced to polymers

- **NGSS: MS-PS1-1; SEP.7**
- **Math: MP.7,8**
- **ELA: 8.SL.1,3,4**

Instruction:

1) Tell the students that everything in the world is made up of tiny groups of atoms called molecules. Some molecules are much larger than others. A single molecule is called a **monomer**. Write this on the board: mono= one. A monomer is a molecule of a single unit.
2) Write: poly=many; then a **polymer** is a large molecule made up of many smaller units called molecules all joined together. Some polymers are made up of thousands of monomers.
3) Tell the students they are all individual monomers- single molecules. One student alone is a monomer; two represents a dimer, three a trimer, etc. Have the whole class join hands- tell them they are modeling a short polymer b/c some polymers are made of thousands of molecules joined together.
4) Polymers are important in our everyday lives. The world as we know it today could not exist without polymers. Styrofoam cups to plastics, adhesives, fabrics, paints, even a life-saving artificial heart valve are all examples of polymers.

Notes

Activity 2: Making our first Polymer (TEACHER DEMO)
Estimated Time: 5 Minutes (5 Minutes Later)

Materials:

- Plastic Cup – 1
- Polyurethane Foam A – 10 mL
- Polyurethane Foam B – 10 mL
- Popsicle Stick - 1

Objective/Standard:
Students will observe the chemical formation of polyurethane foam.

- **NGSS: MS-PS1-2.**

Instruction:

1) Now we are going to create our first polymer.
    a. Polyurethane is a polymer foam.
2) There are two liquid components required to create polyurethane.
    a. These two liquids are incredibly viscous. **DO NOT** pour them into a graduated cylinder to accurately measure 10 mL.
3) Measure 10 mL of water, add it to the cup and mark its volume. Repeat to mark a total volume of 20 mL.
4) Add approximately 10 mL of Poly Foam A to the cup.
5) Have the students come up and make observations. **DO NOT TOUCH,** the foam is incredibly adhesive and sticks permanently to anything.
6) Add approximately 10 mL of Poly Foam B to cup and quickly stir the two liquids together and let the cup sit. .
7) Have the students come up and make observations, do not move the cup. No fumes or by-products are given off from this reaction, but as the foam is forming DO NOT TOUCH it
8) Let it sit until the reaction completes (approximately 20 minutes). It will now be safe for the students to touch. Let them make observations.

Activity 3: Homemade Bioplastic
Estimated Time: 30 Minutes

Materials:

- Microwave – 1
- Paper Bowl – 20
- Corn Starch – 40 TBS
- Water – 60 TBS
- Popsicle Stick - 20

Objective/Standard:

Notes

Students will create a polymer using food-based materials.

- ***MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.***

1) Next we are going to create a bioplastic using the starch obtained from processed corn meal.
    a. Before we begin creating our bioplastic, label the paper bowl given to you so you can retrieve your plastic tomorrow.
2) Combine in a paper bowl
    a. Corn Starch – 29.5 g
    b. Water – 44 mL
3) Using a popsicle stick, stir the contents until uniformly mixed.
4) Place the bowl inside a microwave and heat for 120 seconds on HIGH.
    a. Only the teacher should be handling materials going in and out of the microwave.
    b. The contents will be hot.
    c. **NOTE FOR TEACHER**: Each student will make their own polymer, but they will test them in groups of 4. This way each group will have 4 samples to test. All of the samples do not need to be made during the session; some could be made at the end of the day but at least 1 from each group should be made before the end of the class period. Also, if you can fit 4 bowls in at once, they should be cooked for 4 minutes. Two bowls can still be done for 2 minutes.
5) This bioplastic will need to cool and setup for 24 hours.
    a. We will continue with our testing tomorrow.
6) For the duration of the lesson, while the bioplastics are being microwaved, the students need to divide themselves into groups of 4.
    a. These groups are going to design an experiment for tomorrow testing their homemade bioplastic against a commercial bought bioplastic.
    b. The experiments should include a problem statement, hypothesis and a procedure.
        i. The students will have the start of the next lesson to describe to you, the teacher, their experiment.

Conclusion:
Estimated Time: 5 Minutes

Revisit the Know/Need to Know list and answer any Needs to Know and add any new ones that may have arisen from this activity.

Notes

How good is it?

Logistics

Class age/size: 6th-8th grade/groups of 4

Materials:

- Mass weights (minimum of 5 kg) – 5
- Cotton Thread – 5, 1' lengths
- Nylon Thread – 5, 1' lengths
- Bioplastic from previous lesson – 20
- Commercial Bioplastic – 10
    - http://worldcentric.org/biocompostables/trays/sushi

Time: 60 Minutes

Location: Laboratory
Safety: Students should be careful when working with hot plates and ice baths. Hands should not be submerged in ice bath for any reason. Oven Mitts must be used when removing Pyrex beaker from hot plate. Students should wear eye protection throughout this lesson.

Objectives/Standards

- *Students will learn about tensile strength and perform a strength test on two types of thread.*
    - **NGSS: MS-PS1-4; ETS1-1,2,3,4; HS-PS2-6; ETS1-1,3; SEP.3,4,6,7,8**
    - **Math: MP.3,4,6**
    - **ELA: 6-8.RST.3,8,9**
- *Students will design and perform different tests to compare the relative strength and effectiveness of manmade vs. commercial bioplastic.*
    - **NGSS: MS-PS1-4; ETS1-1,2,3,4; HS-PS2-6; ETS1-1,3; SEP.3,4,6,7,8**
    - **Math: MP.3,4,6**
    - **ELA: 6-8.RST.3,8,9**

Need to Know Items Addressed

- What is Material Science?
- What is tensile strength?
- Does bioplastic serve as an effective replacement to commercial plastics?

Notes

Introduction

In the development of synthetic materials, a battery of tests must be performed to determine their functionality in the real world. This study of durability falls into the realm of material science. Material science is a combination of engineering and science that specifically studies properties of matter. For today's lesson the students will be studying the thermochemical property and tensile property of their bioplastic.

Activity/Activities

Activity 1: Introduction to Material Science (Tensile Strength)
Estimated Time: 15 Minutes

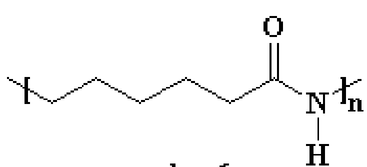
Materials:

- Mass weights (minimum of 5 kg) – 5
- Cotton Thread – 5, 1' lengths
- Nylon Thread – 5, 1' lengths

Objective/Standard:
Students will learn about tensile strength and perform a strength test on two types of thread.

- **NGSS: MS-PS1-4; ETS1-1,2,3,4; HS-PS2-6; ETS1-1,3; SEP.3,4,6,7,8**
- **Math: MP.3,4,6**
- **ELA: 6-8.RST.3,8,9**

Instruction:



nylon 6

1) Students will work in groups of 4 for this experiment.
2) Each group is going to be given a set of mass weights, two different types of thread and an apparatus to support the weight.
3) This experiment is going to test the tensile strength of two commercial purchased threads.
    a. Students should work through this experiment before moving onto testing their bioplastic.
4) One group member is responsible for holding one end of one piece of thread.
    a. The other end should be attached to some container that can retain the mass weights.
    b. Other students should then incrementally add weight to the container.
        i. DON'T just add a bunch of weight to start.
5) The other two students should place their hands underneath the container to catch it once the string breaks.
    a. Students should record the total mass inside the container once the string has broken.
6) Repeat this procedure for the second string.
7) The two strings appear to be the same. They are both the same length, relatively the same thickness; however the nylon string was able to withstand a larger weight. Why?

Notes

   a. Cotton threads are a series of smaller spun pieces of cotton overlapped onto each other. Not exactly the strongest piece of thread. Most ropes are a series of cotton threads twisted together to add strength.
   b. Nylon is actually a polymer. Chemically produced, the individual molecules of nylon are chemically bonded together for added strength.

Activity 2: Testing Methods
Estimated Time: 40 Minutes

Objective/Standard:
Students will design and perform different tests to compare the relative strength and effectiveness of manmade vs. commercial bioplastic.

- **NGSS: MS-PS1-4; ETS1-1,2,3,4; HS-PS2-6; ETS1-1,3; SEP.3,4,6,7,8**
- **Math: MP.3,4,6**
- **ELA: 6-8.RST.3,8,9**

Instruction:

1) Students will stay working in groups of 4.
    a. Each student will have a homemade bioplastic from the previous lesson.
2) As a group, they need to design an experiment to compare their homemade bioplastic with the commercially bought bioplastic.
    a. Potential experiments could be:
        i. Tensile Strength
        ii. Hot temperature resistance
        iii. Cold temperature resistance
        iv. Acid resistance
3) The remaining portion of this lesson is left open-ended to allow the students to design their experiment.
4) Give the students the first 10 to 15 minutes to design their experiment.
    a. Rotate throughout the groups discussing the experiment.
    b. What problem are they interested in addressing?
    c. What is their hypothesis for the outcome?
    d. What variables can they control and change?
5) The remainder of the class should be devoted to performing the experiment and collecting data points from their groups 4 pieces of bioplastic.

Conclusion:
Estimated Time: 5 Minutes

Revisit the Know/Need to Know list and answer any Needs to Know and add any new ones that may have arisen from this activity.

Notes

What is the cost?

Logistics

Class age/size: middle school/in groups

Materials:
- Devices with Internet access

Time: 60 Minutes

Location: Classroom where students can access the Internet

Safety: None

Objectives/Standards

- *Students will research the environmental and actual costs of the solutions.*
  - **NGSS: MS-PS1-3; ESS3-3; EST1-1,2,3; HS-ESS3-2,3,4; ETS1-3; SEP.8**
  - **ELA: 6.RI.7; 8.RI.1,6,8; 8.W.8; 8.SL.2; 6-8.RST.1,2,4,5,6,7,8,9,10**
- *Students will share their findings with their classmates.*
  - **NGSS: MS-PS1-3; SEP.7,8**
  - **Math: MP.3**
  - **ELA: 6.RI.7; 8.SL.1,3,4; 6-8.RST.1,2,7,8,9,10**

Need to Know Items Addressed

- What are environmental costs of the different solutions?
- What are the other costs involved with the possible solutions?

Introduction

The students have done their initial research into the possible solutions for what to do with the apple and peach waste from the orchard and have done activities to more fully understand what is involved with the different solutions, but they have not analyzed the costs. In this activity, they can be back with their groups from the first set of internet research and this time focus on the environmental and actual costs of the different solutions to help them decide on the final solution.

Notes

Activity/Activities

Activity 1: Online research
Estimated Time: 35 Minutes
Materials:

- Devices with internet access

Objective/Standard:
Students will research the environmental and actual costs of the solutions.

- **NGSS: MS-PS1-3; SEP.8**
- **ELA: 6.RI.7; 8.RI.1,6,8; 8.W.8; 8.SL.2; 6-8.RST.1,2,4,5,6,7,8,9,10**

Instruction:

1) Students will work on the same possible solution they did for the first information gathering session and determine environmental and other costs.
2) They will then design a way to present their information to their classmates. They can put together a visual using any means available, PowerPoint or drawn visual.

Activity 2: Sharing of information
Estimated Time: 20 Minutes

Materials:

- Student generated information

Objective/Standard:
Students will share their findings with their classmates.

- **NGSS: MS-PS1-3; SEP.7,8**
- **Math: MP.3**
- **ELA: 6.RI.7; 8.SL.1,3,4; 6-8.RST.1,2,7,8,9,10**

Instruction:

1) Students will share their information with their classmates. Each group should get a short period of time to share. They will use this information with what else has been gathered through the curriculum to make generate their final solutions.

Conclusion:
Estimated Time: 5 Minutes

Revisit the Know/Need to Know list and answer any Needs to Know and add any new ones that may have arisen from this activity.

Notes

Generate Possible Solutions

Logistics

Class age/size: 6-8th grade/in groups

Materials:

- K/NK Charts
- Final Problem Statement
- Generating Solutions sheets or post-it notes
- Information from activities and research

Time: 20 minutes

Location**:** Classroom

Objectives/Standards:

- *Students brainstorm solutions to the problem.*
  - **NGSS: SEP.1,2,3,4,5,6,7**
  - **Math: 9-12.S-IC.3; MP.1,3,4,5,7**
  - **ELA: 8.SL.1,1b,1c; 8.RI.6; 8.W.1,1a,9; 6-8.WHST.1b**

Introduction:

Brainstorming solutions is the next step towards developing the ultimate solutions to the problem. At this stage, students should not be trying to choose solutions, the goals is to generate a large list of solutions for students to consider in the next lesson.

Activity/Activities

The students will brainstorm ideas for the ultimate solution to the problem by writing them on either the Generating Solutions handouts or post-it notes. They will then hang their solutions on the wall. As a class, or as small groups, the students will categorize the solutions according to common themes.

Coaching Questions:

- Have you investigated all of the areas of the Problem Statement?
- Do you have enough information?
- Have you investigated all of the Need to Know items?
- What options are you considering?

Notes

Assessment:

- Do the proposed solutions address the overall task and factors to consider in the Problem Statement?
- Do the proposed solutions show evidence of sufficient content knowledge to support the learners' case?
- Do they actively consider a broad range of solution elements?
- Do they offer valid support for their solution elements?
- Do all learners participate?

Notes

Determine Best Fit Solution

Logistics

Class age/size: 6-8th grade/whole class

Materials:

- K/NK Charts
- Final Problem Statement
- Generating Solutions sheets or post-it notes
- Information from activities and research
- Decision matrix or similar (if desired)

Time**:** 20 minutes

Location: Classroom

Objectives/Standards:

- *Students will determine the best solution to the problem.*
    - **NGSS: SEP.1,2,3,4,5,6,7,8**
    - **Math: 9-12.S-IC.3,6; 9-12.S-MD.5,6,7; MP.1,2,3,4,5,7,8**
    - **ELA: 8.SL.1,1a,1c,1d; 8.RI.6; 8.W.1,1a,9; 6-8.WHST.1b**

Introduction: The students will develop criteria for evaluating which solutions best fit the problem, and determine which solution(s) are a best fit. The key understanding is that there is seldom a perfect solution for a messy problem, just solutions that are a better or worse fit. The students may come up with one solution for the class, a solution with several components, or several solutions.

Activity/Activities
By referring to the Meet the Problem letter and the Problem Statement, the students will develop a list of criteria to judge the proposed solutions. Teachers may have the students use a decision matrix, SWOT analysis, or other methods for evaluating the solutions.

Notes

Coaching Questions:

- What is at stake in the problem? Have you considered all of the stakeholders/factors?
- What are the pros and cons of each possible solution?
- What solutions or combination of solutions seems most reasonable? Why or why not?
- What is the best-fit solution? How do you know?
- What are the potential consequences of this solution?
- What is the hardest question that you might be asked when you present this solution?
- Have you reached consensus?
- Is the solution realistic?

Assessment:

- Does the solution incorporate the information and content that learners have gained throughout this problem?
- Does the best-fit solution address all the factors in the problem statement?
- Do the learners work cooperatively to reach consensus on their shared vision?
- Do they set criteria for establishing priorities?
- Do they analyze the factors by means such as: feasibility, ethics/morals, cost benefit and risk analysis, consequences?
- Do they consider the consequences of their decisions?

Notes

Present the Solution

Logistics

Class age/size: 6-8th grade/whole group

Materials:

- K/NK Charts
- Final Problem Statement
- Generating Solutions sheets or post-it notes
- Information from activities and research
- Decision matrix or similar (if desired)

Time: 2 hours (1 hour for preparation, 1 hour for presentations)

Location: Classroom

Safety: No known issues

Objectives/Standards:

- *Students will design a presentation of their solution and give the presentation to poser of the problem.*
    - **NGSS: SEP.1,2,4,5,6,7,8**
    - **Math: MP.2,3,4,5,6,7**
    - **ELA: 8.SL.1,1a,4,5,6; 8.RI.7; 8.W.1; 8.L.1,3; 6-8.WHST.1b**

Introduction/Activity/Activities:

The students will develop presentations of the solution(s) to the problem. There may be multiple solutions within the class, or one solution with multiple parts presented by different groups. This is an especially powerful experience if the students are able to present their solutions to the problem poser.

Coaching Questions:

- Do you know what your role in the presentation is?
- Are your presentation materials ready?
- Have you considered and prepared for questions from the audience?

Assessment:

- Do the presentations communicate learners' solutions effectively, accurately, and clearly?
- Do learners ask appropriate questions of other presenters?
- Do learners engage with all of the presentations?

Notes

Final Debrief

Logistics

Class age/size: 6-8th grade/whole class

Materials:
- Chart Paper
- Markers

Time: 30 minutes

Location: Classroom

Objectives/Standards:

- *Students will reflect on what the learned from the presentations and from the problem as a whole.*
  - **NGSS: SEP.6,7,8**
  - **Math: MP.3,7**
  - **ELA: 8.SL1,1b.1c,1d,2; 8.RI.6**

Introduction and Activity/Activities:

The learners will reflect up their learning. This can be done through journaling small group discussion, whole class discussion, or any combination of these activities. Students sometimes don't realize how much they have learned until they are asked to reflect and make connections.

Coaching Questions:

- Guide learners to critically analyze their groups' presentation and those of other groups for effectiveness and completeness of the solution.
  - What elements worked and what didn't? How did you know?
  - What did you see in other presentations that was different from yours?
  - What content did other teams find that your team did not?
  - What would you leave out or add to your presentation if you were to do it again?
  - What would be the best solution to the problem?
- Guide learners to critically analyze their processing and group skills.
  - What skills worked for you as you gathered information, and what did not?
  - How effective did you think you were in solving the problem?
  - How effective did you think your group was in solving the problem?
  - How would you change your research tactics for another problem?
  - What helped you most to understand the problem?

Notes

- Guide learners to critically analyze their learning throughout the problem.
  - What new content knowledge did you gain through this problem?
  - How did that content knowledge help you to understand the problem?
  - What questions do you still have about the content of this problem?
  - Did your beliefs change after listening to others?
  - How did your thinking change during this problem?

Assessment:

- Can learners articulate the problem and solution in an individual journal entry?
- Do learners engage in whole group sharing about the presentation, the process, and the learning?

Waste Not, Want Not

Dear Students,

Poser of the problem shares their background.

Poser needs to set up how much waste is generated by them in apples.

Since a certain amount of waste is unavoidable, and we cannot sell this produce for human consumption, we are wondering if there are other possible uses for the fruit. I have heard about corn and soybeans being used to generate energy, such as biogas, biodiesel, and ethanol, as well as being used to make building materials and plastic. I am wondering if there are any possibilities for using our wasted fruit for these purposes. I am also interested in finding out if there are any options for converting the fruit to fertilizer or compost, or salvaging it for human or animal consumption.

Here at poser's location we are interested in finding practical solutions to the problem of managing our waste. In our waste management plan, we want to be good stewards of the environment, but we also understand that our solutions need to workable and cost-effective.

I look forward to hearing your ideas for solving this problem,
Sincerely,

Waste Not, Want Not

Name**________________________________** ***Date*****_________________________________**

Know	Need to Know	Need to Do

Waste Not, Want Not

Name______________________________ Team ________________ Date ________________

Problem Statement

	Here's what I think…	Here's what we (pair) think…	Here's what our group thinks…
Overall Task			
Factors to Consider			

How can we . . .

in such a way that

Waste Not, Want Not

Name:________________________________

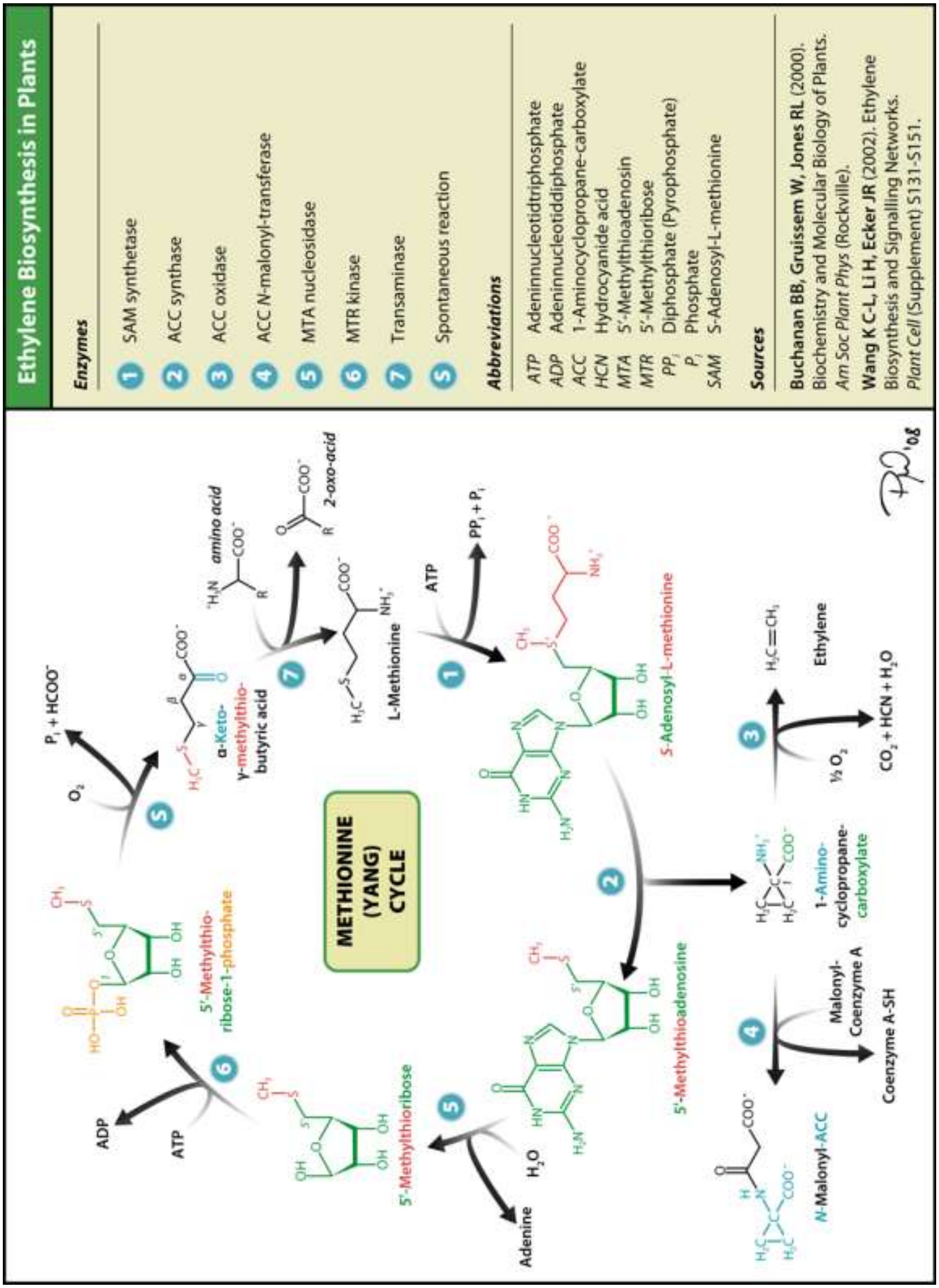
Fruit:________________________________

Storage Condition:______________________

Day	Mass (g)	Change in Mass (g)
0		0

1) What is the total change in mass from start of the experiment?

2) What could have caused the change?



Ethylene Biosynthesis in Plants
Enzymes
1 SAM synthetase
2 ACC synthase
3 ACC oxidase
4 ACC N-malonyl-transferase
5 MTA nucleosidase
6 MTR kinase
7 Transaminase
S Spontaneous reaction
Abbreviations
ATP Adeninnucleotidtriphosphate
ADP Adeninnucleotiddiphosphate
ACC 1-Aminocyclopropane-carboxylate
HCN Hydrocyanide acid
MTA 5'-Methylthioadenosin
MTR 5'-Methylthioribose
PPi Diphosphate (Pyrophosphate)
Pi Phosphate
SAM S-Adenosyl-L-methionine
Sources
Buchanan BB, Gruissem W, Jones RL (2000). Biochemistry and Molecular Biology of Plants. Am Soc Plant Phys (Rockville).
Wang K C-L, Li H, Ecker JR (2002). Ethylene Biosynthesis and Signalling Networks. Plant Cell (Supplement) S131-S151.
METHIONINE (YANG) CYCLE
L-Methionine
ATP
PPi + Pi
S-Adenosyl-L-methionine
5'-Methylthioadenosine
1-Amino-cyclopropane-carboxylate
½ O2
CO2 + HCN + H2O
Ethylene
Malonyl-Coenzyme A
Coenzyme A-SH
N-Malonyl-ACC
H2O
Adenine
5'-Methylthioribose
ATP
ADP
5'-Methylthio-ribose-1-phosphate
O2
Pi + HCOO-
α-Keto-γ-methylthio-butyric acid
amino acid
2-oxo-acid

Waste Not, Want Not

Name:____

Activity 1

Term	**Definition**
Atom	
Element	
Molecule	
Compound	
Solution	
Mixture	

Activity 2

Sample	**1**	**2**	**3**	**4**	**5**	**6**
English Name						
Chemical Symbol						
Vocabulary Word						

1) Is a solution a compound or mixture? Why?

Activity 3
Write your compounds below.

Waste Not, Want Not

Name:_______________________________________

Activity 1

	Activated Charcoal	**Graphite**	**Diamond**
Physical Appearance			
Conductivity			
Hardness			
Mass (g)			
Volume (mL)			
Density (g/mL)			

1) What are the differences between the 3 samples?

2) How are they similar?

Activity 2

	Pre-1982	Post-1982
Physical Appearance		
Conductivity		
Hardness		
Mass (g)		
Volume (mL)		
Density (g/mL)		

1) What are the similarities between the 2 types of pennies?

2) What are the differences?

3) What are the physical and chemical properties of apples and peaches?

Waste Not, Want Not

Name:_______________________________________

Material	Observations	Chemical or Physical Change?	Reasoning for Choice?
Eggshell			
Eggshell in water			
Eggshell in vinegar			
Paper alone			
Paper ripped			
Paper on fire			
Paper in water			
Sodium Chloride alone			
Sodium Chloride in water			
Sodium Chloride in alcohol			
Sodium Chloride on fire			

Waste Not, Want Not

Name:____

Materials:

- Test tube
- Test tube rack (or beaker)
- Small piece of chalk
- Vinegar

Instruction:

1) Put the test tube on the rack
2) Put the small piece of chalk in the test tube.
3) Pour enough vinegar in the test tube to cover the chalk.
4) Let it sit for 10 minutes and record your observations during the 10 minutes.
5) Wash the test tube well and throw away the chalk.

Prediction: What do you predict will happen in this experiment?

Time Elapsed (mins)	Observations
0	
5	
10	

1) What happened immediately after adding the vinegar?

2) What happened over time?

3) What gas was produced by the reaction?

4) Which do you think was the acid? The base?

Waste Not, Want Not

Name:_________________________________

Materials:
- Paper towel
- Tart pan
- Glycerin
- Potassium permanganate
- Spoon
- Stop watch

Instruction:
1) Wet the paper towel and place the tart pan upside down on the center of it.
2) Put a small pile, just slightly larger than a quarter, of potassium permanganate on the tart pan.
3) Use the spoon to make a small volcano of the pile.
4) Fill the top of the volcano with glycerin, start the stopwatch, and step back.
5) Record your observations

Prediction: What do you predict will happen in this experiment?

Observations:

1) What happened to the tart pan? Why?

2) How fast did the reaction happen?

Waste Not, Want Not

Name:_______________________________________

Materials:

- Thermometer
- Calcium Chloride
- Resealable baggie
- Warm water

Instruction:

1) Add 150 mL of warm water to baggie.
2) Take an initial reading of the temperature.
3) Add a scoop of calcium chloride to water.
   Record the temperature every minute for 10 minutes. Try to keep the baggies as closed as possible.
4) Graph your data.

Prediction: What do you predict will happen in this experiment?

Time (mins)	Temperature (°C)
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

1) What is the rate of temperature change?

2) What do you think would happen if you started with hotter or colder water?

Waste Not, Want Not

Name:_______________________________________

Materials:
- Glass jar (about 12 oz.) with screw-top lid
- Thermometer
- Vinegar
- Steel wool
- Beaker

Instruction:
1) Put the thermometer in the jar and close the lid.
2) Wait 10 minutes and record the temperature
3) Put the steel wool in the beaker and cover with the vinegar. Soak for 1 minute.
4) Wrap the steel wool around the bulb at the base of the thermometer, put them in the jar and close the lid.
5) Wait 10 minutes and record the temperature.
6) Record your observations about the steel wool.

Prediction: What do you predict will happen in this experiment?

Initial Temperature (°C)	
Initial Appearance	
Final Temperature (°C)	
Final Appearance	

1) What happened when the vinegar was added?

2) What color was the steel wool at the end?

3) What do we normally call this reaction?

Waste Not, Want Not

Name:_______________________________________

Materials:

- Ammonium chloride (6-12 g)
- Water (30 mL)
- Styrofoam cup
- Stir rod
- Thermometer
- 100 mL graduated cylinder
- Balance

Instruction:

1) Add 30 mL of water to s Styrofoam cup and measure its temperature.
2) Add 6-12 grams of ammonium chloride and mix.
3) Record the temperature every minute for 10 minutes.
4) Dispose down the sink with running water.
5) Graph your data.

Prediction: What do you predict will happen in this experiment?

Time (mins)	**Temperature (°C)**
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

1) What happened to the temperature?

2) How fast did it happen?

3) Does the initial temperature affect the results?

Waste Not, Want Not

Name:______________________________________

Materials:

- Sodium bicarbonate (6-12 g)
- 1M HCl (30 mL)
- Styrofoam cup
- Stir rod
- Thermometer
- 100 mL graduated cylinder
- Balance

Instruction:

1) Add 30 mL of 1M HCl to a Styrofoam cup and record its temperature.
2) Add 6-12 grams of sodium bicarbonate and mix.
3) Record the temperature every minute for 10 minutes.
4) Dispose down the sink with running water.
5) Graph your data.

Prediction: What do you predict will happen in this experiment?

Time (mins)	**Temperature (°C)**
0	
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	

1) What happened to the temperature?

2) How fast was the change?

3) Is this like another reaction already performed? Which one?

Waste Not, Want Not

Name:____________________________________

Activity 1:

________________ Grams ethylene gas produced	X Calculated amount of ethylene gas produced
________________ Grams of fruit (initial mass)	454 grams of fruit

X =_______________

Activity 2:

1 Bushel Apples	42 Pounds Apples
1 Apple Tree	1 Bushel Apples
1 Acre Apples	388 Apple Trees

1 Bushel Peaches	42 Pounds Peaches
1 Peach Tree	4 Bushels Peaches
1 Acre Peaches	109 Peach Trees

2 Acres = _____ Trees

12,000 Trees = _____Acres

10 Acres = _____ Bushels

1 Acre = ________ Grams of Ethylene Gas

Activity 3:

50 Kilojoules
1 Gram of Ethylene Gas

1000 Joules
1 Kilojoule

1 Megajoule
1,000,000 Joules

Y = _____ = grams of Ethylene Gas in 1 Acre of Fruit Trees (Calculated on previous page).

Y grams of Ethylene Gas = _____ Megajoules

3.6 MJ will allow a 100 W bulb to be lit for 10 hours

Waste Not, Want Not

Name:______________________________________

Activity 2

	Observations
Separately	
Immediately after mixing	
After it sets	

1) What happened to the 2 different components after they were mixed?

2) How is the final product different from the 2 individual components?

3) How much final product was produced? Why does this not violate the Law of Conservation of Mass?

Activity 3

	Observations
Before microwaving	
After microwaving	
After 24 hours	

Experimental Design:

Waste Not, Want Not

Name:____

Activity 1

	Characteristics	**Mass held (g)**
Cotton Thread		
Nylon Thread		

1) What was the same between the 2 stings?

2) Why do you think you got different results?

Waste Not, Want Not

Activity 2

Experimental Design:

Results:

Conclusion:

Waste Not, Want Not

Name**________________________________** ***Date*****_________________________________**

What possible elements of a solution do you see emerging?

Why do you think those elements help resolve the problem?

What other elements have you considered and rejected?

Why did you reject them?

Waste Not, Want Not

***Name*______________________________** ***Date*________________________________**

Task:

Factors to Consider	**Solution Element A**	**Solution Element B**	**Solution Element C**
Factor 1			
Factor 2			
Factor 3			
Factor 4			
Pros			
Cons			
Long-term effects			

Our best-fit solution includes: