Matter & Energy

Future of Agriculture Curriculum for Teaching Sustainability

Name: _____ Hour_____Date: _____

Date Packet is due:_____ Why late? _____Score: _____
Day of Week Date If your project was late, describe why

Overview: in this unit, you will be exploring nature of matter and energy. You'll be exploring the basic laws that govern all things that exist and how these principles relate to the function ecosystems.

Main Questions

- What is matter and energy?
- How do atoms, elements, molecules, and bonds relate to matter?
- How do matter and energy change when something is burned?
- How do changes in matter and energy relate to the existence of living organisms?
- How does matter and energy change as it moves through an ecosystem?
- What is the carbon cycle and how does it relate to the transformations of matter and energy in ecosystems?

Weekly Schedule

Monday:
- Introduction to Matter & Energy – 5 Stations Lab
- Model development – what happens to matter and energy as things grow, decompose, or combust?

Tuesday:
- Nutshell Video & Notes
- Class discussion & revisions of explanations

Wednesday:
- Revisit the 5 Stations; Complete the Combustion Lab.

Thursday:
- Review
- Group Quiz

Friday:
- Weekly Reflection
- Career Connections

This material is based upon work supported by the National Science Foundation Graduate Research Fellowship Program, Grant No. DGE-1424871. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

MICHIGAN STATE UNIVERSITY

Semester Schedule

Week 1: Introduction & Lab Safety

Atoms to Ecosystems

Week 2: Matter & Energy
Week 3: Cell Biology
Week 4: Biodiversity & Ecosystems
Week 5: Biodiversity & Habitats
Week 6: Midterm Assessments

Causes of Extinction

Week 7: Extinction
Week 8: Habitat Loss
Week 9: Invasive Species
Week 10: Land & Water Pollution
Week 11: Atmospheric Pollution
Week 12: Overharvesting
Week 13: Midterm Assessments

Sustainable Societies

Week 14: Natural Resources Management
Week 15: Societies & Sustainability
Week 16: Individual Sustainability
Week 17: Personal Campaigns
Week 18: Personal Campaigns

Day 1: - Introduction to Matter & Energy

Introduction: In this activity, you will be visiting four or five different stations to explore how matter and energy are transformed by living organisms. Everything in existence can be categorized as either **matter** or **energy**. Matter is the "stuff" that everything is made from, and energy is how that stuff changes (temperature, motion, etc.). We use the term **mass** to explain how much matter exists in something (e.g. something that is heavier has more mass because it has more matter in it). For our purposes, matter and energy are always separate entities - matter cannot become energy and energy cannot become matter. Matter and energy also cannot be created or destroyed – the amount of matter and energy that exist is constant. By visiting the stations in this activity, you will use your observations to determine what you know and what you are unsure about. You will then use group and class discussions to try to develop explanations based on your observations and prior knowledge.

Directions: As a group, visit each station in the order determined by your instructor. As a group, address the questions below using your observations to guide your thinking. Use a notebook, dry erase board, or scratch paper to record your ideas. Answer as many questions as you can. Be prepared to discuss as a class.

Questions:

1. Plant Growth (Soil)
    a. Observe the plant seedlings. Each of these seedlings began as a tiny seed, but now they are much larger and have more mass (or more plant "stuff"). Where is the new mass of this plant coming from? How does the soil in which this plant is growing affect its accumulation of new mass?
2. Plant Growth (Hydroponics)
    a. Observe the plants growing in the water/nutrient solution. There is little or no soil in this set-up, and yet the plant is continuing to gain mass, getting heavier and heavier as the plant grows larger and larger. Where is the new mass of this plant coming from? How is it possible that a plant can survive and grow larger without soil?
3. Mealworms
    a. Observe the mealworms eating the potato. Note the original weight (or mass) of tub of mealworms and potato chunks. What is happening to the mass of this tub of mealworms? Is it growing heavier or lighter? Given that mass and energy cannot be created or destroyed, does this make sense? How would you explain what's happening to the potato?
4. Combustion
    a. Observe the flame. Note that some kind of carbon-based fuel (ethanol, kerosene, or natural gas) is being transformed when it enters the flame. What is happening to the fuel when it is being burned? How is the matter of the fuel being transformed as a result of the fire? How is the energy in the fuel being transformed as a result of the fire? *If your instructor is using a fuel burner on a scale*: What is happening to the mass of the fuel burner? Is the weight increasing or decreasing? Given that mass and energy cannot be created or destroyed, does this make sense? Explain.
5. Decomposition
    a. Observe the decaying matter in the container. What is happening to the matter that exists in this container? Is the matter of the decaying material disappearing, or is something else happening?

Day 2: Notes & Discussion

Introduction & Directions: In this activity, you will begin by watching a short video about matter and energy. This will help to clarify some of the questions you may have had yesterday. After the video, you will look at a short slideshow presentation that will provide you with specific information about matter and energy. Your instructor may decide to deliver the presentation as a classroom lecture or they may allow you to read the notes individually or in small groups (depending on your previous experience and capabilities with this content). After you have watched the video and finished with the slideshow, you will work in small teams to answer the questions listed below. You should take notes in a notebook, on a dry erase board, or on scratch paper so that you are prepared to deliver your responses during the class discussion that will follow. *Note: your instructor may assign your group to answer specific questions if time is limited.*

URL Links

YouTube Video: https://www.youtube.com/watch?v=2S6e11NBwiw (stop playing at 2:40; the later content may result in incorrect interpretations).

Slideshow Presentation: https://www.factsnsf.org/uploads/1/4/0/9/14095127/2018-1-24_facts_matter___energy_draft_2.pptx (or visit factsnsf.org and use the menu bar).

Discussion Questions:

1. What is the difference between matter and energy? How would you explain these concepts to a 10 year-old?
2. What are the four kinds of energy? Use an example to explain how light energy can be transformed into chemical energy and then transformed into kinetic and heat energy.
3. How are atoms related to matter? What are molecules and how do they relate to matter? What are elements and how do they relate to matter? How are atoms, molecules, and elements all related?
4. *"Plants absorb carbon dioxide and turn it into oxygen."* Why is this statement false?
5. *"Energy is released when your body breaks down the molecules of food that you eat."* Why is this statement false?
6. How are gasoline molecules and sugar molecules similar? Why are both good sources of energy?
7. What happens to the matter of a substance when it is combusted? Does it go away?
8. If it takes energy to break bonds, why does combustion give off energy in the form of heat, light, and motion?
9. Matter cycles among living organisms. Energy flows through living organisms. What does this mean?
10. What is the Carbon Cycle? How does it relate to matter and energy?
11. Explain how the dinosaurs went extinct by summarizing how an asteroid strike changed the flow of energy and the cycling of matter within the earth's ecosystems 65 million years ago.

Day 3: Lab Activity

Introduction: you will be completing two activities today. The first involves re-visiting your stations from earlier. You will once again look at the questions on page 2 and see if you are better capable of addressing them. In particular, pay attention to whether or not your answers might have changed since Monday. The second activity involves combusting ethanol on a glass petri dish and comparing its weight before and after combustion. Your objective will be to explain how and why the changes you are observing are occurring based on the laws of energy and matter that we are discussing this week.

Materials Needed (per group): glass petri dish; ethanol; digital scale or balance; lighter (your instructor may choose to light your petri dishes for you); a large container (to put out the flame); safety glasses/goggles

Directions:

1. Begin by re-observing the stations from the previous day and re-visiting the questions on page 2.
    a. Briefly address each question as a team.
    b. Are you better able to answer these questions now than the first time you tried?
    c. How have your answers changed since you first saw these questions?

2. Next, complete the predictions questions below:

    A. How do you think that the mass of the ethanol and petri dish will change as a result of combustion?

    *I think that the mass of the petri dish and ethanol will*_____ *because* _____

    _____

    B. What do you think will happen to the matter in the ethanol when it is combusted? Will it disappear? Will it become something else? Be as specific as you can:

    _____

    _____

    C. What will happen to the amount of energy in the petri dish? Will it increase, decrease, or stay the same? Explain:

    _____

    _____

    D. How will you be able to tell if energy and/or matter is being transformed? List all of the things that you could observe or measure that would suggest that energy and matter are being changed:

    _____

    _____

3. Next, complete each of the following steps for the ethanol combustion lab. Check the box as you complete each step.
    a. ☐ Add ethanol to an open glass Petri dish.
    b. ☐ Turn on a digital scale so that it reads "0" g. Place the Petri dish with ethanol on the scale. Record the mass of the ethanol and Petri dish below:

       Starting mass of ethanol and petri dish: _____ *g*
    c. ☐ Light the ethanol with the lighter or have your instructor light your petri dish. Then, immediately put the large container on top of both the glass Petri dish with burning ethanol and the Petri dish of BTB. Observe: the flame will go out quickly inside the container
    d. ☐ Place the Petri dish with ethanol on the digital scale and record the mass below.

       Ending mass of ethanol and petri dish: _____ *g*
4. Be prepared to answer the questions below.

A. Any time that the mass of something changes, it is an indication that matter has moved. If something gains mass, it has gained matter. If something loses mass, it has lost matter. Was there any evidence that matter has moved from one place to another in this activity? Explain.

_____

_____

B. If there was matter movement, where did the matter in the fuel go? Did it disappear, or did something else happen? Explain.

_____

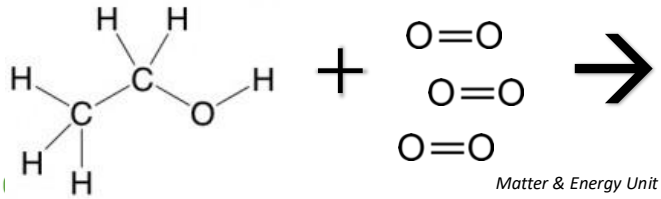
_____

C. Any time there is movement, light, an increase in temperature, or a chemical reaction, it is an indication of energy transformation. Was there any evidence that energy was transformed in this activity? Explain.

_____

_____

D. Both ethanol (C_2H_6O) and oxygen (O_2) molecules were involved in this reaction. What happened to the atoms in those molecules when they were combusted? Explain by completing the drawing below:



E. During a chemical reaction, atoms that are a part of molecules can be rearranged to form different molecules. This often changes the energy contained in the bonds of molecules as energy is absorbed to break bonds and as energy is released when new molecular bonds are formed.

Was there any evidence molecular bonds were either broken and/or formed in this activity? Explain:

F. A friend explains to you that when something is burned, that substance is "used up" and the matter and energy in that substance disappears as it is burned. Are they correct? Explain.

G. A log is burned in a sealed box that is placed on a scale. A remotely-controlled lighter is used to start the log on fire while it is in the sealed box. As the oxygen is completely used up, the flames begin to die. What do you think would happen to the mass of the sealed box as the log burns.

I think that the mass of the sealed box would ***increase/decrease/stay the same*** *(circle one). I think this because*: _____

What do you think would happen to the amount of energy in the sealed box as the log burns.

I think that the energy of the sealed box would ***increase/decrease/stay the same*** *(circle one). I think this because*: _____

H. How is what happens to a log during combustion similar to what happens to the food that you consume and digest every day? List as many similarities as you can:

Day 4: Review & Assessment

Directions: you will begin by reviewing the unit objectives in your small groups. For each objective, rank it as a 1 (*completely unsure*), 2 (*somewhat unsure*), or 3 (*completely sure*) based on your comfort with that objective. After a few minutes of review, your instructor will lead a whole-class review. This is your chance to ask any questions you still might have about the concepts in this unit. Begin with anything you ranked as a "1".

After you have completed the unit review, you will be taking an individual multiple choice quiz and/or a group short answer quiz. These quizzes may be graded in class to help you better understand the question and the correct answer.

Unit Objectives:

1. What is matter? What is energy?
2. What does it mean that matter and energy can neither be created nor destroyed?
3. What are atoms? What are elements? What are molecules? How do these concepts relate to matter?
4. If a person gains weight, what is happening to the amount of matter in their body? What is happening to the amount of atoms and molecules in their body?
5. What is an atomic bond? Is energy absorbed or released when a bond is broken? Is energy absorbed or released when a bond is formed?
6. Why is it that good sources of fuel (such as gasoline or chocolate) have lots of C-H and C-C bonds?
7. What is happening to matter and energy when a substance is combusted?
8. How is the movement of matter among living organisms different from the movement of energy? Why do these differences exist?
9. What is carbon? Why is it important to living organisms? Where does the carbon in living organisms come from?
10. What is the carbon cycle? How does the carbon cycle relate to the movement of matter and energy among living organisms?
11. Where does the mass of a plant come from as it is growing? How does this relate to the carbon cycle?
12. How did changes to the cycles of matter and flow of energy result in the extinction of the dinosaurs?

Day 5: Career Connections

Directions: Begin with a group and class discussion about the topics of this week. What is still unclear? What is still confusing? What seemed most important to remember? How does this relate to Natural Resources?

Then complete your Career Profiles. To complete this activity, see the Career Profile section of the Supervised Career Experience Packet.

Matter & Energy Individual Quiz

Name: _____ Hour_____ Date:_____ Score:_____ /___

Directions: This quiz should be completed on an individual basis. A 3x5 notecard with handwritten notes can be used on this quiz.

1. **A log is burned on a fire. What is happening to the <u>matter</u> in the logs?**
    a. The fire is consuming the matter. When the log is completely burned, the matter in the log is completely destroyed and no longer exists.
    b. The fire is turning the matter in the log into energy. You can see the energy as light and feel the energy as heat.
    c. The fire is converting most of the matter in the log into carbon dioxide and water, which is being released into the air.
    d. All of the above.

2. **A log is burned on a fire. What is happening to <u>energy</u> during the reaction?**
    a. The fire is creating new energy by converting the matter into light and heat.
    b. The fire is converting the chemical energy in the molecular bonds of the wood into light, heat, and motion energy.
    c. The fire is converting chemical energy into heat energy, which eventually consumes all of the energy, causing it to no longer exist.
    d. All of the above.

3. **Which of the following is FALSE?**
    a. Matter cannot be created or destroyed. The amount of matter that exists is constant.
    b. Energy cannot be created or destroyed. The amount of energy that exists is constant.
    c. All of matter is made of atoms; if something gains mass, it is gaining atoms.
    d. When something is digested or burned, the matter in that substance becomes energy.

4. **Which of the following is TRUE?**
    a. When something is combusted (burned), energy is given off because of the formation of molecular bonds.
    b. When something is combusted (burned), energy is given off because of the breaking of molecular bonds.
    c. When something is combusted (burned), energy is given off because of the conversion of matter into energy.

5. **Which of the following best summarizes a combustion reaction?**
    a. The atoms in the wood molecules are being destroyed. This temporarily gives off energy, which eventually dissipates and ceases to exist.
    b. While energy is needed to break the atomic bonds of the wood molecules, more energy is given off by the rearrangement of those atoms to form CO2 and H2O. This excess energy is the heat, light, and motion of the flame.
    c. The atoms in the wood molecules are being converted into energy. This energy is the heat, light, and motion of the flame.

6. **How is combustion similar to what occurs when an animal digests food?**
    a. Both reactions involve the rearrangement of carbon-based molecules into carbon dioxide and water. The formation of CO2 and H2O gives off excess energy.
    b. Both reactions involve the conversion of matter into energy.
    c. In both reactions, matter is destroyed and ceases to exist.

7. **Why is it that both fuels (like gasoline or ethanol) and calorie-rich foods (like fat or chocolate) have high amounts of C-H and C-C bonds?**
    a. C-H and C-C bonds give off a lot of energy when they're broken.
    b. C-H and C-C bonds are high energy bonds. A lot of energy is released when these atoms combine with oxygen to form CO2 and H2O.
    c. Carbon and Hydrogen can easily become energy.

8. **Which of the following is TRUE?**
    a. The same matter and energy continuously cycles among living organisms.
    b. The same matter continuously cycles among living organisms, and energy continuously flows from the sun through living organisms, starting as light and becoming chemical and kinetic energy. All energy eventually becomes heat energy that leaves the earth and flows into space.
    c. The same energy continuously cycles among living organisms, but the atoms that comprise matter are regularly created and destroyed.
    d. Matter routinely becomes energy and energy routinely condenses back into matter.

9. **All living organisms are carbon-based. Where does this carbon come from?**
    a. The carbon in living organisms is created by plants using oxygen.
    b. The carbon in living organisms is formed from the energy in high-calorie foods.
    c. The carbon comes from CO2 in the air, which plants make available to living organisms during photosynthesis.
    d. All of the above.

10. **Which of the following best describes how the dinosaurs went extinct?**
    a. All of the dinosaurs were immediately killed when the earth was struck by an asteroid.
    b. Some dinosaurs were killed by an asteroid and the rest were killed by fires.
    c. While some dinosaurs were killed by the asteroid strike, most went extinct due to reduced rates of photosynthesis because of the large amounts of dust put into the atmosphere.

11. **Which of the following best describes where the mass of a plant comes from as it grows from a seed?**
    a. The mass of a plant primarily comes from minerals in the soil.
    b. The mass of a plant primarily comes from CO2 in the air and water in the soil.
    c. The mass of a plant primarily comes from the conversion of sunlight into matter.
    d. The mass of a plant primarily comes from the conversion of carbon dioxide into oxygen.

12. **Which of the following best describes the carbon cycle?**
    a. Plants convert sunlight into carbon atoms. These carbon atoms are then passed onto other organisms when they consume plants.
    b. Plants convert oxygen atoms into carbon atoms. These carbon atoms are then passed onto other organisms when they consume plants.
    c. Plants convert carbon dioxide and water into glucose and oxygen. The carbon atoms in glucose are then passed onto other organisms when they consume plants. Eventually those carbon-based molecules will reform carbon dioxide and water when consumed or decomposed.

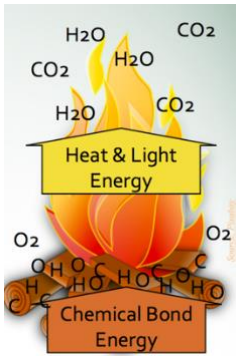
Matter & Energy Group Quiz

Names (F&L): _____

_____Hour_____Date:_____Score:_____/___

Directions: This quiz should be completed in your assigned groups. A 3x5 notecard with handwritten notes can be used on this quiz. Each person should take turns writing an answer. Those not writing should be actively working together to create their group's answer. Those who are not actively involved in answering every question may be asked to complete this quiz alone. Record the writer's name after each question.

1. **A log is burned on a fire. Using the image to the right, explain what happens to the matter and energy in the log during combustion. Be sure to include all of the following in your response: atoms, molecules, chemical energy, heat energy, light energy, carbon, oxygen, hydrogen, carbon dioxide, and water.**



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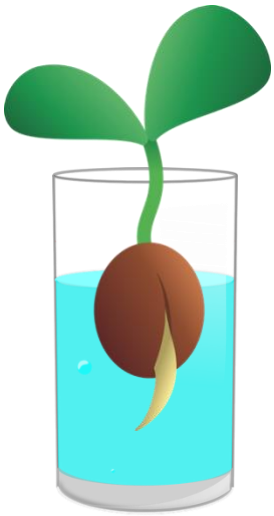
Writer's Name:

2. **A plant seedling is suspended in a glass of water treated with a very small amount of fertilizer. The plant continues to gain mass, growing heavier and heavier each day as it makes more carbon-based plant matter. Where is this new mass coming from? How is it being formed?**



Writer's Name:

3. **You as a human being are a carbon-based organism. Half of the atoms in the dry weight of your body are carbon atoms. Where did this carbon ultimately come from? Be sure to include the following in your answer: plants, photosynthesis, carbon dioxide, water, sugars.**

Writer's Name:

4. **Jane suggests that when a person consumes food, energy is released when the chemical bonds in that food are broken. Carlos thinks that when a person consumes food, the atoms in that food are converted into energy. Aaron argues that the rearrangement of food molecules into carbon dioxide and water is what creates the leftover energy that the body can use. Who, if anyone, is correct? Explain who has the correct answer and why the other responses are incorrect.**

Writer's Name:

Appendix: Setting up the Matter & Energy Stations

Introduction: For this week, you will be guiding students through four different lab demonstrations on two separate days. These demos include the following:

- Plant growth (soil): you should have some kind of seedlings available for students to investigate. Ideally these were planted in advance. Radish seedlings work particularly well but require at least a week to germinate and emerge from the soil. In absence of this, you could use a standard houseplant from your home, classroom, or neighboring classroom.
- Plant growth (hydroponics): you should also have a plant that is growing in a water-based nutrient solution. There are a number of ways this can be accomplished. If you already have a hydroponics system in your classroom, you can use this based on the instructions that came with the system. If you are lacking a hydroponics system, you can start a seedling in a plastic six-pack greenhouse tray a few weeks prior to the lab using standard potting soil. Once the seedlings have grown enough that they start to have visible roots, you can transfer them to a net cup (available to order on Amazon or other online stores) or a plastic cup that has strips cut out of it. This can then be inserted into foam insulation or the cover of a small plastic tub and immersed in water with dissolved fertilizer (such as Miracle Grow) at a rate of ½ tsp per gallon. The water should be agitated and oxygenated using an aquarium pump and an air stone. While non-rooting vegetables such as lettuce or tomatoes work best for hydroponic growth, radishes will grow the fastest (and can work for up to 2-3 weeks).
    - If need be, you can use a picture or video of a hydroponics system, but this would be less impactful for student sense-making. Try https://www.wikihow.com/Build-a-Homemade-Hydroponics-System
- Mealworms: live mealworms can be purchased from a science supply catalog or an online store (such as Amazon). Mealworms can be stored in container (be sure to provide a source of fresh air) and should be given chunks of potatoes while they are being used in the classroom. Mealworms can be disposed of in a compost pile or can be used as a feed supplement if you or a student has chickens.
- Combustion: standard Bunsen burners with a natural gas fuel source can be used. If possible, a glass fuel burner (such as product no. SB34435 at www.enasco.com) is ideal so that students can visibly see the fuel source.
- Decomposition: this component of the lab consists simply of decomposing organic matter such as banana peels, apple cores, bread chunks, etc. (and possibly inorganic trash such as plastic and metal) in a sealed glass or plastic jar. A mason jar or sealed plastic jug can work well for this. The goal is for students to be able to visibly see the organic matter as it is decomposing. The jar should be sealed due to odor, but can be opened periodically to increase the rate at which decomposition occurs. The jar can be filled on the day of the lab or in advance so that students can see decomposition as it occurs.

Overview: your class should be divided into groups of four students. Each group will rotate from station to station, using guiding questions to help them develop models to explain what is happening in each station. Students will complete these exercises twice. The first time will occur prior to any instruction in order to elicit their prior explanations and ideas about these phenomena. The second occurrence will be after students have had some direct instruction about matter and energy in order to help them to explicitly compare their previous responses to their instruction for the week.

Materials: pre-grown seedlings, top soil, water bath (can just be tap water and a large container) greenhouse six-pack seedling pots, hydroponics system (or a plastic tub, water, fertilizer, net cups or cut plastic cups, and aquarium aerator), live mealworms w/ container, potato, glass fuel burner with ethanol or kerosene OR a Bunsen burner with gas access, clear jar or plastic container with sealable airtight lid, food scraps (such as banana peels, apple cores, and bread chunks) and possibly inorganic litter (such as food wrappers), scale or balance.

Amazon Prime Purchasing Keywords

- Net cups: "hydroponic net cups 3 inches"
- Seedling six-pack trays: "Seedling Starter Trays, 6-cells Per Tray"
- Fuel burner: "alcohol lamp with metal cap"
- Mealworms: "live mealworms 100 ct"

Instructions: students should visit each station in groups of 3-4. They should use the accompanying section in the packet for each day's exercises and answer the questions as they visit each station. Each station visit should be brief (3-5 minutes). You may want to use an online timer (by Googling "4 minute interval timer") to help keep students on track. Once each group of students has visited each station and completed their questions, time should be allowed for class discussion and sharing of ideas and conceptual models.

- Plant growth (soil): this station should have multiple radish seedlings available for students to observe and investigate. Seedlings should be started at least a week (7+ days) in advance. You should have enough seedlings available to have each group of students rinse away the soil using a water bath and compare the weight of the seedling to unplanted radish seeds. The purpose of this station is to help students begin to ask questions about the source of the increasing mass of the plant seedling.
- Plant growth (hydroponics): this station only requires a plant that is growing in a nutrient/water solution. The purpose of this station is to help challenge the notion that many students have that plants "eat" soil. By having them see a plant growing in a water solution without any soil, it can help them to better understand that plant mass comes from CO_2 in the air and water that is absorbed by the roots.
- Mealworms: this station should consist of a tub containing mealworms and pieces of potato. You should add the pieces of potato the day before or at the start of the day and record the mass of the tub/mealworm/potato combination. If you have a sufficient number of scales/balances, you should allow students to determine how the weight of the tub has changed since the morning as the mealworms consume the potato. The purpose of this station is to help students understand how matter and energy are changed during digestion and cellular respiration.
- Combustion: this station consists of a glass fuel burner combusting ethanol or kerosene on a balance. You should record the initial weight of the burner/fuel combination. If you do not have a glass fuel burner, you can use a Bunsen burner w/ gas hookup as an alternate. The purpose of this station is to help students appreciate the similarities between the products and reactants in both combustion as well as cellular respiration.
- Decomposition: this station consists of decomposing organic (and possibly inorganic) matter in a see-though container. A large mason jar or a clear plastic container with an airtight cap would work well for this. The purpose of this station is to help students consider how the process of decomposition occurs and how it is similar to both combustion and cellular respiration.

Appendix: Setting up the Combustion Lab

Introduction: For this lab, students will be measuring the change in mass that occurs as ethanol is combusted. They will be connecting their observations to their conceptual understanding of the rearrangement of the atoms in the ethanol into carbon dioxide and water molecules, and the conversion of chemical bond energy into heat, light, and motion energy.

Materials: glass petri dish; ethanol; digital scale or balance; lighter (your instructor may choose to light your petri dishes for you); a large container (to put out the flame); safety glasses/goggles

Set-up: students should be assigned to groups of 3-4. Each student group should have a glass petri dish partly filled with ethanol, a digital scale or balance, a large clear container (big enough to cover both the petri dish and the scale, and safety goggles.

Directions: you may choose to have students light their own petri dish or you may want to light their petri dishes for them so that you can ensure that they have completed their predictions prior to starting the activity. Once the mass has been recorded and the prediction questions are completed, the petri dish of ethanol should be lit ignited, and the container should immediately be placed over the dish. Once the flame has been extinguished, students should record the final mass and answer the accompanying questions.

While this is a rather simple lab, it addresses topics that can be challenging for students. Even college students and adults tend to think that combustion results in the elimination or disappearance of matter and energy. Student groups should be encouraged to vocalize their ideas and discuss each question together. Students should *not* answer questions alone without talking as a group. A whole-class discussion should be used as a follow-up and students should be encouraged to revise their answers if needed. These discussions should be used to help guide (but not tell) students to the conclusion that combustion is a rearrangement reaction in which no atoms are created or destroyed, but simply re-organized into new molecules (CO2 and H2O).

Students may also need guidance in understanding that energy is needed to break the bonds of the ethanol and oxygen molecules but that energy is released when carbon dioxide and water molecules form. Because the energy needed to break the ethanol and oxygen molecules is less than the energy released from the formation of water and carbon dioxide molecules, excess energy is released. This energy can be observed as the light, motion, and heat of the flame. Ultimately all of the leftover chemical energy will be converted into heat that will dissipate into space.

Question D may be particularly challenging for students if they lack a chemistry background. The purpose of this question is to help students understand that the same amount of carbon, oxygen, and hydrogen atoms will be on the right side as were on the left side. If you have molecular modeling kits, these can be helpful in helping students to understand that atoms are not disappearing during combustion, just becoming invisible gases (CO2 and water vapor). Additional guidance and support may be needed for students for this question.

Lastly, students should be guided to the realization that combustion and digestion result in similar outcomes. Both entail the "rearrangement" of carbon-based molecules (either fuel or food) into carbon dioxide and water. Because the energy needed to break the bonds of food/fuel is less than the energy released from the formation of CO2 and H2O, energy is made available. In combustion, this energy is observed as the heat, light, and motion of a flame. In digestion, the leftover energy is made available to the person or animal as chemical energy (ATP) that can be used to power cells. This will be covered in more detail in the next unit.