Matter & Energy

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 – Data Dive
- 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 Data Dive; Ethanol Combustion Investigation.

Thursday:
- Review
- Assessment

Friday:
- Weekly Reflection
- Career Connections

Semester Schedule

Week 0: Introduction & Lab Safety

Atoms to Ecosystems

Week 1: Matter & Energy
Week 2: Cell Biology
Week 3: Biodiversity & Ecosystems
Week 4: Biodiversity & Habitats Lab
Week 5: Midterm Assessments

Causes of Extinction

Week 6: Extinction
Week 7: Habitat Loss
Week 8: Invasive Species
Week 9: Land & Water Pollution
Week 10: Atmospheric Pollution
Week 11: Overharvesting
Week 12: Midterm Assessments

Sustainable Societies

Week 13: Natural Resources Management
Week 14: Societies & Sustainability
Week 15: Individual Sustainability
Week 16: Personal Campaigns
Week 17: Personal Campaigns

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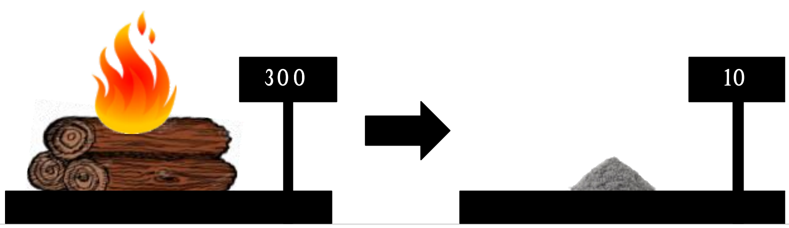
Day 1: - Matter & Energy Data Dive

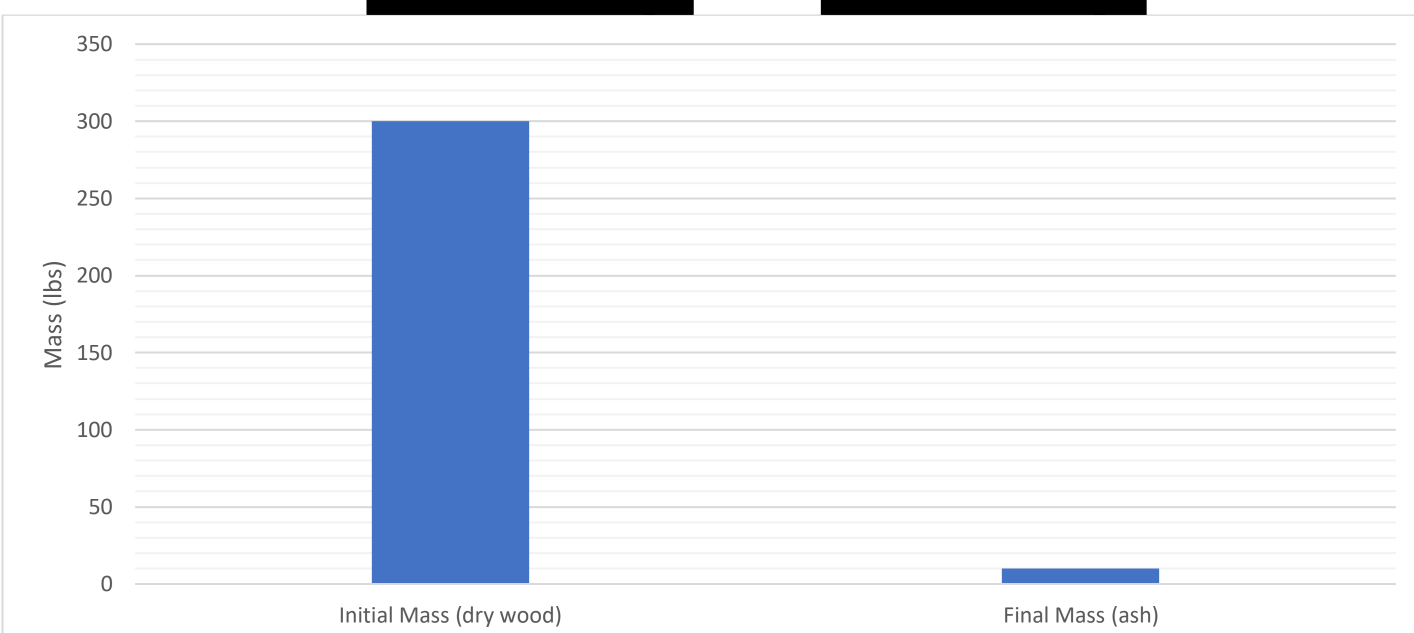
Overview: In this activity, your group will review data from two different scenarios in order to identify patterns and trends that you will use to develop an explanatory model. You will then compare your observations and explanations to those of other groups in order to check your accuracy and refine your explanatory model.
Introductory video: https://www.youtube.com/watch?v=YLpxYq-Ox5I

Scenario 1

Directions: Begin by reading the hypothetical scenario below. Then look at the data provided below. Use this information to answer the questions on the following page. If you are unsure about how to interpret the data, work with your group and seek help from your instructor if necessary. Your instructor will decide if you should record your answers using the space provided in this packet, a dry erase board, a digital document, or another option.

Introduction: A high school student sells firewood to a state park campground as a part time job. This student has to weigh the wood on a large scale at the state park because they are paid by the pound. When the student weighs the dry wood, the scale reads 300 lbs. Unfortunately, a spark from a nearby fire lands on some dry leaves on the wood, causing it to burst into flames. Because the wood is dry, it burns rather quickly. After a while, all that remains are a pile of ashes weighing 10 lbs.





How to read this graph: The initial weight (or *mass*) of the wood can be determined by looking at the first bar on the left (labeled *Initial Mass*). The top of this column aligns with the value of 300 lbs. on the y-axis (the scale on the left-hand side). The final mass of the wood (the ashes) can be determined by looking at the bar on the right. You can see that this column only goes up to 10 lbs. on the y-axis.

1. In your groups, answer the following questions:
   a. What was the initial mass of the wood?
   b. What was the final mass of the wood (i.e. the mass of the ashes)?
   c. What was the total change in mass? (Initial mass – Final mass = Total Change in Mass).

2. A group of students are asked to explain what happened to the mass of this wood. Read the following responses from students.
   a. Avery thinks that the atoms in the wood were turned into heat and light energy when the wood was on fire, and that the energy dissipated away. This causes a loss of mass.
   b. Bristol thinks that the fire destroys the atoms in the wood, causing a release of energy that can be detected as light and heat.
   c. Chandra thinks that the molecules that comprise the wood are being broken apart, and that the atoms in these molecules are being rearranged to form new molecules that aren't visible to our eyes; this process gives off energy.

   For each individual, decide as a group whether you agree, partially agree, or disagree. Then briefly provide your reasoning for your decision. If you are unsure, provide your best guesses at this time.

   Avery: agree partially agree disagree

   Reasoning: ____

   ____

   Bristol: agree partially agree disagree

   Reasoning: ____

   ____

   Chandra: agree partially agree disagree

   Reasoning: ____

   ____

3. What do you think happened to the wood when it burned? As a group, discuss what you think happens when a substance when it burns. Why isn't the mass of the ashes equivalent to the mass of the dry wood? What happened to the other 290 lbs. of matter that was in the wood before it burned?

____

____

____

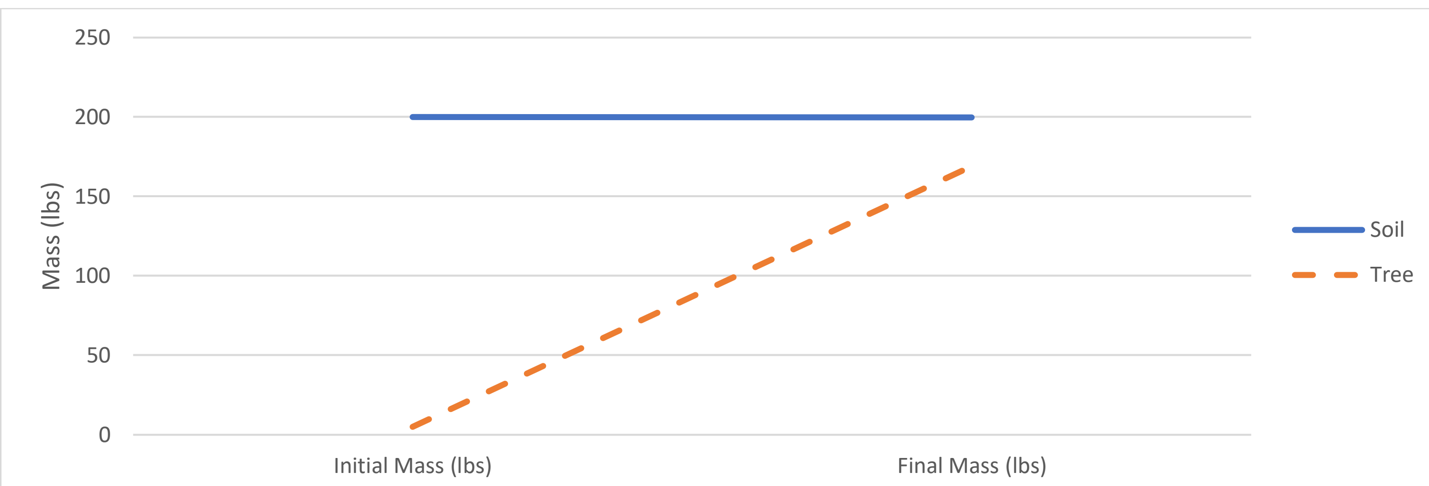
Be prepared to discuss your ideas with other groups and/or as a class.

Scenario 2

Directions: Begin by reading the hypothetical scenario below. Then look at the data provided below. Use this information to answer the questions on the following page. If you are unsure about how to interpret the data, work with your group and seek help from your instructor if necessary. Your instructor will decide if you should record your answers using the space provided in this packet, a dry erase board, a digital document, or another option.

Introduction: Jean Baptista van Helmont (1577-1644) performed a classic experiment, which he describes below. Read the paragraph and then address the questions that follow.

"I took an earthen pot and in it placed 200 pounds of earth which had been dried out in an oven. This I moistened with rain water, and in it planted a shoot of willow which weighed five pounds. When five years had passed the tree which grew from it weighed 169 pounds and about three ounces. The earthen pot was wetted whenever it was necessary with rain or distilled water only. It was very large, and was sunk in the ground, and had a tin plated iron lid with many holes punched in it, which covered the edge of the pot to keep air-borne dust from mixing with the earth. I did not keep track of the weight of the leaves which fell in each of the four autumns. Finally, I dried out the earth in the pot once more, and found the same 200 pounds, less about 2 ounces."



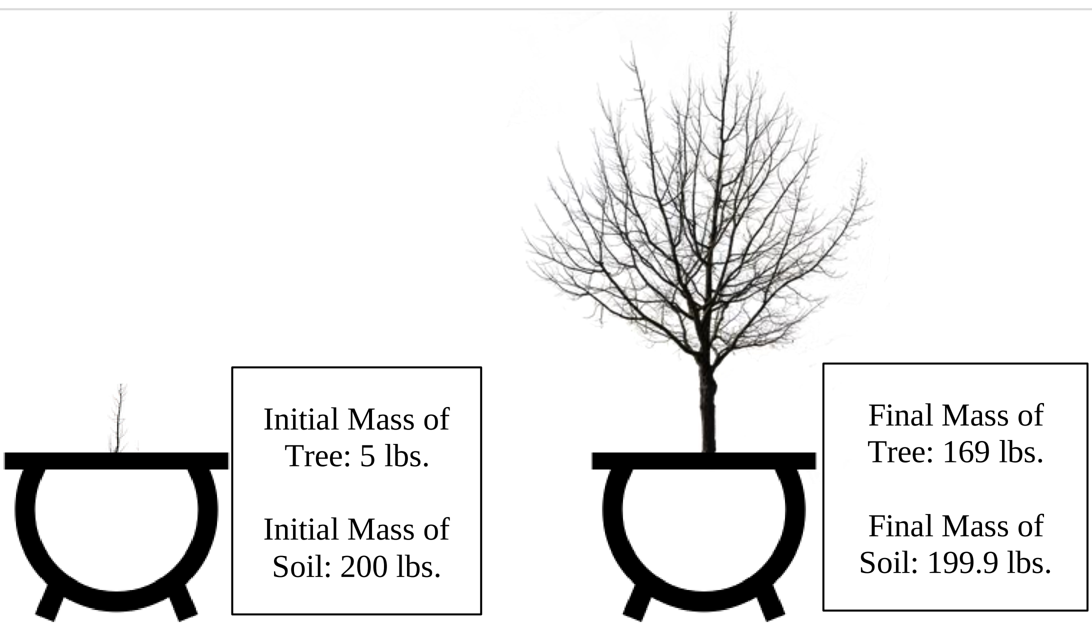


Image source: https://pixabay.com/illustrations/search/weeping%20willow/

1. In your groups, answer the following questions:
    a. How did the change in mass over the five-year period differ between the tree and the soil?

2. A group of students are asked to explain how they think a tree acquires mass as it grows. Read the following responses from students
    a. Avery thinks that a tree absorbs most of its mass from minerals in the soil through its roots.
    b. Bristol thinks that trees are primarily acquiring their mass from water in the soil and from carbon dioxide in the air.
    c. Chandra thinks that a tree acquires most of its mass from the seed itself, and that it creates more atoms through photosynthesis.

    For each individual, decide as a group whether you agree, partially agree, or disagree. Then briefly provide your reasoning for your decision.

    Avery: agree partially agree disagree

    Reasoning: ____

    ____

    Bristol: agree partially agree disagree

    Reasoning: ____

    ____

    Chandra: agree partially agree disagree

    Reasoning: ____

    ____

3. Does the data from van Helmont's experiment (see previous page) disprove any of these student's ideas? Explain:

    ____

    ____

4. From where do you think a tree acquires most of its mass? Summarize your ideas:

    ____

    ____

    ____

    Be prepared to discuss your ideas with other groups and/or as a class.

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 FACTS Video: https://www.youtube.com/watch?v=ktFZTp9ZUbQ

If time allows, also consider showing 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: Ethanol Combustion Investigation

Introduction: you will be completing two activities today. The first involves re-visiting your ideas from the Data Dives on Day 1. You will once again look at those questions to see if you are better capable of addressing them. In particular, pay attention to whether or not your answers might have changed since you first encountered these questions. 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 with a recap of the core ideas from Day 2: https://www.youtube.com/watch?v=r8ybol_HVoM

2. Next, briefly return to the data and questions from Day 1. Briefly address each question as a team.
    a. Are you better able to answer these questions now than the first time you tried?
    b. How have your answers changed since you first saw these questions?

3. 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:

    ____

    ____

4. 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

5. 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.

____

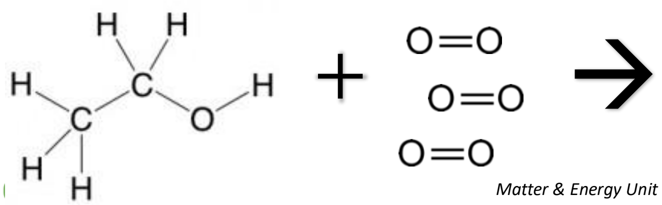
____

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 consumed, 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 CO_2 and H_2O 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 CO_2 and H_2O.
    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 CO_2 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 CO_2 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.

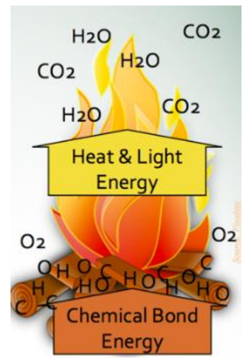
Matter & Energy Group Quiz

Names (F&L): ____

______________________________________Hour_______Date:________Score:________/___

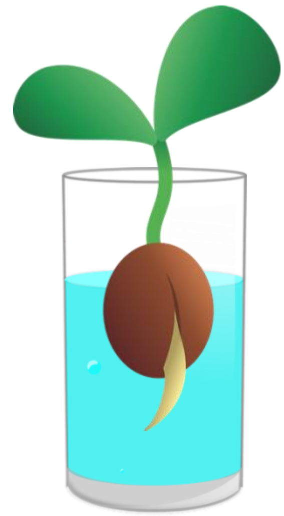
Directions: This quiz should be completed in your assigned groups. A 3x5 notecard with handwritten notes can be used on this quiz. Each person should take turns writing an answer. Those not writing should be actively working together to create their group's answer. Those who are not actively involved 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.**



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: Data Dives / Case Studies

Overview: Data Dives and Case Studies are exercises in which students are presented with data from experiments or scenarios, and are asked to identify trends and develop explanatory models in a process that is very similar to what actual scientists do on a regular basis.

Directions: Students should consider the data or scenario in their assigned groups. They should work with their group members to make sense of the information provided and try to determine the conclusions that can be drawn from it. Students may struggle with this, especially in their first attempts and particularly if your students have limited experience reading graphs and data tables. It may be necessary for you to project the data onto a large screen and guide students by explaining the steps that you would use to make sense of what is being reported. This may be difficult; just like explaining the steps of tying your shoes can be challenging because you rarely have to think about it, it can be exceptionally challenging for someone who is scientifically literate to identify the thought processes that they use to make sense of data. It may be helpful to jot down your ideas in advance and have them ready prior to the start of this class.

Students are likely to struggle to varying extents. That is ok! Be sure to float from group to group to assist. Be sure to remind group members to help each other out. It might ideal to assign groups with a mix of abilities. Encouraging struggling students to work with their better-prepared peers, and conversely, encouraging high performing students to advance their abilities by working with individuals with different skill sets helps to prepare students for the kinds of situations they will encounter in their careers and personal lives.

Plan to allow for about 15-20 minutes to introduce the activity and review how to interpret this information with your students. About a third to half of the class period should be reserved for allowing students to work in their individual groups. The remaining time should be reserved for intergroup or whole-class discussion so that students can engage in scientific debate and argumentation.

It would a good idea to remind students that the term *argumentation* is used differently between scientists and the general public. While argumentation generally has a negative connotation (such as a “heated argument”), argumentation among scientists is generally very good-natured and polite. The goal is not to “win” an argument but rather to expand the understanding of the phenomenon by all involved. Often scientists on opposing sides of an issue will both change their stance as a result of the improved understanding that results from engaging in argumentation. Similarly, students should not be trying to disprove each other or prove that they have the “right” answer. Rather, students should be examining the differences in their conclusions, the manner in which each conclusion was reached, and the similarities and agreements that exist among different conclusions.

Students may reach a conclusion that is not entirely supported by evidence. The temptation may be to point out errors in their reasoning. However, when students are struggling, they are also likely improving their abilities in evidence-based reasoning, which is one of the most important goals of this kind of instruction. Try to resist the urge to correct student errors; rather, try to probe their understanding and challenge them to re-examine the evidence to check the validity of their conclusions and the conclusions of other groups. Consider using the 9 Talk Moves (next page) to support productive classroom dialogue.

Remember – students should re-visit their explanations and models repeatedly over the course the week. If they don’t get it right on the first try, they will have more opportunities to do so.

Goals for Productive Discussions and Nine Talk Moves

Goal: Individual students share, expand and clarify their own thinking

1. Time to Think:

Partner Talk

Writing as Think Time

Wait Time

2. Say More: "Can you say more about that?" "What do you mean by that?" "Can you give an example?"

3. So, Are You Saying…?:
"So, let me see if I've got what you're saying. Are you saying…?" (always leaving space for the original student to agree or disagree and say more)

Goal: Students listen carefully to one another

4. Who Can Rephrase or Repeat?

"Who can repeat what Javon just said or put it into their own words?" (After a partner talk) "What did your partner say?"

Goal: Students deepen their reasoning

5. Asking for Evidence or Reasoning:

"Why do you think that?" "What's your evidence?" "How did you arrive at that conclusion?" "Is there anything in the text that made you think that?"

6. Challenge or Counterexample:

"Does it always work that way?" "How does that idea square with Sonia's example?"
"What if it had been a copper cube instead?"

Goal: Students think with others

7. Agree/Disagree and Why?:

"Do you agree/disagree? (And why?)" "Are you saying the same thing as Jelya or something different, and if it's different, how is it different?" "What do people think about what Vannia said?"
"Does anyone want to respond to that idea?"

8. Add On:

"Who can add onto the idea that Jamal is building?"
"Can anyone take that suggestion and push it a little further?"

9. Explaining What Someone Else Means:

"Who can explain what Aisha means when she says that?" "Who thinks they could explain in their words why Simon came up with that answer?" "Why do you think he said that?"

Source: https://inquiryproject.terc.edu/shared/pd/TalkScience_Primer.pdf

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.

Appendix: Review and Asssessment

Introduction: In this section, we will discuss strategies to guide your students during review and assessment for a vocabulary-intensive unit.

While recent reforms to science education (as outlined by the NRC's *K12 Framework* and NGSS) minimize the emphasis on having students learn vocabulary, we have found that we cannot completely eliminate vocabulary from ecological instruction for a number of reasons. Most importantly, we have found that in order for students to sufficiently engage in reasoning and sense-making about ecological phenomena, they need to have an appropriate language with which to develop explanations and solutions.

However, in the FACTS curriculum, we view vocabulary as a *means to an end* and not as a central objective to the curriculum. In other words, we don't care very much whether students have memorized the definitions of terms, but whether they can accurately use those terms to describe and understand phenomena, and ultimately create evidence-based arguments, explanations, and solutions. We view vocabulary as part of a "sense-making toolkit" that enables students to organize their reasoning and argumentation.

As such, we recommend that you provide students with opportunities to practice mastering the vocabulary in this course while also recognizing that mastery of vocabulary is a secondary objective in these units. This means that assessing vocabulary can work as a formative assessment but is not ideal by itself as a summative assessment. The primary goal of this curriculum is to enable valid evidence-based reasoning and sense-making, and your summative assessments should reflect this.

There are a few strategies you might considering adopting to support these objectives:

- While multiple-choice assessments are provided in the weekly packets, we take the stance that these options should not be used by themselves as a final summative assessment.
    - You might consider assigning this as optional homework, allowing students to use a 3x5 card with handwritten notes, and/or assigning completion points in lieu of scores based on the percent correct.
- Teachers have also created hybrids of the multiple choice and short answer assessments, selecting some questions from each option. Their experiences suggest that the multiple-choice assessments help to prepare students for the more intellectually rigorous short answer questions.
- You might also consider having a space on a chalkboard/dry-erase board for publicly posting course vocabulary or hanging a large sheet of paper and adding vocabulary and definitions if students start to struggle.
- Teachers have also used vocabulary practice as an option for a bell-ringer activity, using options such as short, ungraded online quizzes to start class.

You as the instructor are best positioned to decide what will be most effective for your classroom. Feel free to use or disregard these suggestions as you see fit. However, we do strongly recommend that you avoid positioning memorization of vocabulary as one of the primary objectives of this course, and instead emphasize valid reasoning and sense-making about ecological phenomena as your top priority.