



Unit Title: Matter, Energy, & Green Energy

Lab Activities for Middle School Science

Subject/target grade: 6th Grade Science

Unit Summary: The purpose of this unit is to provide teachers with a variety of activities for their students to actively explore the properties and principles of matter and energy. Each of the lessons in this unit was developed and implemented in a 6th grade science classroom at Washington Middle School in Calumet MI to supplement existing lessons and curriculum. Students participating in these activities will get hands on experience collecting and interpreting data on:

- A) Properties of matter such as mass, density, physical and chemical changes, Law of Conservation of Mass, and molecular structure.
- B) Properties of energy such as differences between potential and kinetic energy, specific forms of energy, energy conversions and transfers, and the Law of Conservation of Energy.
- C) Basic principles of renewable (“green”) energy such as wind energy, solar energy, energy transfer efficiency, cost-benefit analyses, energy audits, and the Law of Conservation of Energy.

Each lesson contains a series of 5-8 laboratory stations and is accompanied by an instructional video and lab worksheet to be completed by the students. These lessons can be delivered either as a single multi-day lab practical or as individual activities throughout a normal curriculum unit.

Next Generation Science Standards:

MS-PS1-1: Develop models to describe the atomic composition of simple molecules and extended structures. (*Clarification Statement: Emphasis is on developing models of molecules that vary in complexity. Examples of simple molecules could include ammonia and methanol. Examples of extended structures could include sodium chloride or diamonds. Examples of molecular-level models could include drawings, 3D ball and stick structures, or computer representations showing different molecules with different types of atoms.*)

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. (*Clarification Statement: Examples of reactions could include burning sugar or steel wool, fat reacting with sodium hydroxide, and mixing zinc with hydrogen chloride.*)

MS-PS1-3: Gather and make sense of information to describe that synthetic materials come from natural resources and impact society. (*Clarification Statement: Emphasis is on natural resources that undergo a chemical process to form the synthetic material. Examples of new materials could include new medicine, foods, and alternative fuels.*)

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. (*Clarification Statement: Emphasis is on qualitative molecular-level models of solids, liquids, and gases to show that adding or removing thermal energy increases or decreases kinetic energy of the particles until a change of state occurs. Examples of models could include drawings and diagrams. Examples of particles could include molecules or inert atoms. Examples of pure substances could include water, carbon dioxide, and helium.*)

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. (*Clarification Statement: Emphasis is on law of conservation of matter and on physical models or drawings, including digital forms that represent atoms*).

MS-PS1-6: Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.* (*Clarification Statement: Emphasis is on the design, controlling the transfer of energy to the environment, and modification of a device using factors such as type and concentration of a substance. Examples of designs could involve chemical reactions such as dissolving ammonium chloride or calcium chloride*).

MS-PS3-3: Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.* (*Clarification Statement: Examples of devices could include an insulated box, a solar cooker, and a Styrofoam cup*).

MS-PS3-4: Plan an investigation to determine the relationships among the energy transferred, the type of matter, the mass, and the change in the average kinetic energy of the particles as measured by the temperature of the sample. (*Clarification Statement: Examples of experiments could include comparing final water temperatures after different masses of ice melted in the same volume of water with the same initial temperature, the temperature change of samples of different materials with the same mass as they cool or heat in the environment, or the same material with different masses when a specific amount of energy is added*).

MS-PS3-5: Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. (*Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object*).

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.

MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Math CCSS 6th grade:

MP.2: Reason abstractly and quantitatively.

MP.4: Model with mathematics.

6.EE: -Represent and analyze quantitative relationships between dependent and independent variables.

6.SP.B.5: Summarize numerical data sets in relation to their context

Learning Objectives:

Students will be able to:

- Demonstrate how applying electrical energy can break chemical bonds to form new molecules
- Determine the density of regular and irregular shaped objects
- Define endothermic and exothermic and perform simple chemical reactions to demonstrate endothermic and exothermic reactions
- Construct models describing the atomic composition of organic and inorganic molecules
- Perform a chemical reaction demonstrating the Law of Conservation of Mass
- Demonstrate how a substance undergoing a physical change follows the Law of Conservation of Mass
- Demonstrate how different materials absorb and release energy from sunlight
- Determine how the intensity and angle of sunlight affects energy transfer
- Demonstrate how the color of a surface relates to energy transfer from sunlight
- Determine how the rate of energy transfer is affected by insulation
- Explain how energy transfer between hot and cold water occurs
- Develop a set of procedures for communicating wirelessly based on light signals
- Calculate the potential and kinetic energy of a rock being dropped from a table.
- Describe how energy from light is converted and transferred as heat.
- Demonstrate how a wind turbine can be used to generate electricity
- Compare the efficiency of various wind turbine designs
- Explain how the angle, distance, and spectrum of a light source affects solar power generation
- Perform simple cost benefit analyses to compare alkaline and rechargeable batteries

Table of Lessons:

Lesson Title- Brief Description	Learning Objectives	NGSS Addressed or CE addressed (codes)	Materials
Properties of Matter: Lab Practical <ul style="list-style-type: none"> • This lesson is intended to supplement existing lessons and curriculum and provide activities to assess their understanding of the structure/properties of matter and chemical reactions. Students will apply what they have learned from prior lessons in a variety of hands-on experiments and activities to answer the questions of: 	Students will be able to: <ul style="list-style-type: none"> • Demonstrate how applying electrical energy can break chemical bonds to form new molecules • Determine the density of regular and irregular shaped objects • Define endothermic and exothermic and perform simple chemical reactions to demonstrate endothermic and exothermic reactions 	<ul style="list-style-type: none"> • MS-PS1-1 • MS-PS1-2 • MS-PS1-3 • MS-PS1-4 • MS-PS1-5 • MS-PS1-6 Math: <ul style="list-style-type: none"> • MP.2 • MP.4 • 6.EE • 6.SP.B.5 	Station # 1 <ul style="list-style-type: none"> • Electrolysis water bath • Test tubes • Genecon generator • Test tube tweezers • Sodium Hydroxide (NaOH) solution • Wood splint • Timer Station # 2 <ul style="list-style-type: none"> • Triple beam balance • Set of density cubes (<i>10 different materials</i>) • Metric ruler

<p>1. What is matter? 2. What are the general properties of matter? 3. What is the difference between a physical change and a chemical change?</p>	<ul style="list-style-type: none"> • Construct models describing the atomic composition of organic and inorganic molecules • Perform a chemical reaction demonstrating the Law of Conservation of Mass • Demonstrate how a substance undergoing a physical change follows the Law of Conservation of Mass 		<p><u>Station # 3</u></p> <ul style="list-style-type: none"> • Triple beam balance • Irregular shapes (<i>e.g. balls of clay, pebbles, paper clips, etc.</i>) • Graduated cylinder (100 ml) • Water <p><u>Station # 4</u></p> <ul style="list-style-type: none"> • White Vinegar • Baking Soda (1.5 tsp) • Thermometer (glass, red-spirit filled) • Styrofoam cups (12 oz.) • Graduated cylinder (100 ml) <p><u>Station # 5</u></p> <ul style="list-style-type: none"> • Water • Baking Soda (1 tsp) • Thermometer (glass, red spirit filled) • Styrofoam cups (12 oz.) • Calcium Chloride (1.5 tsp) • Graduated cylinder (100 ml) <p><u>Station # 6</u></p> <ul style="list-style-type: none"> • Styrofoam balls (approximately 1” diameter) • Toothpicks • Markers (5-6 color options to indicate different elements in molecules) <p><u>Station # 7</u></p> <ul style="list-style-type: none"> • Magnesium Sulfate (1 tbsp.) • Sodium Carbonate (1 tsp) • Citric Acid • Universal pH indicator • Water • Thermometer (glass, red spirit filled) • Clear plastic cups (12 oz.) • Graduated cylinder (100 ml) • Triple beam balance
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			<p>Station # 8</p> <ul style="list-style-type: none"> • Powdered sports-drink mix (1 tsp) • Water • Clear plastic cups (12 oz.) • Triple beam balance • Graduated cylinder (100 ml) <p>All Stations</p> <ul style="list-style-type: none"> • Safety equipment (goggles, gloves, etc.)
<p>Principles of Energy: Lab Practical</p> <ul style="list-style-type: none"> • This lesson is intended to supplement existing lessons and curriculum and provide activities to assess their understanding of energy. Students will apply what they have learned from prior lessons in a variety of hands-on experiments and activities to answer the questions of: <ol style="list-style-type: none"> 1. What is energy? 2. What are the two basic forms of energy and how is energy transferred between forms? 3. What is temperature? 4. How is energy transferred from one type to another? 	<p>Students will be able to:</p> <ul style="list-style-type: none"> • Demonstrate how different materials absorb and release energy from sunlight • Determine how the intensity and angle of sunlight affects energy transfer • Demonstrate how the color of a surface relates to energy transfer from sunlight • Determine how the rate of energy transfer is affected by insulation • Explain how energy transfer between hot and cold water occurs • Develop a set of procedures for communicating wirelessly based on light signals • Calculate the potential and kinetic energy of a rock being dropped from a table. • Describe how energy from light is converted and transferred as heat. 	<ul style="list-style-type: none"> • <u>MS-PS1-6</u> • <u>MS-PS3-3</u> • <u>MS-PS3-5</u> • <u>MS-PS3-4</u> <p>Math:</p> <ul style="list-style-type: none"> • <u>MP.2</u> • <u>MP.4</u> • <u>6.EE</u> • <u>6.SP.B.5</u> 	<p>Station # 1</p> <ul style="list-style-type: none"> • 2x Incandescent lamp with 60 - 100 Watt bulb • 4x Graduated cylinder (250 ml) • Sand • Water • 4x Thermometer (glass, red spirit filled) • Timer <p>Station # 2</p> <ul style="list-style-type: none"> • 2x Incandescent lamp with 60 - 100 Watt bulb • 4x Graduated cylinder (250 ml) • Sand • Water • 4x Thermometer (glass, red spirit filled) • Timer <p>Station # 3</p> <ul style="list-style-type: none"> • Incandescent lamp with 60 - 100 Watt bulb • 3x Thermometer (glass, red spirit filled) • Clear tape • Black construction paper • Timer <p>Station # 4</p> <ul style="list-style-type: none"> • 3x Incandescent lamp with 60 - 100 Watt bulb • Construction paper (Black, Blue, Red, White, Green) • 5x Thermometer (glass, red-spirit filled) • Timer

			<p>Station # 5</p> <ul style="list-style-type: none"> • Water • Hot Plate • 2x Thermometer (glass, red spirit filled) • Styrofoam cups (12 oz.) • 4x Glass beakers (400 ml) • Timer <p>Station # 6</p> <ul style="list-style-type: none"> • Aquarium or clear plastic tub with center divider • Hot plate • Ice bath • 2x Metal can or pot (must hold at least 1,000 ml) • Water • Food coloring (Red & Blue) • 6x Thermometer (glass, red spirit filled) <p>Station # 7</p> <ul style="list-style-type: none"> • Prisms • Mirrors (<i>variety of concave & convex</i>) • Flashlight <p>Station # 8</p> <ul style="list-style-type: none"> • Rock • Triple beam balance • Meter stick or tape measure • 3x Stopwatch or timers <p>All Stations</p> <ul style="list-style-type: none"> • Safety equipment (goggles, gloves, etc.)
<p>Green Energy</p> <ul style="list-style-type: none"> • This lesson is designed as a supplemental activity for the <i>Principles of Energy: Lab Practical</i> lesson in order to introduce students to Green or Renewable Energy and allow them to incorporate Engineering Design principles into their exploration. Students will apply what they have learned from 	<p>Students will be able to:</p> <ul style="list-style-type: none"> • Demonstrate how a wind turbine can be used to generate electricity • Compare the efficiency of various wind turbine designs • Explain how the angle, distance, and spectrum of a light source affects solar power generation 	<ul style="list-style-type: none"> • <u>MS-ETS1-1</u> • <u>MS-ETS1-2</u> • <u>MS-ETS1-3</u> • <u>MS-ETS1-4</u> <p>Math:</p> <ul style="list-style-type: none"> • <u>MP.2</u> • <u>MP.4</u> • <u>6.EE</u> • <u>6.SP.B.5</u> 	<p>Station # 1</p> <ul style="list-style-type: none"> • Wind turbine kit (<i>There are many options available for purchasing these kits online: Home Training Tools, Thames-Kosmos, etc.</i>) • Voltmeter (<i>Note that this is included with the Home Training Tools kit above</i>) • Box fan • Wire (12-gauge red and black) • DC-motor (<i>Note that this is included with the kits</i>)

<p>prior lessons in a variety of hands-on experiments and activities to answer the questions of:</p> <ol style="list-style-type: none"> 1. What is “Green Energy” 2. Is it possible for a problem/question to have multiple solutions? 3. How do we evaluate which competing solution is “best”? 	<ul style="list-style-type: none"> • Perform simple cost benefit analyses to compare alkaline and rechargeable batteries 		<p><i>above)</i></p> <ul style="list-style-type: none"> • Wheel (mounted on DC-motor) <p>Station # 2</p> <ul style="list-style-type: none"> • Desk Lamp • 100 Watt full spectrum lightbulb • Wire (12-guage red and black) • Alligator clips • Solar panel kit (<i>There are many options available for purchasing these kits online: Thames-Kosmos, Solar Sphere, etc.)</i>) • DC-motor • Wheel (mounted on DC-motor) <p>Station # 3</p> <ul style="list-style-type: none"> • Desk Lamp • 100 Watt light bulb (cool white, or any non-full spectrum bulb) • Wire (12-guage red and black) • Alligator clips • Solar panel kit (<i>There are many options available for purchasing these kits online: Thames-Kosmos, Solar Sphere, etc.)</i>) • DC-motor • Wheel (mounted on DC-motor) <p>Station # 4</p> <ul style="list-style-type: none"> • Rechargeable AA batteries with charger • Alkaline AA batteries • Wire (12-guage red and black) • DC-motor • Wheel (mounted on DC-motor) <p>Station # 5</p> <ul style="list-style-type: none"> • Kill a Watt (or similar) electricity monitors (<i>the number of monitors used will depend on the number of devices being tested in the classroom and these can be purchased at sites such as Amazon.com, Walmart, Staples, etc.)</i>)
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			<ul style="list-style-type: none"> • Electronic devices (examples include desktop computer monitor and tower, laptop computer, desk lamp, projector, etc.) <p><u>All Stations</u></p> <ul style="list-style-type: none"> • Safety equipment (goggles, gloves, etc.)
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Safety Considerations: Students must be required to wear appropriate safety equipment at each laboratory station (e.g. safety goggles and gloves should be worn while working with chemicals). A review of lab safety protocols should be conducted before students begin these activities (see Pre-teaching in *Properties of Matter: Lab Practical*).

Properties of Matter: Lab Practical:

- Broken Glass (*thermometers and/or glassware*)
- Spills (*water, chemical solutions, etc.*)

Principles of Energy: Lab Practical:

- Broken Glass (*thermometers and/or glassware*)
- Spills (*water, chemical solutions, etc.*)
- Burns (*two stations involve heating water on a hot plate*)

Green Energy:

- There is a slight risk of electrical shock if equipment is not used properly.

Evaluation Plan:

Formative Assessment Tools

Properties of Matter Lab Practical:

- Students will work in small groups to complete a series of laboratory activities to collect and interpret data on various properties of matter.
- Students will develop hypotheses and collect data to determine if their hypotheses are valid.
- Students will create graphical displays of data they collect.

Principles of Energy Lab Practical:

- Students will work in small groups to complete a series of laboratory activities to collect and interpret data on different forms of energy and energy transfers.
- Students will develop hypotheses and collect data to determine if their hypotheses are valid.
- Students will create graphical displays of data.

Green Energy:

- Students will work in small groups to complete a series of laboratory activities to collect and interpret data on different forms of renewable (“Green”) energy and explore the concepts of energy transfer, transfer efficiency, conservation of energy, and .
- Students will perform cost-benefit analyses on different battery options.
- Students will perform a classroom energy audit and answer a series of questions regarding the importance of responsible energy consumption.

Summative Assessment Tools

Properties of Matter Lab Practical:

- Students will collect and interpret data and answer a series of questions while completing a laboratory worksheet demonstrating the properties of matter.
- If time allows, students will grade their laboratory worksheets during an in-class discussion.

Principles of Energy Lab Practical:

- Students will collect and interpret data and answer a series of questions while completing a laboratory worksheet demonstrating different forms and transfers/conversions of energy.
- If time allows, students will grade their laboratory worksheets during an in-class discussion.

Green Energy:

- Students will collect and interpret data and answer a series of questions while completing a laboratory worksheet demonstrating examples of renewable (“Green”) energy.
- If time allows, students will grade their laboratory worksheets during an in-class discussion.

Resources (websites):

[UCDavis ChemWiki](#)

Provides useful information regarding the chemical and physical properties of matter.

[Arbor Scientific: Genecon Generators](#)

Provides information on purchasing and using Genecon hand-crank generators.

[National Geographic: Atmosphere and Wind](#)

Provides information on the Earth’s climate and wind patterns.

[HyperPhysics: Specific Heat](#)

Provides information on specific heat (useful for the heating and cooling of Earth’s surface activities).

[U.S. Department of Energy: Solar](#)

Provides information on solar energy.

[U.S. Department of Energy: Wind](#)

Provides information on wind energy.

Brief description of how this unit relates to your graduate research.

These labs were designed to provide middle school students with “hand-on” activities to explore the properties and principles of matter, energy, and renewable/green energy. Although the material covered in these lessons does not directly relate to my research in aquatic ecology & fisheries biology many of the laboratory protocols and research methods outlined in these lessons are similar to protocols and procedures that I follow in field and laboratory settings. While the research topics may differ the general scientific process of developing hypotheses, following repeatable methods for collecting data, analyzing/interpreting the data, and reporting results and conclusions is the cornerstone of all branches of science. Each lesson in this unit was developed in collaboration with my partner teacher, John Asiala, at Washington Middle School in Calumet MI and designed to supplement the current curriculum he teaches in his classroom. Our goal with each of these lessons is to allow teachers to either select an individual activity to supplement specific lessons in their classroom or to use the entire lesson as an assessment tool at the end of a unit of curriculum.