**METEROLOGY**

**SEMESTER DRIVING QUESTION:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

* Why did we have three snow days at the end of winter break?
* What is the polar vortex?

**TOPIC 1: ATMOSPHERE & AIR PRESSURE**

**ABSTRACT:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

Students have previously investigated varying chemistry topics including atomic theory, physical and chemical properties and changes as well as chemical reactions. Skills and knowledge acquired throughout these units will be revisited as they progress through the assorted Meteorology topics included in the following semester. The first unit to be covered will involve investigations on atmosphere and air pressure. In particular, the composition and arrangement of the atmosphere will be investigated as well as the changing physical properties of the atmosphere. By the end of the unit, students will have explored the gaseous composition of the atmosphere using modeling methods, what air pressure is and its relationship with thermal energy and elevation as well as the physical properties of the layers of the atmosphere using analytical methods. In the following units, the concept of energy within the atmosphere will be expanded as heat transfer through the atmosphere is explored in regards to solar energy.

**BIG IDEAS:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

Life on the planet Earth is partly made possible by the envelope of gases that surrounds it. This layer is called the atmosphere. Earth’s atmosphere is made up of nitrogen, oxygen, carbon dioxide, water vapor and other gases as well as extremely small particles of solids. Nitrogen is the most common element in the atmosphere. It is a building block for many nutrients required by living things. Oxygen is the second most common element in the atmosphere. Animals use oxygen directly in a process that releases energy from the food that they eat. Carbon dioxide is a compound that contains carbon and oxygen atoms chemically bonded together. Although there is only a small amount in the atmosphere, carbon dioxide is essential to plant life as they use it to produce food for themselves. Water vapor, or water that is a gas, contains hydrogen and oxygen atoms chemically bonded together. The amount of water vapor in the atmosphere varies over time and location. Some places may contain little water vapor while others contain a lot. There are traces, or small amounts, of other gases such as Argon, Neon, Helium and Methane gas as well as particles of solids such as dust, ash and salt.

The atmosphere has different physical and chemical compositions at different altitudes. The four main layers of the atmosphere are classified according to changes in altitude and in relative temperature. These layers are called the troposphere, the stratosphere, the mesosphere, and the thermosphere. The troposphere is the layer closest to the Earth. As we increase altitude in the troposphere, or as we move away from Earth’s surface, the temperature decreases. The point at which the temperature starts to increase again is called the tropopause. The tropopause marks the beginning of the next layer called the stratosphere. As we increase altitude in the stratosphere, the temperature also increases. The point at which the temperature starts to decrease is called the stratopause. The stratopause also marks the beginning of the next layer called the mesosphere. As we increase altitude in the mesosphere, the temperature decreases. The point at which the temperature increases again is called the mesopause. The mesopause also marks the beginning of the next layer called the thermosphere. As we increase altitude in the thermosphere, the temperature also increases. The thermosphere is the outermost layer of the atmosphere and blends with the gas molecules found in space. The atmosphere is an integral part of the global ecosystem. Altering the concentrations of the natural gas components, or adding new ones, can have serious consequences for the life systems on Earth.

The atmosphere is constantly changing, with gases moving around the globe as well as in and out of living things, water and land. The air included in the atmosphere has unique physical properties including mass, density and pressure. Mass is the amount of matter within a substance. Density is the amount of mass in a given area. The density of air can be calculated by dividing the mass of the air by how much volume it takes up. If there are more molecules of a gas in a given volume of air, the density is higher. If there are fewer molecules, the density is lower. The squishing feeling you can sometimes feel is called pressure. It occurs as a result of a weight pressing on the surface of an object. In the atmosphere, the air molecules exert a pressure, called air pressure, as a result of the weight of a column of air pushing down on a given area. The molecules within the column of air push in all directions. Denser air (air with more gas molecules per area) exerts more pressure than less dense air. Altitude, or elevation or height, is the distance above the average level of the surface of the oceans or the sea level. Altitude can affect both density and air pressure. Low altitudes, or the lower parts of the air column, will have the greatest air pressure because the weight of the rest of the atmosphere within the column above it is pressing on it. Because there is more pressure, the lower the altitude, the denser the air is. High altitudes, though, or the higher parts of the air column, will have the least air pressure because there is not much weight pressing on that part of the air column. Because there is less pressure, the less dense the air is at higher altitudes.

**STATE & NATIONAL STANDARDS:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Michigan State Standards:**

* E.FE.07.12 - Compare and contrast the composition of the atmosphere at different elevations.
* E.FE.07.11 - Describe the atmosphere as a mixture of gases.

**Next Generation Science Standards:**

* MS-ESS2-5 – Collect data to provide evidence for how the motions and complex interactions of air mass results in changing weather conditions.

**Framework for K-12 Science Education**

* Scientific Practices:
  + *Developing and using models*
  + *Analyzing and interpreting data*
* Crosscutting Concepts:
  + *Patterns*
  + *Energy and Matter: Flows, cycles and conservation*
  + *Stability and Change*
* Disciplinary Core Ideas:
  + *“Earth’s Systems, encompasses the processes that drive Earth’s conditions and its continual evolution (i.e., change over time). It addresses the planet’s large-scale structure and composition, describes its individual systems, and explains how they are interrelated. It also focuses on the mechanisms driving Earth’s internal motions and on the vital role that water plays in all of the planet’s systems and surface processes“(NRC, 2012, p. 107).*

**SYNTHESIZED OBJECTIVES:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

* Collect, analyze and interpret data on the relative composition of gases and other particles in the Earth’s atmosphere.
* Analyze and interpret data on the physical properties of the atmosphere at different elevations.
* Develop a model to show the relative locations and size of the four main layers of the atmosphere (troposphere, stratosphere, mesosphere and thermosphere).

**DRIVING THEORIES:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Driving Theory #1:**

Earth’s atmosphere is made up of nitrogen, oxygen, carbon dioxide, water vapor and other gases as well as particles of liquids and solids. Nitrogen is the most abundant element in the atmosphere. It is a building block for many nutrients for living things, especially proteins. Plants and animals obtain nitrogen through a secondary source; i.e. eating other substances that already contains it. Oxygen is the second most abundant element in the atmosphere. Animals take and use oxygen directly to release energy from food substances that they eat. Carbon dioxide is a compound that contains carbon and oxygen atoms chemically bonded together. Although there is only a small amount in the atmosphere, carbon dioxide is essential to plant life as they use it produce food for themselves. Water vapor, or gaseous water, contains hydrogen and oxygen atoms chemically bonded together. The amount of water vapor in the atmosphere varies in time and space. Some places may contain little water vapor while others contain a lot. There are traces, or small amounts, of other gases such as Argon, Neon, Helium and Methane as well as solid particles such as dust, smoke and salt.

**Observations, experiences, data, examples:**

* Students can identify the percent compositions of the gases that make up the atmosphere by analyzing graphs and data.
  + Gas composition pie chart (<http://www.agci.org/classroom/images/Atm_Composition.png>)
  + Gas composition percent by volume (<http://www.ux1.eiu.edu/~cfjps/1400/TBL01_0T2.JPG>)
* Students can relate to the importance of nitrogen by identifying foods high in protein that they might eat (almonds, carrots, chicken, venison, eggs).
* Students can relate to the important of oxygen by identifying uses of oxygen that we have previously discussed in our chemistry unit:
  + Breathing and respiration
  + Combustion reactions (Methane bubbles demo, Law of Conservation of Mass lab)
  + Slow chemical reactions such as rusting of iron, tarnishing of silver, oxidation of pennies.
* Students can calculate how much oxygen is actually in the air by performing an experiment with an inverted test tube over a cup of water with a lit candle.
* Students can relate to the importance of carbon dioxide by identifying how plants and humans help to cycle both oxygen and carbon dioxide when we respire and plants photosynthesize.
  + <http://vdinh.weebly.com/uploads/1/3/5/5/13557835/4244573_orig.jpg?1>
* Students can relate to the trace gases especially with the greenhouse effect.
  + <http://www.ecy.wa.gov/climatechange/images/greenhouse_effect2.jpg>
* Students can identify how water cycles from land, water to air and back with their knowledge of the water cycle.

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**Driving Theory #2:**

The atmosphere is constantly changing, with gaseous atoms and molecules moving around the globe as well as in and out of living things, water and land. The air included in the atmosphere has unique physical and chemical properties. Air has mass, density and pressure. The density of air can be calculated by dividing the mass of the air by how much volume it takes up. If there are more molecules of a gas in a given volume of air, the density is higher. If there are fewer molecules, the density is lower. The force pushing on an area or surface is known as pressure. Air pressure, though, occurs as a result of the weight of a column of air pushing down on a given area. The molecules within the column of air push in all directions. Denser air exerts more pressure than less dense air. Altitude, or elevation, is the distance above the average level of the surface of the oceans or the sea level. It can affect both density and air pressure. The lowest point in a column of air will have the greatest air pressure because it has the weight of the whole atmosphere above it pressing on it. Air pressure decreases as altitude increases. As air pressure decreases, the density decreases. Thus, as density decreases, the altitude increases.

**Observations, experiences, data:**

* Students can investigate whether or not air has mass.
  + Compare and contrast deflated versus inflated balloons.
  + Explain what they observe in the series of demonstrations using key words such as air density, air pressure and temperature(<http://www.middleschoolchemistry.com/lessonplans/chapter1/lesson5>)
* Students can investigate what happens when there are differences in air pressure with a series of demonstrations:
  + Blow up a balloon and observe what happens. Why does it make a noise when it’s popped?
  + Why do your lungs expand when you take a deep breath?
  + Why does a peep get bigger when it is put in a vacuum?
  + Fill a gallon milk jug about a quarter of the way full with very hot water and screw the cap on tight. Let stand for approximately an hour. What do you think will happen? What actually happened?
* Students can read how air density changes depending on environmental conditions
  + “USA Today: Understanding Air Density and its Effects”
* Students can construct, analyze and draw conclusions on the patterns of air density, air pressure and air temperature as altitude changes.
* Analogies to help explain air pressure:
  + “Imagine you are a part of a human pyramid. Where is the most of the pressure in the pyramid? The people who are forming the base are probably experiencing the most pressure.”
  + “Imagine having one science textbook on your lap. If we add another one on top of the first one, what do you feel? What if we add two more? Or another two more? You will feel the most pressure as the weight of the other books ‘press’ on you. What about the book on the top of the stack? It will be feeling the least pressure because there is nothing ‘pressing’ on the book. This is the same within the layers of the atmosphere. The lower levels (closer to Earth) feel more pressure than the upper levels (closer to space).”
* “Why does the recipe on a boxed cake say to change the temperature for higher elevations?”
  + <https://www.kingarthurflour.com/recipe/high-altitude-baking.html#changes-tab>

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**Driving Theory #3:**

The atmosphere has different physical and chemical compositions at different elevations. The four main layers of the atmosphere are classified according to changes in altitude and in relative temperature. These layers are called the troposphere, the stratosphere, the mesosphere, and the thermosphere. The troposphere, the innermost layer, is where Earth’s weather occurs and clouds form. The temperature of the troposphere decreases as altitude increases. The stratosphere can be divided into the lower and upper stratosphere. The upper stratosphere contains a layer of ozone, or oxygen, which aids in absorbing energy from the sun which is responsible for heating air. The upper stratosphere is warmer than the lower stratosphere. The mesosphere is found in the middle of the atmosphere and protects the Earth from meteoroids, or shooting stars. The thermosphere is the top of the atmosphere and blends with the gas molecules found in space. It has a high temperature relative to the motion of the gas molecules found within this layer.

**Observations, experiences, data, examples:**

* Students can graph how temperature changes depending on altitude and use this to identify the five layers of the atmosphere.
* Students can create a scale model of the layers of the atmosphere to show how big each layer is relative to each other.
* For each layer of the atmosphere, students can relate to a phenomena that occurs there:
  + Troposphere = weather, clouds
  + Stratosphere = ozone layer, greenhouse effect
  + Mesosphere = meteors
  + Thermosphere = International Space Station (the movie Gravity), Southern & Northern lights
  + Exosphere = blending into outer space

**Misconceptions:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

* Plants are the only things on Earth to generate oxygen gas. Which, in reality, the ocean also serves as an important source of oxygen gas.
* The atmosphere is actually heated from the ground up, even though the original energy comes from the sun.
* Greenhouse gases make up a major portion of the atmosphere. In reality, they only make up a small portion but when heated still have a profound impact on atmospheric conditions.
* Air and oxygen are the same things, but really, air is a mixture of many gases.
* Hot air weighs less than cold air but, in reality, they have the same weight. It is simpler the movement of the molecules that is different.
* The atmosphere is made up of only air but, in reality, there are many more particles than we think because we can’t see them due to their small size.

**Activity Sequence:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Driving Question:**

“Why do your ears ‘pop’ when you fly in an airplane or when you climb a mountain?”

**Driving Question Explanation:**

Your ears pop when you are in an airplane, or when you climb a mountain, because the air at higher elevations is less dense that the air below. The density of air is directly related to the pressure of air. As density increases, the pressure also increases. Air pressure is greater closer to the Earth’s surface because air near the surface feels the pressure from the weight of all of the air above it. As you travel to higher elevations and the air pressure decreases, the air trapped inside of your ear begins to push outward. Your body attempts to relieve this discomfort by “popping” your ears. This pop is the release of the additional pressure from inside of your ear outwards.

**Students will be able to construct an explanation to the Driving Question based on the following patterns and trends from the data we will collect:**

* Air has mass. This mass comes from the variety of gases that make up air. A majority of air is made up of Nitrogen, Oxygen and Carbon Dioxide. Other gases include water vapor, ozone and a variety of other trace gases.
* The relative amount of each gas contributes to airs density which describes how much gas is present per designated volume.
* The density of air is related to air pressure. More dense air results in greater air pressure.
* Air pressure is related to altitude. Air pressure at lower elevations is much more than air pressure at higher elevations.

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| **OBJECTIVE:** | | |
| Collect, analyze and interpret data on the relative composition of gases and other particles in the Earth’s atmosphere. | | |
| **RELATION TO DRIVING QUESTION:** | | |
| The air that surrounds us has mass. The mass comes from a variety of gases such as carbon dioxide, nitrogen, oxygen and water vapor. The relative composition of the air changes over a period of time at the same location or it can change as location changes (both across the Earth’s surface and outward from the Earth’s surface). | | |
| **ESSENTIAL QUESTION:** | **TEACHING ACTIVITY & SCIENTIFIC PRACTICES:** | **ASSESSMENT:** |
| *Does air have mass?* | **Finding the Mass of Air Lab**  I will ask the class the essential question. This initial discussion will get at student’s ideas about whether the air (something we can’t see) has measurable mass and where does that mass come from. Students will follow the PEOE method as we perform an experiment using balloons and triple beam balances. | Students will turn in a sheet that has their predictions, explanations and observations recorded on it. In addition, exit tickets may be used that ask students to predict what they might learn next. |
| *Where does air’s mass come from? If we had super powered microscopes as eyes, what would we see?* | **Hypothesis Checklist**  Students will develop a hypothesis as to what air is made of. As a class, we will develop a hypothesis checklist. | The hypothesis checklist will be kept hanging on the side of the room throughout this activity sequence. |
| *How much of each gas is in the atmosphere?* | **Percent Composition of the Atmosphere Activity**  Using graphing paper as a grid, students will color in the appropriate amount of squares relative to the percent composition of each gas within the atmosphere. Doing so, students will visually identify the major gases and the minor gases of the atmosphere. | Students will turn in their finished product with associated answers to questions. In addition, exit tickets may be used that ask students to reflect on the activities and identify the take away message. |
| **Test Tube and Candle Experiment**  Students will perform this lab to calculate the rough percent composition of oxygen in the atmosphere. After being provided the essential question (How much oxygen is in the atmosphere?), students will develop a hypothesis, perform the experiment, revise their hypothesis and communicate their results. |
| *How much of each gas is in the atmosphere?* | **Bead Model of the Composition of the Atmosphere**  Students will use colored beads that represent the different gases of the atmosphere. They will contain the beads in a Ziploc bag. | Students will turn in their answers to associated questions with the activity. In addition, exit tickets will be used that ask students to reflect on the activity and identify the take away message. |
| *Why do we need the atmosphere help us stay alive on Earth?* | **“Why do we need the atmosphere?” Notes**  Students will follow along with a power point presentation that provides key information as to why we need all of the gases that make up the atmosphere. They will record this ideas in a graphic organizer. | Students will turn in their answers to associated questions with the activity. In addition, exit tickets will be used that ask students to reflect on the activity and identify the take away message. |
| **Atmosphere Design Lab**  <http://forces.si.edu/atmosphere/interactive/atmosphere.html>  Students will identify how the composition of the atmosphere varies at places across the world but if it varies too much there can be severe consequences. This virtual lab will allow students to explore these consequences. |
| *What is the atmosphere made of and why do we need it?* | **Summary Chart**  Students will complete a summary chart that organizes each of the gases in the atmosphere, the percent composition within the atmosphere as well as its purpose in sustaining life on Earth. | Students will use the information they learned to answer a series of multiple choice questions in the final test (summative assessment). |

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| **OBJECTIVES:** | | |
| * Analyze and interpret data on the physical properties of the atmosphere at different elevations. * Develop a model to show the relative locations and size of the four main layers of the atmosphere (troposphere, stratosphere, mesosphere and thermosphere). | | |
| **RELATION TO DRIVING QUESTION:** | | |
| Your ears pop when you are in an airplane, or when you climb a mountain, because the air at higher elevations is less dense that the air below. The density of air is directly related to the pressure of air. As density increases, the pressure also increases. Air pressure is greater closer to the Earth’s surface because air near the surface feels the pressure from the weight of all of the air above it. As you travel to higher elevations and the air pressure decreases, the air trapped inside of your ear begins to push outward. Your body attempts to relieve this discomfort by “popping” your ears. This pop is the release of the additional pressure from inside of your ear outwards. | | |
| **ESSENTIAL QUESTION(S):** | **TEACHING ACTIVITY:** | **ASSESSMENT:** |
| *Why do astronauts have to wear space suits?*  *Why do airplanes fly at certain elevations?*  *Why are there no clouds in space?* | **Hypothesis Checklist**  Students will record their ideas about why astronauts need to wear space suits be we, on Earth, do not. It allows students to discuss the possible functions of the atmosphere, especially after following the last activity regarding the purpose of each gas present in the atmosphere. The other questions will also prompt students to identify why we have the atmosphere. | The hypothesis checklist will be kept and adjusted as students learn more about the layers of the atmosphere. |
| *How does the atmosphere change? As we move around the globe as well as outward towards space?*  *How big is the atmosphere, relative to the Earth?* | **Layers of the Atmosphere Video (No sound)**  <http://www.youtube.com/watch?v=3CerJbZ-dm0>  Students will watch a video that depicts movement through the layers of the atmosphere from the Earth out to space. In small groups, students will devise an explanation for the video that describes what they are seeing. | Students will turn in their descriptions for the video (without sound) and will be revisited at the end of the activity sequence. In addition, exit tickets may be used that ask students to predict what they might learn next. |
| *What is air pressure?* | **KWL Reading: “Understanding Air Density and its Effects”**  Students will identify the relationship between air mass and density. The reading uses real world examples to exhibit the phenomena including playing sports in Colorado and humidity during the summer. | Students will turn in their associated responses to the questions posed after the reading as well as their predictions and explanations for the demonstrations. In addition, exit tickets may be used that ask students to identify parts that do not make sense still. |
| **Air Pressure Demonstrations**  **(**<http://serc.carleton.edu/earthlabs/hurricanes/5.html>)  Following the PEOE method, students will attempt to predict what will happen during each of the following demonstrations: Collapsing Pop Can, Ruler and Newspaper, Egg in a Bottle, Soda Bottle and Ping Pong Ball, etc. |
| *How is temperature related to altitude?* | **Layers of the Atmosphere Simulation**  <http://www.glencoe.com/sites/common_assets/science/virtual_labs/ES14/ES14.html>  Students will use this simulation to collect data on the density, pressure and temperature found at the different levels of the atmosphere. In addition, they will make observations of various meteorological phenomena throughout the layers of the atmosphere. | Students will turn in their graphs and associated responses to the posed questions following the activity. In addition, exit tickets may be used that ask students to attempt to generalize the relationship between temperature and altitude. |
| **Temperature vs. Altitude Graph**  Using data from scientific investigations, students will plot the relationship between temperature and altitude. They will detect ways that this relationship changes and use it to identify the layers of the atmosphere. |
| *How can you differentiate between the four layers of the atmosphere?* | **Layers of the Atmosphere: Small Group Model**  Students will work in small groups to create a scale model of the atmosphere. On the poster students will include the altitudes, temperature pattern and atmospheric phenomena that can be found at each layer. | Upon construction of the large class model, students will use sticky notes to identify trouble points or additional notes of clarification. |
| *What are the physical and chemical properties of the four layers of the atmosphere?* | **Layers of the Atmosphere (With sound)**  [**http://www.youtube.com/watch?v=3CerJbZ-dm0**](http://www.youtube.com/watch?v=3CerJbZ-dm0)  Students will watch a video that depicts movement through the layers of the atmosphere from the Earth out to space. Individually, students will devise an explanation for the video that describes what they are seeing. | Students will revise their original descriptions using colored pens. They will also add additional notes and explanations. These revisions and further explanations will be turned in. |
| *What are the physical and chemical properties of the four layers of the atmosphere?* | **Summary Chart**  Students will complete a summary chart that organizes each of the layers in the atmosphere, the relative temperature changes in each layer as well as other physical and chemical properties. | Students will use the information they learned to answer a series of multiple choice questions in the final test (summative assessment). |