Lesson Plan

Grade/Subject 6th & 8th	**Title**
Core: 6.2.2 & 8.1.3	***Cold Air Pool***

Standard/Objective

6.2.2 Develop a model to predict the effect of heat energy on states of matter and density. Emphasize the arrangement of particles in states of matter (solid, liquid, or gas) and during phase changes (melting, freezing, condensing, and evaporating). (PS1.A, PS3.A)

8.1.3 Plan and conduct an investigation and then analyze and interpret the data to identify patterns in changes in a substance's properties to determine whether a chemical reaction has occurred. Examples could include changes in properties such as color, density, flammability, odor, solubility, or state. (PS1.A, PS1.B)

Lesson Performance Expectations (description):
Students will examine how a cold air pool develops due to the mountains surrounding Utah valleys. They will consider clean air as a natural resource that is available in an uneven distribution due to the geologic processes that formed the mountains.

Materials: Materials for a demonstration 2-3 ft long acrylic tube 3" in diameter, plastic tubing, hot water, ice cubes, 2 shallow pans, bulb syringe, 2" glass tube, ring stand and clamp, lighter. (This kit is available from Breathe Utah PD courses)

Time: 50 minutes

Teacher Background Information: Cold air pools (formerly called temperature inversions) build up in Utah valleys during the winter when cold air is trapped beneath warm air and fills with air pollutants. The cold ground contributes to the cold air pool; the cold ground keeps the air cool and the cold, dense air settles beneath the warm air above it, holding the pollution near the ground. Cold air pools do not happen in the summer when the ground is warmer because the air is warmed and rises, taking pollution with it.

Student Background: Students should have studied convection currents and be aware that hot air rises and cold sinks.

Student Performance

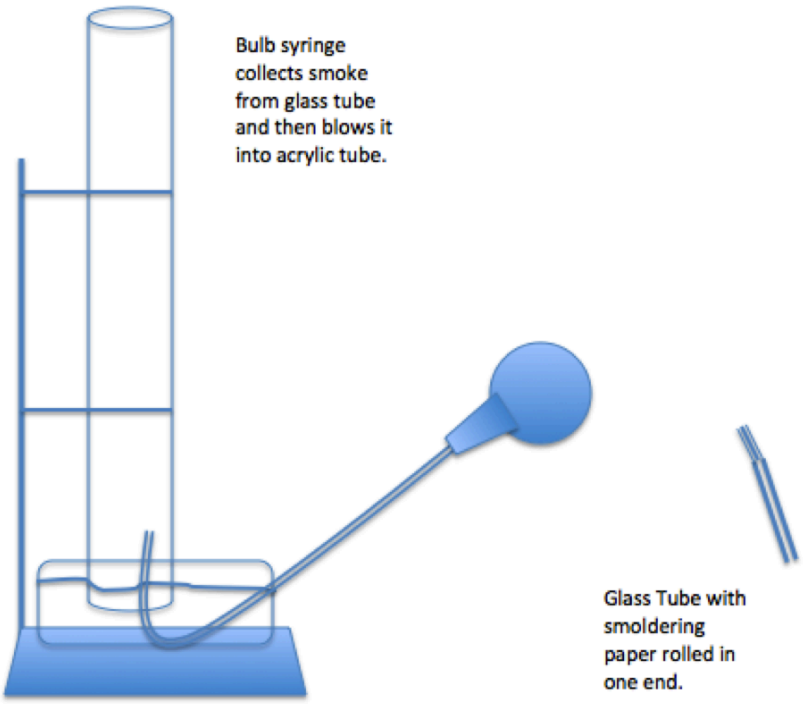
Phenomenon: ***Observation of event, data or other evidence of activity.***

Show students a picture of a typical inversion in a Utah Valley.
https://docs.google.com/presentation/d/1o6oQUKz_aop0_Sxgvbnqy0stCmN_wCHBi1C5synGfyc/edit#slide=id.p

Ask students to explain the phenomenon but do not explain it yourself.

Gathering: *(Obtain Information, Ask Questions/Define Problems, Plan & Carry Out Investigations, Use Models to Gather Data and Information, Use Mathematics/Computational Thinking.)*

1. Explain to students that they will be observing a model of the events that lead to the conditions seen in the photo.
2. Prepare ahead of time hot water (near boiling) and cold water with ice cubes in shallow pans.
3. Set up the apparatus as pictured:



4. Roll a small piece of paper into a tube and place it in the end of the glass tube. Light it and use the bulb syringe to draw the air through it and trap smoke in the syringe. Remove the syringe and place it in the plastic tubing and squeeze the smoke into the bottom of the acrylic tube. The smoke will sit there until you lift the tube. If the tube has been sitting in the ice water, the smoke will sink. If it has been sitting in the hot water, the smoke will rise out of the top of the tube.
5. Ask students if there are any other ways they would like to see the model tested.

Reasoning: *(Evaluate Information, Analyze Data, Use Mathematics/Computational Thinking, Construct Explanations/Solve Problems, Develop Arguments from Evidence, Use Models to Predict & Develop Evidence.)*

1. Ask students to fill out their student sheets to explain how the model is related to a Utah valley.
2. Ask students to determine which season is modeled by the warm and cold water.

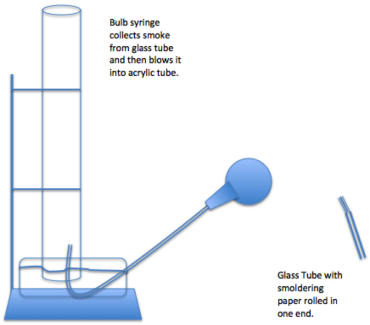
Communicating: *(Communicate Information, Argue from Evidence (written & oral), Use Models to Communicate).*

1. Ask students to list ways the air could be kept cleaner, given the valleys have the shape created by their geological past.
2. Introduce the term "cold air pool" and ask students to define the term, based on their understanding of the model.

Teacher Resources:
Breatheutah.org, Student worksheet, Student answer sheet.
Link to video of cold air pool

Assessment of Student Learning

Model of Inversion



1. Two demonstrations were performed using the materials in the model pictured above. The results were different. What factor changed in between the two demonstrations?
    a. The shape of the long tube.
    b. The amount of smoke added to the tube.
    c. The temperature of the water in the dish.*
    d. The length of time the demonstration took.

2. In one demonstration, the smoke rose out the top of the long tube. What two factors allowed this to happen?
    a. The smoke was warm.*
    b. The smoke had larger particles..
    c. The smoke was less dense than the air.*
    d. The smoke was trapped by the long tube.

3. What was the long tube a model of?
    a. Pollutants
    b. Houses
    c. Weather
    d. Valley*

4. Why was a classroom model used to show this phenomenon? Choose all that apply
    a. Models are used when the scale is too large.*
    b. Models are used to demonstrate unsolvable problems.
    c. Models are used when something happens too slowly.*
    d. Models are used to show ideas that cannot be measured.
    e. Models are used to show things that do not happen in nature.

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Extension:	Links to the geologic events that formed the Basin and Range of Utah and Nevada can be found at: http://geography.about.com/od/physicalgeography/a/basinrange.htm Students who like additional challenges may be directed to find out more and present to the class.

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Student Page
Name_____

1. Phenomenon: Write down three questions that you have about the pictures.

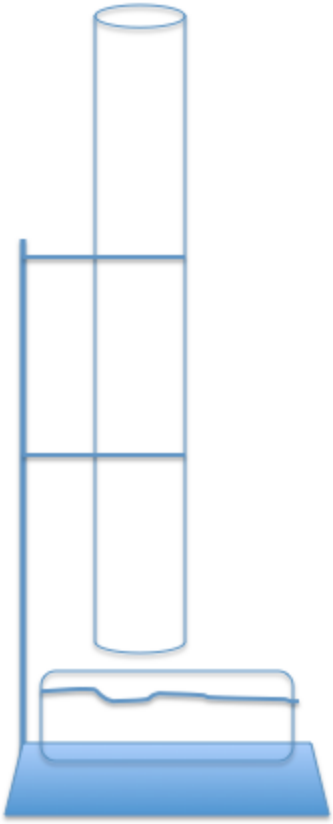
   A.

   B.

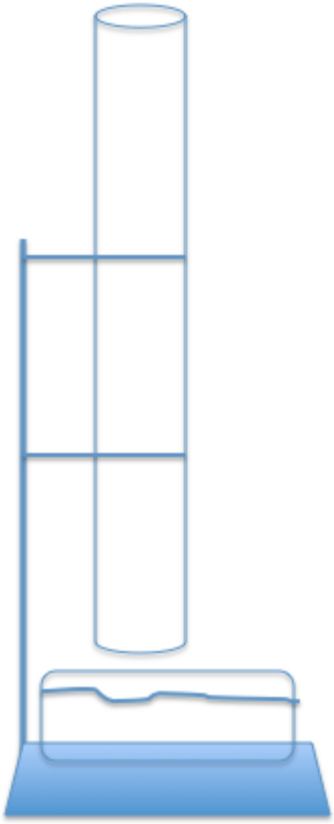
   C.

   Predict what accounts for the buildup of pollution in Utah valleys?

2. Draw what happens as your teacher models the formation of air pollution:



Cold water



Warm Water

A. What do the parts of the model represent?

Tube:

Warm and cold water:

Smoke:

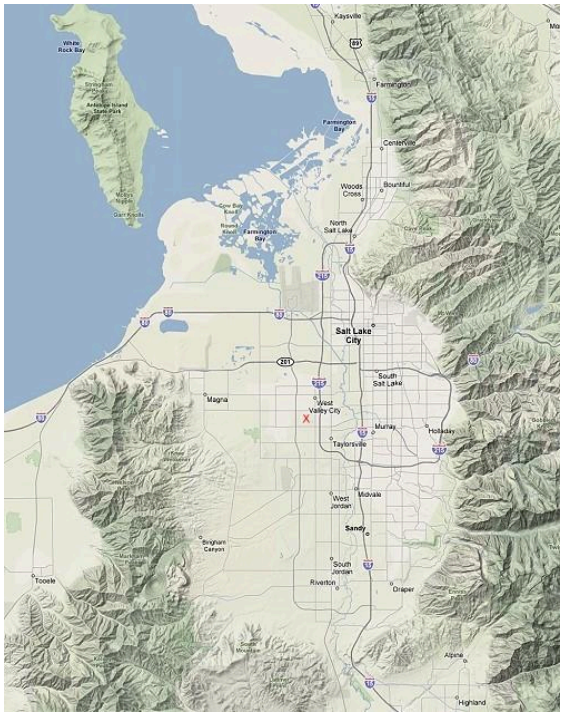
B. Which season is modeled by the cold water? Warm water?

C. Why does the smoke act differently in the two models?

3. What could prevent the buildup of pollution in Utah Valleys in summer or winter?

4. The condition in the cold water tube is called a “cold air pool”. Describe what that means:

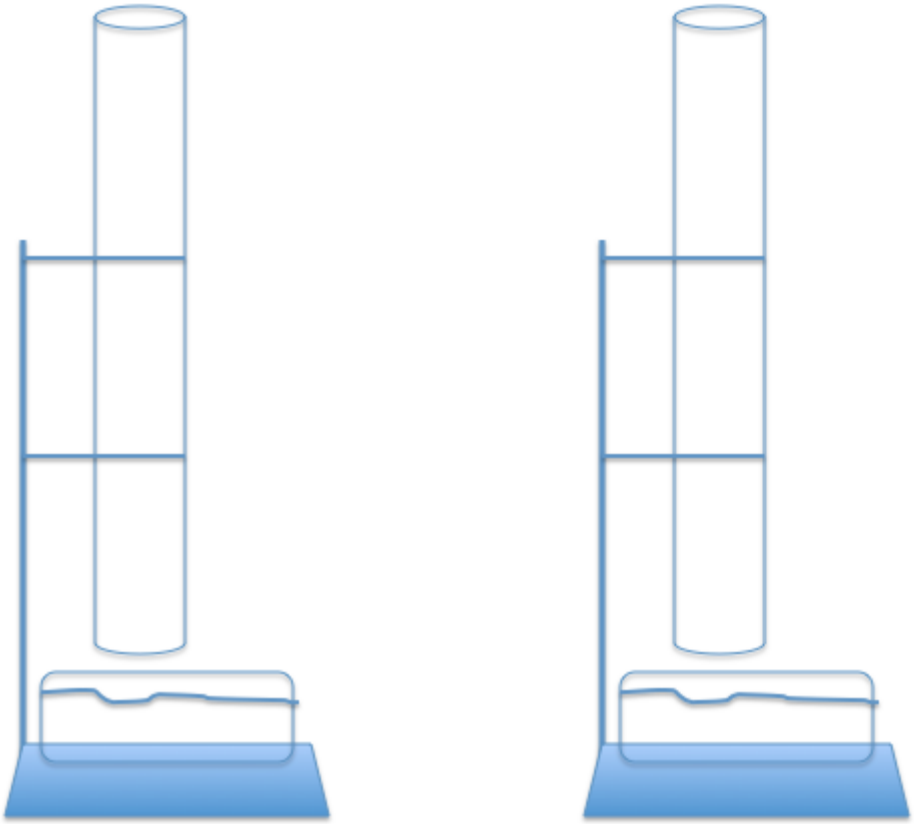
5. Look at the map below. How would you describe the shape of the Salt Lake Valley? How does the unique shape of Utah valleys contribute to air pollution problems?



Student Answer Sheet

1. Phenomenon: What accounts for the buildup of pollution in Utah valleys? *The Air is trapped in the valley due to topography, temperature and density.*

2. Draw what happens as your teacher models the formation of air pollution:



Cold water Warm Water

(smoke settles in the bottom of the tube and stays) (Air flows out of the top of the tube)

B. What do the parts of the model represent?

Tube: *Valley walls*

Warm and cold water: *The season, Cold is the winter, Warm is the summer*

Smoke: *The PM 2.5 and other pollutants*

B. Which season is modeled by the cold water? *Winter* Warm water? *Summer*

C. Why does the smoke act differently in the two models? *Warm air is less dense and will rise when the bottom of the tube is lifted. You can see this because the smoke goes up. Cold air is more dense and sinks out the bottom of the tube along with the smoke.*

3. What could prevent the buildup of pollution in Utah Valleys in summer or winter? *We cannot stop inversions or cold air pools. What we can do is reduce the amount of pollution that we put into the air.*

4. The condition in the cold water tube is called a "cold air pool". Describe what that means: *Cold air is more dense and will sink below the warmer air. The cold air pools at the bottom of the valley or tube.*

5. How does the unique shape of Utah valleys contribute to air pollution problems? *Utah valleys are small with mountains that encircle them. This creates a 'bowl' shape that the cold air pools into. If the valley is one sided or has open ends then the air can move more freely. When the air pools the pollution is trapped and cannot get out until a storm/wind occurs.*