TEMPERATURE INVERSION
LESSON PLAN

What is a temperature inversion? What does it mean for the air?

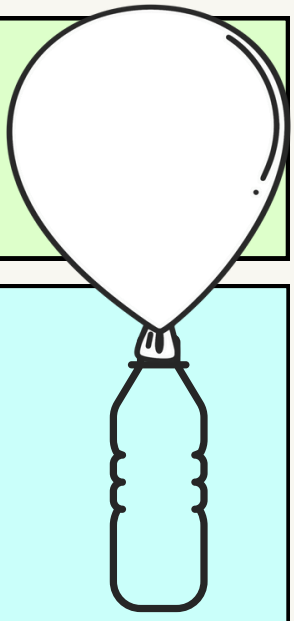
Topic Areas: Environmental Science, Weather, Atmosphere, Air Quality, Air Pollution, Public Health

Goal: Learn how temperature changes at different levels in the atmosphere can influence air quality

Lesson Objectives:

- Understand that warm air is less dense than cool air
- Understand how temperature inversions work and how they influence air quality

Adaptable for different grade levels



Part 1: Air Temperature & Density Demonstration

Materials:

- 1 empty, two-liter plastic bottle
- 1 balloon
- 1 large bowl
- Hot water
- Ice

1. Fit the mouth of the balloon over the mouth of the empty, two-liter bottle.
2. Stand the bottle in the center of the bowl. Fill the bowl with hot water, around the outside of the two-liter bottle. After a few minutes, the balloon will start to inflate.
3. Carefully pour the water out of the bowl and fill the bowl with ice water. The balloon will start to deflate.

Ask students why they think the balloon inflated and deflated in response to the hot and cold water. What changed? *When air is warmed, it expands and needs more space, so it stretches out the balloon. When air is cooled, it contracts and needs less space, so the balloon deflates. In this closed system, the mass of air in the bottle remains constant. It demonstrates that the warm air requires more space (and thus is less dense, based on the fact that density = mass/volume) than the cool air. Warm air rises because it is less dense than cold air.*

This part of the activity is adapted from the College of Engineering at the University of Colorado Boulder. *www.teachengineering.org*

GASP

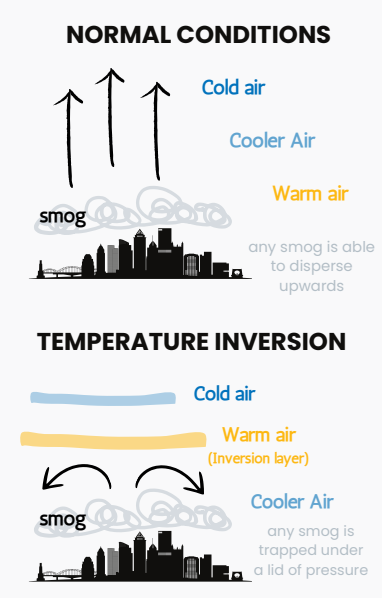
BACKGROUND

Part 2: Temperature Inversions

Temperature inversions are natural occurrences that occur year-round but most often in the winter. It's important to understand that they are a normal weather event and are neither caused by, nor the cause of, air pollution. However, an inversion can trap air pollution near the ground, increasing the potential for higher concentrations of air pollution down at breathing level Because of this, temperature inversions and air pollution issues are often linked.

Inversions result in unhealthy air pollution episodes when a layer of pollution is trapped between stagnant layers of cold and warm air. Air pollution is trapped under a "lid" that keeps unhealthy air at breathing level until it's able to disperse under normal weather conditions.

Geographical differences, like valleys versus flat plains, are also a factor since the "lid" can more easily trap unhealthy air in a valley, like a bowl. Picture many towns in Southwestern PA - they are often situated along rivers and surrounded by hills, with pollution sources also along the river.



Normally, the warmest layer of air is closest to the surface. Air mixes upwards into cooler layers, along with any air pollution. An inversion occurs when the ground cools quickly, often on a clear, calm night. Surface-level air cools along with it, making that air denser than the layer of warmer air above it.

What are other weather conditions that influence air quality?

- Heat is part of the reaction that causes ground-level ozone, a major pollutant.
- Moisture and humidity can lead to mold, which is harmful to indoor air quality.
- Strong or calm winds influence whether pollution stays (or accumulates) close to its source or is dispersed.

"No Burn Days"

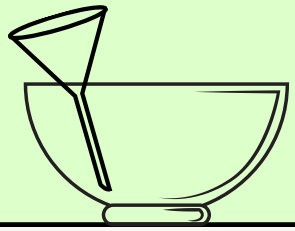
An example of how knowledge of inversions can lead to more informed decision-making is the implementation of "No Burn Days." A ban on open burning can go into effect when a strong inversion is forecasted.

ACTIVITY

Part 2: Model a temperature inversion using water

Materials:

- large clear bowl or container
- water
- measuring cup or second container
- salt
- food dye (red, blue, and green)
- funnel



Fill the large clear bowl or container about half-full with water. (The exact quantity doesn't matter, but this will be the top layer of "air" so you'll want it to be about equal to the bottom level so you can easily see both layers.) **Mix in a few drops of red food coloring.** *Explain that the red water represents warm air and warm air is lighter or less dense than cold air, as discussed in the first activity.*

Fill the measuring cup with water (about as much water as you have in the bowl) and saturate it with salt. You can do this by adding salt until no more dissolves. **Put several drops of blue food coloring in the salt water.** *Explain that the blue water represents cold air and cold air is more dense than warm air. Saltwater is also more dense than freshwater.*

Pour the blue saturated water slowly and carefully through the funnel making sure that the end of the funnel is on the bottom of the bowl. You should have two layers, blue on the bottom and red on the top. It will be easier to see the distinct layers from the side of the container rather than from above. Ask the students why this happened. *Explain that this is what happens in an inversion where you have cold heavy air under warmer, lighter air. This is a stable condition that inhibits vertical mixing and thus dilution of pollution.*

Demonstrate what can happen to pollutants that are released under these conditions. **Take green food coloring and put it into the bowl drop by drop.** It will layer out between the blue and the red. Ask the students to describe what they see. **Explain that the pollutant does not mix but becomes confined in the area it is emitted into.**

Show what happens when the wind begins to blow or a storm comes in and vertical mixing occurs. **Mix up the contents of the bowl and the pollution will be diluted.** *(Wrap up activity idea: Students each draw a picture of a town or city in a valley. Label where the temperature layers of the inversion (cold, warmer, cooler) might be during an inversion and talk about what pollution sources are in the students' towns and how people might be affected if the pollution settles.)*