

## Lesson 8 - Highs, Lows and Wind

## Overview

In this lesson, students connect what they have learned about density, air pressure and differential heating to the weather--ultimately they will do this with tornadoes. Here, they differentiate between high and low pressure systems. They simulate the movement of air molecules between those systems through a demonstration. Students call upon their own experiences to discuss weather conditions and identify how scientists measure the movement of molecules using a 3D animation. They will begin to understand that tornadoes and other storms are low pressure systems and recognize that wind always blows from areas of high pressure to areas of low pressure.

TIME: 1 CLASS PERIOD

### Students will:

- **Engage** by giving examples of 'happy' and 'lousy' weather.
- Explore by modeling the air molecules associated with high and low pressure systems.
- **Explain** by observing 3D animations of high and low pressure systems.
- ► Elaborate by discussing why wind blows in weather systems.
- Evaluate by deciding whether tornadoes develop from high or low pressure systems.

## **Content Background**

Weather maps will indicate areas of HIGH '**H**' and LOW '**L**' air pressure signifying the type of weather conditions one can expect. This air pressure can really be thought of as the relative weight of the air molecules above. Weight or pressure of the air above is measured at the surface of the Earth with a barometer. The amount of air molecules packed in a specified volume of air near the Earth's surface, or high atop a mountain, is associated with the density of the air.

High and low pressure systems involve air that has a certain amount of moisture. The air has variable types of air molecules, and different temperatures and density.

Low pressure systems are associated with a lot of moisture and precipitation. As you know, nitrogen makes up 78% of the molecules in the air. When there is low pressure, the number of water vapor molecules in the air increase and displace nitrogen molecules for a certain volume. One molecule of nitrogen is heavier than one molecule of water. Therefore, when water molecules replace nitrogen molecules, the air weighs less and is lighter. Although the air is more humid, it is less dense. Less dense air results from heating from the Sun. This excites molecules making them spread apart and become less dense.

High pressure systems are associated with dry air. Dry air has more molecules of nitrogen or oxygen with it than humid air. Dry air molecules are heavier than air with a lot of water vapor molecules. This means high pressure air is generally more dense than moist air masses. Also, high pressure air is generally cooler; the molecules are closer together, sometimes with less heat energy. These molecules are not as excited and spread apart. They stay closely-packed together with less heat.

Dry air, containing the heavier molecules, is dense; it stays close to the ground. There is little cloud formation. High pressure systems are associated with abundant sunshine and blue skies.

In contrast, low pressure, low density, lighter air rises. You know what happens to air when it rises, since if you have ever driven or hiked up a mountain, the air is cooler. When less dense air rises, it cools and clouds form. Precipitation often occurs. Low pressure systems are associated with humid air, clouds and precipitation, all conditions that bring about storms. Storms such as Atlantic hurricanes, or cyclones as they are called in the South Pacific, and even blizzards and tornadoes, are low pressure systems. The center of the storm or tornado has the lowest pressure. If you weigh the air in the center of the storm, it measures the lightest.

Air molecules move from areas of high pressure, or cooler, heavy, sinking air, to areas of low pressure, or warmer, light, rising air. This movement of air molecules creates **wind**. In a low pressure area, the molecules rise. Molecules from high pressure areas rush in to replace them. Wind speeds depend on the small or big differences in pressure across a certain distance. When a front passes through an area, representing a difference in pressure between two air masses, high winds are expected. A **front** is the boundary that separates two air masses with different characteristics, such as temperature and moisture.

High and low pressure areas can change within a period of hours, impacting the direction of winds. For example, on a sunny day at the beach, the land heats up more quickly than the water. The heated air over the land rises, and molecules of air from over the water rush onshore to fill in the gap over land. This is a sea breeze. At night, the opposite occurs. Land cools quickly, but the water temperature remains basically the same. Winds will generally go from the land toward the water.





#### **Misconception Alert:**

When people talk about humid air, they often say that the air feels 'heavy" In fact, humid air is lighter, less dense and it is this air that is associated with low pressure systems.



A hygrometer measures the humidity of the air.

## Aim:

How do HIGH and LOW pressure hold the clues to understanding the way wind blows?

## **Materials Needed:**

- 1 bag large jelly beans
- 1 bag small jelly beans
- Plastic baggy

## Engage

#### <u>Say:</u>

"For some people the weather has a significant impact on the mood that they experience. For you, a 'happy' or a 'lousy' day may be associated with certain weather conditions. While there are many other things that affect your day, think about what type of weather conditions would make a 'happy' or 'lousy' day in your mind. Fill in the chart with your answers."

 $\checkmark$ 

**Objectives:** 

Students will be able to:

✓ Compare and contrast HIGH and LOW pressure systems in terms of wind,

Explain that wind always blows from

HIGH pressure to LOW pressure areas.

humidity, air pressure and other conditions.

Students should work in pairs for this activity.

## Discuss the conditions that you notice during 'happy' or 'lousy' weather. Record your ideas in the chart below:

Happy Weather	Lousy Weather
Sunny, warm, dry, pleasant, etc.	Cloudy, rainy, cold, snowy, etc.

## Explore

#### Say:

"As we learned, the atmosphere is made up of molecules. With heat transfer, molecules move around in the atmosphere affecting weather. In the following demonstration, we will use jelly beans to represent air molecules."

Conduct the following demonstration for the class:

**Teacher Tip:** You may also do this as a class activity. Provide each group of students with the necessary materials.





### **Teacher Demonstration**

1. Fill a plastic baggy with 50 large jelly beans.

#### <u>Ask:</u>



The jelly beans represent molecules in the atmosphere. Which molecules do the jelly beans represent?

The atmosphere is made up of mostly nitrogen and oxygen as well as other molecules in small amounts. The jelly beans represent these molecules.

- 2. Allow various students to feel the weight of the bag.
- 3. If you have access to a scale or balance, weigh the bag and record the weight.

4. Remove 10 large jelly beans and replace them with 10 small jelly beans. Show students the different sizes of the jelly beans and tell them that the small jelly beans represent water molecules.

#### <u>Ask</u>:



Do you think the bag weighs more or less than before?

The bag weighs less because some heavier molecules were replaced by lighter molecules.

#### Say:

"What we just observed is a model of what happens in the atmosphere. Water molecules, represented by the small jelly beans, are lighter than the molecules of nitrogen and oxygen. They are represented by the large jelly beans that make up most of the air.

When it gets more humid, or a storm system moves into an area, the air contains more moisture or water molecules. Water molecules displace and replace other gas molecules in the air, such as nitrogen and oxygen. Air that has a lot of moisture is lighter than air that is dry. This air, which is lighter compared to air around it, rises and forms clouds. The result can be precipitation."



#### Say:

"Recall from the previous lessons that scientists use a tool called a barometer to measure air pressure. The barometer in the animation shows you the air pressure as Hurricane Andrew, pictured in the upper left corner, approaches and leaves South Florida.

◊ Show students the *Hurricane Animation*.

- Launch the 3D-VIEW menu by
  - double-clicking on the desktop icon.
- Click on: Atmosphere.
- Click on: Lesson 8 Highs, Lows, and Wind.
- Click on the *Hurricane Animation*.



Hurricane Animation

Students will watch how the air pressure changes as Hurricane Andrew approaches and leaves South Florida. Notice the density of the molecules hitting the mercury.

#### <u>Ask:</u>

3D-VIFW



Describe what happens to the weight of the air as the hurricane moves through.

From the plot, you notice the Florida air pressure started high and it dropped dramatically as the storm approached Florida. Then when the storm was heading away, the pressure went from low to high again. Clouds decreased as pressure went up again.



Is the storm associated with HIGH or LOW pressure systems?

Low pressure. The barometer reading falls as the hurricane blows through.

Read the following passage as a class.

**Hurricanes** are among the most powerful and dangerous weather phenomena on Earth. They are intense storms that form over a warm ocean when certain conditions in the atmosphere are present. For example, Hurricane Andrew formed over the warm, tropical water off the coast of Africa. Like all hurricanes, Andrew was a low pressure system moving across the ocean. Severe precipitation and high winds affected hundreds of miles surrounding the storm's center, or 'eye', as it reached the Florida coast and traveled inland. Tornadoes will sometimes form from thunderstorms associated with hurricanes.





◊ Show students the *3D Hurricane Andrew* image.



Credit: AVHRR data. NASA/NOAA

#### 1. What characteristics of Hurricane Andrew do you observe?

High clouds near the center; 'hole' where the eye of the hurricane is located; circulation; bands of high clouds from the center (cirrus); etc.

## Explain

## Show students the *3D High and Low Pressure Systems Animation*.



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- Launch the 3D-VIEW menu by double-clicking on the desktop icon.
- Click on: Atmosphere.
- Click on: Lesson 8 Highs, Lows and Wind.

• Click on the *3D High and Low Pressure Systems Animation.* 



3D High and Low Pressure Systems Animation

Students should work in pairs to complete the chart below and answer the questions that follow.

Using the animation of a HIGH and LOW pressure system, list the characteristics that you see in the chart below: Teacher Tip: Evaporation and rising air is covered more thoroughly with the interaction between systems in *Project 3D-VIEW's 3D Water Cycle Animation* in the Earth Systems Unit.

High Pressure System	Low Pressure System
Possible Observations:	Possible Observations:
-Sinking air molecules -More dense air molecules -Molecules moving from the high to the low pressure system -Air molecules moving clockwise	-Rising air molecules -Less dense air molecules -Map shows it's green –it's raining -Air molecules moving counterclockwise

# 2. Think of a weather map on a typical news program. Sometimes there will be a 'smiley face' next to the H for high pressure, or a 'frowning face' next to the L for low pressure. Why is this?

With the high pressure system, you would expect fair weather. The low pressure system means more moisture, clouds and rain, less pleasant weather.

**Teacher Tip:** It is important to introduce the idea that air tends to move from an area of HIGH to LOW as molecules flow to simply reach equilibrium. Specifically, in this lesson, students will determine that winds blow from an area of HIGH pressure to an area of LOW pressure. Heavy air sinks toward areas where the air is not as heavy.



It is easy to remember how to figure out the effect that HIGH and LOW air pressure will have on your picnic or soccer game! Think:



stands for **HAPPY** weather, **HIGH** pressure, **HEAVY**, sinking air

In a 'HAPPY' HIGH air pressure area, the weather is nice. The HEAVY air is dry. There is no rain. Dry air has mostly nitrogen and oxygen molecules. This dry air is heavier than air with a lot of water molecules. The dry and dense heavy air sinks under moist air.

The air molecules are tightly packed and **dense** and HIGH in pressure. These molecules stay close to the ground. Dense air tends to be cool because molecules are tightly packed and not excited with heat energy. Therefore, high pressure systems are also associated with cool air.

L is for LOUSY weather, LOW pressure, LIGHT, rising air

'LOUSY' LOW pressure areas have air that is full of water, moisture, and clouds. Moisture-filled air is **humid** air. Low pressure air is less dense than high pressure air.

Heat from the Sun causes air molecules to become excited and spread apart, taking up less space. Since the molecules are lighter, and less dense, they rise. Low pressure air can also be warmer because molecules are excited by heat energy.



High and low pressure air masses affect our local weather.

◊ Return to the chart in the **Engage** section of the lesson.

<u>Ask:</u>



Were your descriptions of 'Happy' and 'Lousy' weather correct?

*Discuss and compare students' initial associations with weather to what they learned so far.* 

## Elaborate

#### Ask:



What is wind?

Allow students to share their diverse answers. Wind is moving air molecules.

#### <u>Say:</u>

"Wind is something with which we all have experience. Let's view an animation that will show us what wind really is!"

◊ Show students the *3D Sea Breeze Animation*.



- Launch the 3D-VIEW menu by
- double-clicking on the desktop icon.
- Click on: Atmosphere.
- Click on: Lesson 8 Highs, Lows, and Wind.
- Click on the *3D Sea Breeze Animation*.



3D Sea Breeze Animation

◊ Students should work in pairs to answer the questions.

#### After viewing the animation, answer the following questions:

#### 2. Describe what is happening in the animation.

At a beach during the day, the land heats up. Air molecules rise. Molecules from over the ocean blow in to fill the void in the air over the land.

The opposite happens at night.

#### 3. In which direction do the molecules blow?

Air flows from areas of high pressure to areas of low pressure.



4. The animation shows 'cooler, heavier air' sinking. Explain why heavy or dense air is typically cooler.

Molecules that are densely packed are not currently excited by energy from the Sun. Therefore, it makes sense that dense molecules are usually cooler than less dense molecules that may be excited by heat from the Sun.

As we saw in the 3D animations, wind blows from areas of HIGH pressure to areas of LOW pressure. The greater the differences in pressure, the faster the wind will blow.

Let's see how winds blow around HIGH and LOW pressure systems.

View the *3D High and Low Pressure Systems Animation* again and answer the following questions:

5. Do the winds around a LOW blow clockwise or counterclockwise?

*Counterclockwise (Clockwise in the southern hemisphere)* 



*Clockwise (Counterclockwise in the Southern Hemisphere)* 

**Teacher Tip:** Since HIGH, or HAPPY, is a positive word, some students will easily associate HIGH with 'clockwise' flow and the more negative word, LOW, or LOUSY, with 'counterclockwise' wind flow around the center.



**Systems** Animation

## **Evaluate**

1. Are tornadoes associated with HIGH pressure or LOW pressure systems? How do you know?

Storms are generally low pressure systems, associated with 'lousy' weather. Tornadoes form as a result of thunderstorms.

#### 2. In a tornado, do winds blow clockwise or counterclockwise?

#### Counterclockwise

3. On the image below, draw the direction that the wind would blow.



4. Draw two pictures, one that shows a 'HIGH pressure day' and one that shows a 'LOW pressure day'. Use the following vocabulary words to describe your pictures:

- humid
- light air
- air pressure
- e clockwise
- moleculesheavy air
- counterclockwise
- counterclockwise

'HIGH pressure day' would be sunny and clear. The air molecules are more tightly packed in this heavy air. The air pressure is greater. The winds in this system blow clockwise.

'Low pressure day' would be cloudy and rainy. The light air rises as the air molecules move farther apart. The air is more humid with possible rainy conditions, and the winds blow counterclockwise.