In The Blink of an Eye

Subject: Science

Grade Level: 6th – 8th Grades

Rationale or Purpose: This activity introduces the concept Bernoulli's principle as it relates to a hurricane. The "eye" of a hurricane is considered to be the calmest part of the storm. However, this is a common misconception in that a lot of energy and force is actually generated toward the eye!

Source of Lesson: *Hot Science – Cool Talks* CD-ROM # 44: "Is Climate Change Increasing Hurricane Activity?"

Materials:
- Movie clip of *Twister* scene in which a cow gets "sucked" up into a tornado
- Pencil/paper

Lesson Duration: 20 – 25 minutes

TEKS Objectives:

6th Grade Science 111.22

(2A) plan and implement investigative procedures including asking questions, formulating testable hypotheses, and selecting and using equipment and technology
(2B) collect data by observing and measuring
(2C) analyze and interpret information to construct reasonable explanations from direct and indirect evidence
(3C) represent the natural world using models and identify their limitations
(5A) identify and describe a system that results from the combination of two or more systems
(5B) describe how the properties of a system are different from the properties of its parts

7th Grade Science 112.23

(2A) plan and implement investigative procedures including asking questions, formulating testable hypotheses, and selecting and using equipment and technology
(2B) collect data by observing and measuring
(2C) organize, analyze, make inferences, and predict trends from direct and indirect evidence
(2D) communicate valid conclusions
(5A) describe how systems may reach an equilibrium
(8A) illustrate examples of potential and kinetic energy in everyday life
(14A) describe and predict the impact of different catastrophic events on the Earth

8th Grade Science 112.24.

(2A) plan and implement investigative procedures including asking questions, formulating testable hypotheses, and selecting and using equipment and technology
(2B) collect data by observing and measuring
(2C) organize, analyze, evaluate, make inferences, and predict trends from direct and indirect evidence
(2D) communicate valid conclusions
(3A) analyze, review, and critique scientific explanations, including hypotheses and theories, as to their strengths and weaknesses using scientific evidence and information
(3C) represent the natural world using models and identify their limitations
(10B) describe interactions among solar, weather, and ocean systems
(12B) relate the role of oceans to climatic changes

Background Information[1]:

Daniel Bernoulli, a Swiss scientist of the 18th Century, studied the relationship of fluid speed and pressure. When a fluid flows through a narrow constriction, its speed increases. This is easily noticed by the increased speed of a stream when it flows through the narrow parts. The fluid must speed up in the constricted region if the flow is to be continuous. Bernoulli wondered how the fluid got the energy for this extra speed. He reasoned that the energy is acquired at the expense of a lowered internal pressure. His discovery, now called **Bernoulli's Principle, states: The pressure in a fluid decreases as the speed of the fluid increases.**

Bernoulli's Principle is a consequence of the **conservation of energy**. When a fluid flows, it has kinetic energy because of its motion. It also has gravitational potential energy, or stored energy due to the Earth's gravitational field. If the fluid picks up speed, or accelerates, it has more kinetic energy than before. Let's suppose that the fluid does not move up or down as it travels through the constricted region. Then its gravitational potential energy does not change. How, then, does the accelerating fluid in the constricted region gain kinetic energy?

The answer is that the surrounding fluid does work on the part that goes through the constricted region. The accelerating fluid is pushed from behind by the forces that produce pressure. They do work on the accelerating fluid and the accelerating fluid has to do work on the fluid ahead of it. It turns out that when the fluid is accelerating, more work is done on it than it does on the fluid ahead. In this way, its kinetic energy increases.

All through the fluid, some parts are gaining energy while others are losing energy. The net energy of the entire fluid is unchanged. Air pressure drops in a tornado or hurricane. As it turns out, a house with no vents and airtight closed doors is in more danger of losing its roof than a well-vented building. This is because the air pressure inside is higher than that outside. Therefore, it is more likely for the roof to be pushed off than blown off.

Procedure:

1. At the start of this lesson, engage the students by playing the movie clip of Twister of the scene where the cow gets 'sucked' up into a tornado-like waterspout.
2. Ask the students why this happens. They may think it is due to the wind's velocity.

[1] Source: BBC (http://www.bbc.co.uk/)

3. Introduce Bernoulli's Principle: As the speed of a moving fluid (liquid or gas) increases, the pressure within the fluid decreases. As the fluid decreases in pressure, it rises!
4. Ask the students to come up with their own formula or symbology to explain Bernoulli's Principle.
5. **Demonstration of Bernoulli's pressure principle in action**: have your students hold a sheet of paper in front of their mouths with their lower lips slightly above the bottom of the paper (this works best if the paper is torn in half). When you blow across the top surface, the paper rises. This is because the moving air pushes against the top of the paper with less pressure than the air that pushes against the lower surface, which is at rest.
6. Show the diagram (below) of how a hurricane is energized. The speed of water vapor increases between A and B as gains energy from the heat of the ocean. By the time this water vapor arrives at the eye (a very low pressure region), it gets drawn upward into the atmosphere. As the air travels though C and D, it loses energy and cools causing it to sink.

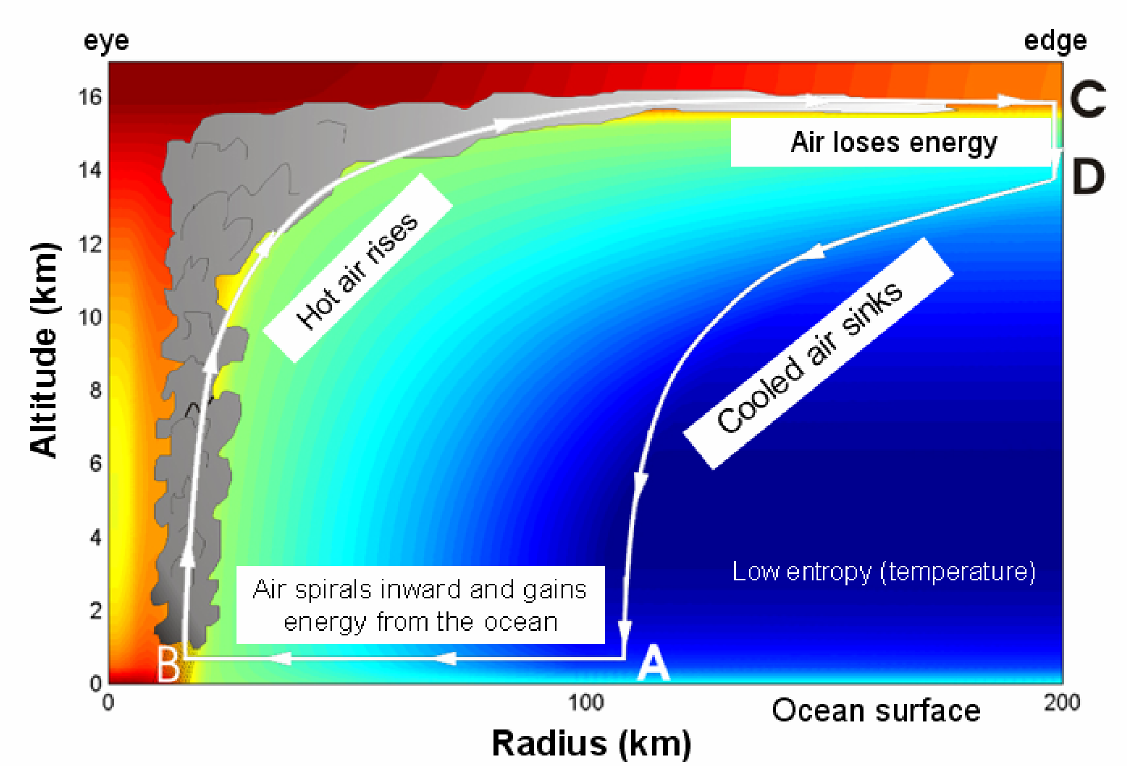

Figure 1. The Water Cycle of a Hurricane. The colors depict the **entropy** distribution; cooler colors indicate lower entropy. Loosely, this means the total heat content of the air. Note that as air approaches the eyewall, its entropy increases rapidly, reflecting the large input of heat from the ocean.

Adapted from figure 10.2 in *Divine Wind: The History and Science of Hurricanes.*

7. Explain that although the eye of the hurricane is considered "calmer" as compared to the rest of the storm, there is still significant force generated by the energy transformations of water in the hydrologic cycle. This force

of motion toward the eye, and the lack of pressure inside the eye, draws the air upward, and thus feeds energy into the rotating hurricane.

8. Introduce a simplified Bernoulli's formula: p = mv, where p = momentum, m = mass, and v = velocity. Have students work through sample problems.

Inquiry

- We've given extensive examples of Bernoulli's Principle in action through hurricanes. What are other examples of Bernoulli's Principle? This principle can be used to explain airplane flight, a "curveball" in baseball, and why windows tend to explode, rather than implode in hurricanes or tornadoes.

Ideas for Data Collection and Analysis:

- You may want your students to keep a journal, recording their predictions, diagram of the Bernoulli demonstrations, etc.
- Concept mapping of the how Bernoulli's Principle can be applied to hurricanes, curveballs, and airplanes
- Encourage questions and connections
- Relate Bernoulli's Principle to the hydrologic cycle in hurricanes