



Convection Cells and Rain Lesson Plan

NS 696 V: Weather and Climate for Educators

Intended for: High School Physical Science classes, though could this be done at middle school level as well.

Science Standards:

Materials Needed: Aquarium (multiple ones if possible), water, container for water, water ionizer (mist machine), incense or something else that will smoke, matches or lighter, incandescent bulb with power source, cookie sheet with raised edges, ice cubes

Background Information Assumed: What energy is, energy balance, physical properties of atmosphere, etc.

Objective: Students will understand and be able to explain principles involved in convection cell formation. Based on what students learn and prior knowledge, students will be able to predict what will happen when more water is introduced into their mini atmosphere.

Theory: (As taken from Little Shop of Physics, Colorado State University) Convection cells have an important role in thunderstorms and other weather phenomenon. Convection cells occur due to the fact that earth is heated differentially. At the poles, sunlight shines at an angle and is spread out over a much larger area. This creates a high pressure area of colder, denser air. As the cold air sinks, it becomes even colder. It moves away from the poles to low pressure areas with warmer, less dense air. This warm air is pushed up by the buoyant force of the colder denser air. As the warm air rises, it cools, and the convection cell recycles itself, over and over again.

Air rises for a simple reason: it warms up, and warm air rises. When the sun rises, it warms the earth. So air near the earth's surface will warm. But it won't go anywhere just yet. It is said that the air is stable.

Imagine that you "nudge" a parcel of air and move it upward. As this rising air moves upwards it expands. As it expands it cools. (The air had to do work to expand, and so its

temperature must decrease; the only source of energy for the work of the expansion is the thermal energy of the gas. For the large air masses that move in the atmosphere, this is an adiabatic expansion; no thermal energy is transferred from the adjacent air.)

A rising parcel of dry air will cool by about 10 degrees Celsius for each 1000m it rises. This is called the dry adiabatic lapse rate. So the parcel of air “nudged” upward will cool.

Now suppose you measure how the temperature varies with altitude in the atmosphere. A measurement of actual change in temperature with height in the atmosphere is the environmental lapse rate. This can vary, but a typical value, for the “standard atmosphere” is 6.5 degrees Celsius of cooling for a 1000m rise in elevation.

This means that a parcel of air that we “nudge” upward will be cooler than the air it meets; it cools of by 10 degree Celsius for every 1000m it rises, but the air only cools of by 6.5 degrees Celsius. This means that the atmosphere will be stable. The parcel we “nudged” upward will cool off, be cooler than the air surrounding it, and then fall.

Now suppose you warm up the air near the earth so that the temperature falls more quickly with height. Suppose the temperature drops by 12 degrees Celsius for every 1000m. Then the air parcel we “nudge” upward will cool less than the air around it. The air will be warmer than the air around it, so it will keep on rising. A small nudge turns it into a runaway rise; the air is unstable.

As the days heat up this is exactly what happens. The temperature profile changes until the atmosphere becomes unstable, and air masses start to rise, forming clouds as they go.

Structure of the Lesson:

Engage and Explore: Groups of students will be given written procedures to be followed.

1. Light incense stick, put into bottom corner of aquarium, put cookie sheet over top of aquarium, observe, write down observations, make hypothesis of observations
2. Repeat procedure from #1, but now also place powered incandescent bulb near bottom corner of aquarium as well, again observe, write down observation, make hypothesis of observations
3. Repeat procedure from #2, but now place ice cubes on top of cookie sheet, observe, write down observations, make hypothesis

Between each step (1, 2, and 3) clear aquarium of smoke before going to next step!

Explain: Concepts already learned leading up to Activity, then explain what everyone is seeing (see Theory) while recreating the activity again in front of class

Extend: Repeat all steps, but this time instead of smoke from the incense use the ionizer (mist machine). Does anything change? Why? Explain your hypothesis based on previous knowledge!

Evaluate: “Grow and Glow” or any variety of other evaluation tools depending on students, time, etc.

Lesson generated by David Dennis