

Birth of a Hurricane: Energy Cycles that Form Devastating Storms

Lesson plan for grades 3-8 (Teacher can adapt this lesson to individual grades depending on activities selected)

Length of lesson: 60 min

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SOURCES AND RESOURCES:

- Hurricanes in the Gulf of Mexico: The History and Future of the Texas Coast, By Dr. Kerry A. Emanuel
<http://www.esi.utexas.edu/k-12-a-the-community/hot-science-cool-talks/gulf-hurricanes-our-history-and-future>
- Parts of a Hurricane diagram and explanation
<http://www.accuweather.com/en/weather-blogs/HurricaneFacts/what-are-the-parts-of-a-hurric/31027>
- Differences between a tropical storm and a hurricane
<http://www.komonews.com/news/archive/4097441.html>
- Categorizing hurricanes
<http://geography.about.com/od/lists/a/hurrcategories.htm>
- Create a Cane simulation/game
<http://www.nhc.noaa.gov/outreach/games/canelab.htm>
- Aim a Cane simulation/game
<http://www.nhc.noaa.gov/outreach/games/movncane.htm>

POTENTIAL CONCEPTS TEKS ADDRESSED THROUGH THIS LESSON (Grades 6-8 Emphasized):

§112.18 Force, Motion, and Energy, Grade 6: 9A, 9B, 9C

§112.19 Force, Motion, and Energy, Grade 7: 8A

§112.20 Force, Motion, and Energy, Grade 8: 10A, 10B, 10C

PERFORMANCE OBJECTIVES:

Students will be able to:

- Describe the process by which hurricanes are formed and the conditions they are formed in
- Make basic hurricane predictions based on patterns and given information
- Discuss the effects that hurricanes have on the environment
- Define Conduction, Convection, and Radiation

MATERIALS (per group of four):

- Hurricane Power Point Presentation (provided after the Worksheet for this lesson)
- Computers with solid Internet access (at least 1 for each pair of students)
- Hurricane worksheet (provided after the Evaluation section of this lesson)

CONCEPTS:

Conduction: Heat transfer from one object to another through direct contact. This can be seen when a pan handle conducts some of the heat from the pan that is on the stove.

Convection: Heat transfer by the physical movement of an object or particle from surface to surface. This can be seen when heated water at the bottom of a pot rises to the surface of the water.

Radiation: Heat transfer from a heat source through a single medium to an object in the form of waves. This can be seen by the rays of the sun heating the earth's surface.

Storm Surge: Large tsunami like waves that are caused by dramatic wind torrents directly above the ocean's surface. These torrents are often the products of strong tropical storms and/or hurricanes.

BACKGROUND:

Hurricanes have played pivotal roles in the cultures of many coastal civilizations. When the Spaniards first set foot on the islands within the Caribbean, there were written and pictorial documents of these cyclic storms. The Mayan's polytheistic religion even made room for a storm god named Huracan. This name was later translated into the word Hurricane. These circular storms have even caused havoc and mass destruction in our modern and advanced world.

Around the year 1908, the most devastating hurricane to ever hit North America caused cities to be completely demolished and nearly 8000 lives to be lost. To this day, it is considered the largest natural disaster in US history. Often called the Galveston hurricane, this monstrosity of a storm (possibly a category 5) managed to work its way through the gulf of Mexico nearly undetected by the early warning systems of the US. Despite the Cuban's initial reports of the storm turning past Florida and heading for Texas, the US safety officials stated hurricane warnings up towards New York. Acting as a grim lesson, the technologies and techniques behind predicting hurricane patterns and movement have greatly increased after that point. (see minute 18:54 in Emanuel Lecture)

Many questions arose from the rubble at Galveston including how these storms actually work and what can be done to best prevent another catastrophe. With more technologies allotted to the meteorologists and scientists, they were able to figure out the mechanics of these storms and how they come into existence. Referred to as an engine, these storms use an intricate series of moisture and pressure shifts caused by simple radiation, conduction, and convection to grow and move around the ocean. (see minute 12:46 in Emanuel Lecture). From such information comes the ability to predict hurricane paths and intensity.

Newer and better early warning systems and being developed constantly to give evacuation sites even more time to act. Since these systems only act as warning, it is ultimately up to the evacuation teams to get people out of a danger zone when it needs to be done. (see minute 32:59 in Emanuel Lecture)

PREPARATION:

Use the notation (slide #) to go to each slide on the Hurricane Power Point Presentation (see materials). Have computers set up or brought in. Make sure each computer is functioning and has proper Internet access. A good idea might be to have all of the computers on the “Create a Cane” web page. Have a “hurricane worksheet” printed off for each student. Have any objects that the teacher wishes to use to demo ready for class.

ENGAGE:

Teacher Says: Can someone raise their hand and tell me what they see in these pictures? (slide 2) That's right, these are pictures of hurricanes. But how could you tell? What parts of the image tell you that this is a hurricane and not simply a tornado or a bunch of random clouds?

Possible Student Responses:

- There is an empty spot in the center.
- The clouds are forming a circular shape and focus into the center like a funnel.

Teacher Says: Those are some great responses and for the most part, you guys are exactly right. Hurricanes have several distinct characteristics that allow scientists to distinguish them from common storms or other phenomenon. In order to be professional and proper in our investigations today, let's learn some proper terminology.

(slide 3) Believe it or not, the term hurricane is actually a term specific to the western world. Dating back to the Spaniards initial voyages to the Americas in the early fifteen hundreds, there exist written documents of tribes, particularly the Mayans, depicting circular storms. These storms were often said to be the doing of their storm god Huracan which the Spaniards later transformed into the word hurricane. In the eastern world, these storms came to be called typhoons after the Greek monster Typhon. However, for convenience, the universal language of science coined the term *tropical cyclone*. This term is perfectly interchangeable with Hurricane and Typhoon.

We've been talking about hurricanes but we haven't even exactly defined what one is. Just as most of you stated earlier, there are several key components to determining if a storm counts as a hurricane (slide 4). Look at this diagram. This image represents the cross section of a hurricane, or a view of the hurricane as if it were cut in half down its axis. Let's start by naming the most obvious characteristic, the eye of the hurricane (portion 4). The eye is like a pipe in the middle of the storm that is actually calm and dry hence the phrase, “the eye of the storm.” Bordering the eye is the eye wall (portion 3) which is has the exact opposite

conditions. For reasons that will be explained later, the eye wall has the most violent winds and heaviest rain. If you can notice, the air in the eye wall is rapidly rising up towards the opening of the eye. The air then becomes calmer and sinks. Forming rings around the eye of the hurricane are the feeder bands which also are characterized by heavy wind and rain (portion 2). Finally, tens of thousands of feet above the surface of the ground is the outflow (portion 1) which forms the visible spiral that is indicative of the hurricane formation. The size of the outflow can occasionally signify the hurricane's intensity.

Now, let's talk about what differentiates a hurricane from some other tropical storm (slide 5). In actuality, the answer to this question is quite simple. When a simple storm cluster is located in the vicinity of the Caribbean, it is named a tropical depression. The signature of these storms is nothing more than moderately heavy rains and the fact that it has the potential of further development. (slide 6) Once the wind speeds of the storm surpass the 39mph barrier, the storm then becomes categorized as a tropical storm and given a name such as "Tropical Storm Lucy." More often than not, these storms actually dissipate or weaken. Only 13% of the time do these storms actually turn into category 3-5 hurricanes (slide 7). If the storm's wind speeds surpass the 74mph barrier, then it can be considered a Hurricane or Tropical Cyclone and keeps its existing name. Categorizing these hurricanes then depends on several variables such as maximum sustained wind speed, damage category, storm surge size, and approximate pressure. Researchers and meteorologists can use various instruments and techniques to calculate these values and assign a proper category to each hurricane.

Zoom out for a second (slide 8). We've talked about the technical definitions of a hurricane but we haven't gone over the obvious chaos that one can cause. How do hurricanes impact the environment? What kinds of destruction can they cause?

Possible Student Responses:

- Hurricane winds can blow trees down and destroy houses.
- Waves are often created by hurricanes that flood huge areas of land.
- Hurricanes can destroy beaches and cause minor changes to coastal terrains.

Teacher Says: Those excellent responses. Hurricane winds are responsible for not only tearing down standing objects but also for creating giant surface waves known as **storm surges** (slide 9). These storm surges are what often cause the devastating flooding that is characteristic of upper category hurricanes. Like some of you already mentioned, hurricanes have the ability to drastically change coastal terrain. A combination of the ocean waves and powerful winds manage to relocate tons of sand and soil to various parts of the affected area. That is why beaches might have different sediments or coloration even years after a major hurricane has hit. Something that people overlook and don't realize is that hurricanes very often give rise to dozens of adjacent tornadoes. The pressure shifts around the hurricane and the fluctuating moisture content in the air allow for small twisters to spin off the hurricane's path and separately cause destruction.

It can be scary to see such natural destruction occur. But what's behind the curtain; what exactly allows for a hurricane to form?

EXPLORE:

Teacher Says: From the knowledge that you currently possess, it may be somewhat difficult to tell me what the ideal conditions for a hurricane are.

1. I want everyone to open their laptops and go to the “Create a Cane simulation game” (see resources for link).
2. When I tell you to begin, I want everyone to follow the instructions on the screen and create the ideal conditions for a hurricane.
3. If you are lost, hold your cursor over the question marks and a bubble will appear with advice and information. Make sure you read this information carefully as it pertains to the next part of the lesson.
4. Your goal is to get to 80 points. To do this you must adjust the 4 sets of conditions to optimize the chances of creating a hurricane.
5. If you achieve the 80 points, go ahead and do the other stages in the game until I call time.
6. If you have questions, don't hesitate to raise your hand and ask for help.

I want everyone to stop now. Let's get together and discuss the things you learned and noticed while playing the game.

EXPLAIN :

Teacher Says: Let's talk about the four categories of conditions that you all played around with to optimize the chances of a creating a hurricane. The first thing we'll talk about will be the wind levels. What kinds of things did you notice about this feature in the game? What things did you do that optimized your hurricane probability?

Possible Student Responses:

- There was an upper, middle, and lower layer of winds as well as a direction of winds option.
- To optimize your points you had to have all the levels of winds be blowing in the same direction.
- You actually got the most points if your winds were light or medium rather than strong..... this was confusing to me.

Teacher Says: Hurricanes can reach 50,000 ft. into the sky (slide 10). At these heights there are dramatic changes in pressure and temperature. For convenience and simplicity, scientists and meteorologists often split the sky into 3 main atmospheric levels which everyone played around with in the simulation.

Side notes: Particles of air or water that have more energy/heat behave differently (slide 11). Warmer water and air rises to the top of a surface while cooler temperature water or air tends to sink to lower levels. Warmer particles are also more “energetic” and tend to further apart from each other. This constitutes for the fact that warmer air is lower in pressure than cooler air.

Teacher Says: As we continue to dissect and analyze this game we will continue to notice that heat transfer and pressure shifts play a key role in the formation of a hurricane. So, in order to be formal and proper with our understandings, let's learn some scientific terms to describe the methods by which heat/energy is moved around.

The primary source of heat that is responsible for most of the world's sea water evaporation is the sun. The heat waves that travel from the sun to the earth's surface is referred to as **radiation** (slide 12). This type of heat transfer is summarized by waves of heat traveling through a single medium to another object.

There is also the existence of **convection** in the mechanism by which a hurricane is formed (slide 13). Hurricanes are formed by various pressured airs of varying temperatures shifting around in a specific manner. This is done by convection, which is the transfer of heat by the actual movement of material. In this case, the air that is being heated shifts up to higher altitudes and displaces cooler air. Once at those altitudes, the air cools off and sinks back down as new hot air is rising. This ultimately creates a convection cycle that causes lots of wind to be created. **Conduction** is the third method by which heat can be transferred, but this is not very applicable to the formation of hurricanes (slide 14). Conduction is the process by which heat is transferred directly from one object to another via contact. This is like how a pan draws the heat from a stove top.

Moisture content was also a major factor in this game. Does anyone have any ideas why it was more beneficial to have moist air rather than dry air?

Possible Student Responses:

- Moist air has water in it so it allows for hurricanes to make more rain.
- If the air is wetter than it is harder to change its temperatures

Teacher Says: Those are some interesting responses. The primary reason why moisture content in air is so important is because there is a greater degree of convection occurring. When sufficient rates of convection occur in certain atmospheric conditions, clouds and thunderstorms can form. Over time and with the right conditions, these storms can mature into hurricanes.

In order to create moisture in the air, there has got to be a supply of water vapor and it has to be cyclic in terms of going from liquid to vapor and back to liquid (slide 15). The ocean water is perfect for this. In fact,

there was an option in the simulation that allowed you to adjust ocean temperature. The higher the ocean temperature, the greater the rate of evaporation and convection, which are both vital to storm formations.

Let's now turn our attention to how the location of origin for these storms plays a role in their path and strength (slide 16). In the simulation, what did you notice as you moved to lower and higher latitudes? That's right; there was a sweet spot in terms of the ideal latitude range to create hurricanes. Being too close or too far from the equator is actually detrimental to the conditions required to create a hurricane. The ideal range is from 10 degrees latitude to about 30 degrees latitude.

We've discussed the basic principles behind the formations of hurricanes, but what about their origins. Where do these storms brew and where do they go?

ELABORATE:

Teacher Says: Get back on your computers. You will all be doing a similar activity to the Create a Cane that was done earlier. This time the simulation is called Aim a Hurricane (see resources for link).

1. Go through the game and follow the written instructions. If an error is made, a bubble will appear that will tell you what was done incorrectly.
2. Play around with the different combinations of placement.
3. Look at the "Aim a Hurricane" section on your worksheet. Try to play around with the settings until you find a combination that result in a hurricane path traveling through the specified locations on the map.
4. Raise your hand for any assistance or questions regarding the activity.

Teacher says: Alright class, I need everyone's attention back to the front. I was walking around and noticed that many of you were able to position hurricanes to hit their targets. This is a valuable activity that will help you understand hurricane paths. If one looks at hurricane paths they can notice that they curve and zig zag about (slide 17). However, with a good understanding of the pressure systems in an area, scientists and meteorologists can predict hurricane paths to provide proper warning to certain cities.

Fun Fact: Did you know that hurricanes in the northern hemisphere spin clockwise while hurricanes in the southern hemisphere spin counterclockwise?

EVALUATE:

Teacher Says: Today you have all taken in a tremendous amount of important information. You have done on-line activities that have introduced you to how hurricanes are formed and what kinds of paths they can take. Use the knowledge you have gathered over the period of this lesson to think a little. Knowing that moisture, wind, and temperature conditions are vital to the formation of a hurricane, what time periods in the year would you suspect there to be the greatest occurrences and least occurrences of hurricanes in the vicinity of the Caribbean and Gulf of Mexico?

Use the blank graph on your worksheet (see Materials section) to draw an estimated trend.
I will be walking around and answering any questions anyone has.

Name: _____ Date: _____

Hurricane Lesson

Aim a Hurricane Activity

1. Create the conditions necessary to form a hurricane path that goes through the city of **New Orleans**.
2. Create the conditions necessary to form a hurricane path that goes through the city of **Norfolk**.
3. Create the conditions necessary to form a hurricane path that goes close to the cities of **Houston** and **Corpus Christi**.

Question 1: What colored path did the hurricane often follow? How did the placement of the hurricane affect its final location?

Question 2: Why do you imagine the simulation stops after the hurricane has been on land for a decent amount of time? Why does it not continue to keep moving?

Use the empty graph below to draw a trend/line representing the times in the year when you think the number of hurricanes increases and decreases.

Name: _____ Date: _____

Hurricane Lesson

Occurrences
of
Hurricanes

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Jan.	Feb	Mar	Apr.	May	Jun.	July	Aug.	Sep	Oct	Nov	Dec
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Month