**Ozone Depletion**

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**Lesson Breakout and Student Goals**

1. **Sea Urchin/UV Radiation Discussion**
   1. SWBAT understand the importance of ozone in the atmosphere for protecting living things from UV radiation
2. **Cotton Ball Activity**
   1. SWBAT understand how density plays a crucial role in the ozone
3. **UV Beads Experiment**
   1. SWBAT understand how ozone thickness can protect against UV radiation
4. **Ozone Data Worksheet**
   1. SWBAT manipulate data to understand the total ozone over time
      1. students will need to know the definition of a Dubson Unit (DU)
5. **Montreal Protocol of 1987 discussion**
   1. students will be able to use the data to explain the affect humans have on the ozone

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**Sea Urchin / UV Radiation Discussion**

A. Show this picture to the students:

icrographs of Sea Urchin
Larvae

Pictured above are two green sea urchin embryos. The healthy embryo is on the left. On the right, a green sea urchin embryo exposed to enough ultraviolet (UV) radiation to cause damage displays an abnormal, extended gut. (Micrographs courtesy Nikki L. Adams, University of California, Santa Barbara)  
Source: http://earthobservatory.nasa.gov/Features/UVB/uvb\_radiation2.php

B. Ask the students to state their observations.

C. The ozone layer protects the Earth from UV rays. How might damage to the ozone layer affect wild shallow water-dwelling sea urchins?

Students should infer that damaging the ozone layer takes away the protection it provides and allows UV light to penetrate the atmosphere at high, sometimes dangerous, levels.

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**Cotton Ball Activity – Thickness of the Ozone Layer**

Gently place the cotton balls in a graduated cylinder so they just barely touch each other.

1. How many cotton balls fit in the graduated cylinder? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Next, use the chopstick to push down on the cotton balls. Add as many cotton balls as you can, as you push down on them with the chopsticks.

2. How many cotton balls fit in the graduated cylinder? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

3. Now, imagine the cotton balls represent the thickness of the ozone layer. Which amounts of cotton balls would be a better protector from the ultraviolet rays coming from the sun? Explain.

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4. Can you guess what people may do to affect the thickness of the ozone layer?

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**UV Beads Experiment**

UV Beads are special beads, which change color when placed in direct sunlight from the UV rays.

Experiment: What will happen to the UV beads when covered by different amounts of cotton balls?

Procedures:

1. Wrap four 100ml graduated cylinders in opaque fabric or paper such that no light can penetrate the sides of the cylinders.

2.Place 10 UV beads into each of four 100 ml graduated cylinders.

3. Do not add any cotton balls to the first graduated cylinder.

4. Place one cotton ball in the second graduated cylinder.

5. Place four cotton balls in the third graduated cylinder.

6. Place eight cotton balls in the fourth graduated cylinder.

7.Place all four graduated cylinders in the same location in the sunlight.

8. After twenty minutes make observations of the UV beads and record the observations.

Was there a difference in the beads of the different graduated cylinders?

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9. If so, how can you explain the difference?

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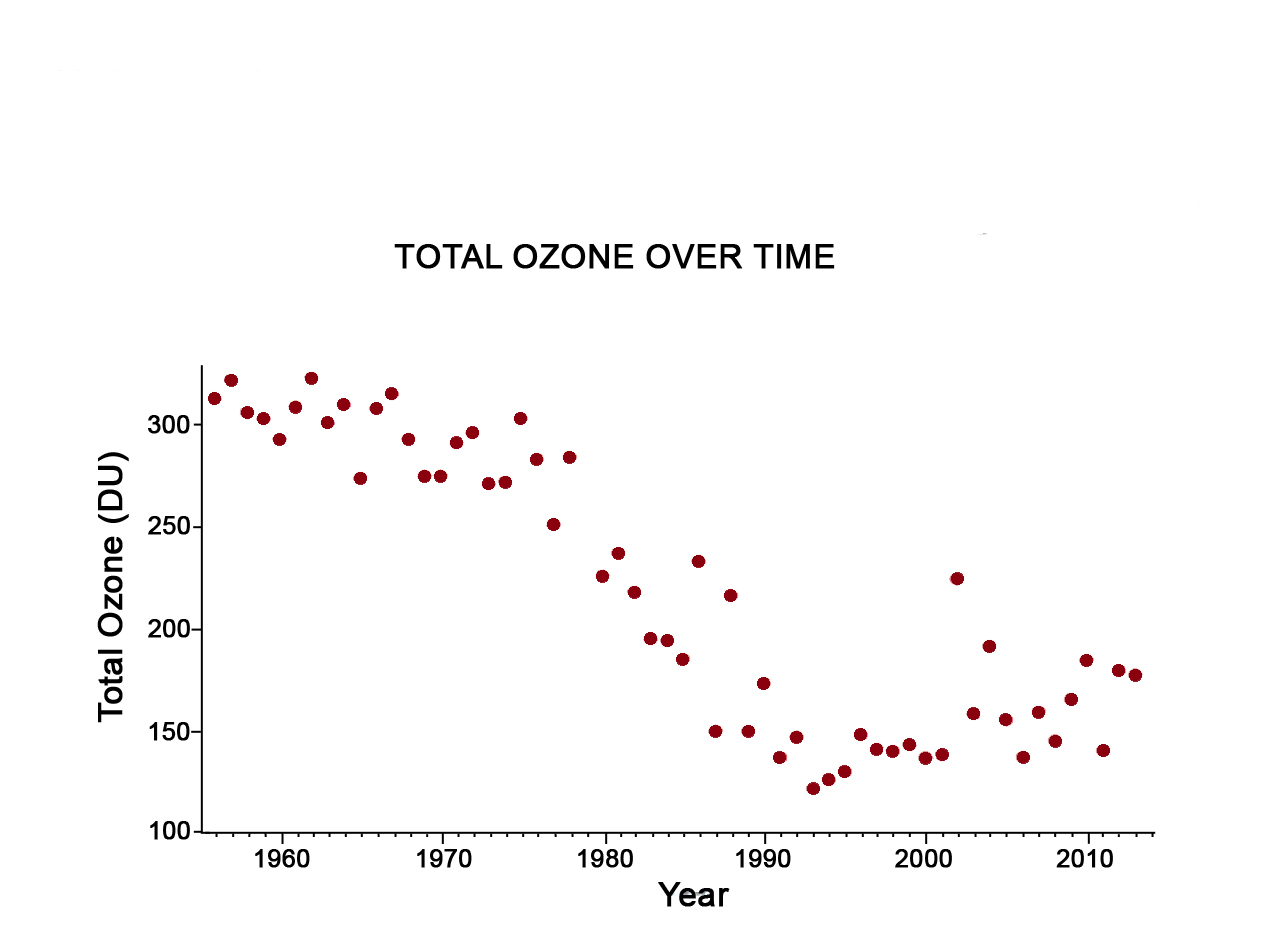
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**Ozone Data Manipulation**

**HOW WE MEASURE OZONE:** The Dobson Unit is the most common unit for measuring ozone concentration. One Dobson Unit is the number of molecules of ozone that would be required to create a layer of pure ozone 0.01 millimeters thick at a temperature of 0 degrees Celsius and a pressure of 1 atmosphere (the air pressure at the surface of the Earth). Over the Earth’s surface, the ozone layer’s average thickness is about 300 Dobson Units or a layer that is 3 millimeters thick.

Look at the following graph and then answer the questions below.

Source: <http://ozonewatch.gsfc.nasa.gov/facts/history_SH.html>

1.What is the label of the y-axis? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

2. Explain what this means: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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3. What is the label of the x-axis? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

4. What is the normal amount of total ozone (DU)? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

5. What is the range of ozone levels from 1956 – 1963? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

6. What do you notice happening from 1978 – 1990? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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7. Why do you think this may be happening? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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8. What do you notice happening after 2000? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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9. How can you explain this? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

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**Montreal Protocol of 1987**

(TEACHERS: This can be used a class discussion as well as a research project.)

Using the following site, answer the questions below:

United Nations Environment Programme - http://ozone.unep.org/new\_site/en/montreal\_protocol.php

Environmental Protection Agency - http://www.epa.gov/ozone/intpol/history.html

A. What was the Montreal Protocol of 1987?

B. Why was it created?

C. What countries were involved?

D. What products were banned due to this protocol?

E. Are some of these products still in use? Explain.

F. Is it possible to continue to use products that were banned and continue to fix them instead of buying new products?

G. In what year was the Protocol last updated?

Using the information you have researched about the Montreal Protocol of 1987 – look at the graph on the previous worksheet and answer the following question:

What happens to the total ozone after 1990? How can you explain this?

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