

# APES in a BOX: The Review Sessions

## Climate Change and Ozone Depletion

### Global Change

**Extinction** of species is a natural occurrence. It is said that 99% of all organisms that have ever lived are now extinct. The rate at which this natural process of extinction occurs is called the **background extinction rate**. Current extinction rates have been calculated to be 100 times greater than the background extinction rate. This rapid increase in the extinction rate is being referred to as The Sixth Mass Extinction. The sixth differs from the previous five in that they were all natural occurrences. The current extinction rates are driven by increased development, poaching, commercial fishing, and other human activities. As we struggle to maintain our economies and care for our increasing population, the inadvertent side effect is often destruction of habitat leading to a loss of biodiversity.

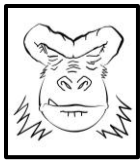
### The Fine Print

The **Endangered Species Act** protects endangered plants, animals, and their habitats. The ESA is a U.S. Law that was established in 1973.

**The Convention on International Trade in Endangered Species (CITES)** is an international treaty that regulates the trade of species that are threatened or endangered.

**Global Warming** is simply an increase in the average temperature near the surface of the earth. The more controversial definition of global warming includes the assumption that the recorded warming is driven by anthropogenic causes. The possible connection between human activity and global warming lies in our production of greenhouse gases. It is theorized that CO<sub>2</sub>, methane, and other greenhouse gases that are generated from human activities, such as burning fossil fuels and maintaining livestock, are increasing the greenhouse effect to the point that the Earth's average temperature is increasing. This increase in temperature is resulting in the rapid melting of the planet's glaciers and polar ice. This rapid melting could lead to an increase in sea level and a disruption in the ocean currents that drive weather and climate patterns. Ocean currents are often referred to as the ocean's conveyor belt since they carry heat from the equator and redistribute it throughout the earth.

An interesting side story in the global warming saga is that of the Earth's albedo. **Albedo** refers to the reflectivity of the surface of the Earth. Simply put, surfaces like ice reflect more of the energy from the sun while surfaces such as bare rock or soil absorb more of the energy. As glaciers and icecaps recede, more rock and soil



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will be exposed. This will result in more of the sun's energy being absorbed by the surface of the Earth, further increasing the intensity of the warming effect. This is an example of a **positive feedback mechanism**.

## **Evidence of Climate Change**

Climate change, including global warming, is a complex issue. The work of many scientists from many countries is considered. Complex computer modeling is used as ideas about climate change are formed. One important thing to consider is that climate change means climate change. While some portions of the Earth will become drier others will experience record precipitation. While temperature increases in some areas, it will decrease in others. Climate change is a complex issue that cannot be simplified into a brief discussion. Without jumping into the debate on climate change, the following list represents some of the conclusions of research that support the theory that the Earth is currently undergoing rapid change.

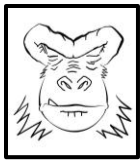
1. Since the beginning of the industrial revolution, atmospheric concentrations of CO<sub>2</sub>, methane, and nitrous oxide have increased significantly.
2. Due to the sheer volume of CO<sub>2</sub> that is generated, CO<sub>2</sub> is the greatest anthropogenic contribution of greenhouse gases.
3. Most research indicates that human contributions with a warming effect are greater than human contributions that have a cooling effect on the climate.
4. Milankovitch cycles are changes in the Earth's rotation and orbit around the sun. Throughout the history of the Earth, these cycles have impacted climate change.
5. Solar output varies and has some regular cycles of increased and decreased output. Changes in solar output can account for only a small warming effect, not one of enough magnitude to account for observed warming.
6. CO<sub>2</sub> concentrations have increased dramatically since the 1950s.
7. Since the early 1900s, the Earth's average temperature has risen by almost 1 degree Celsius.
8. Glaciers and sea ice have been melting at increasing rates. Since 1979, more than 40% of the polar ice cap in the northern hemisphere has receded.
9. Precipitation trends are changing with some areas becoming wetter and some areas becoming drier.



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10. Sea levels have risen slightly. This is partially due to the **thermal expansion** of the ocean.
11. **Coral bleaching** occurs when temperatures rise and cause the symbiotic algae to leave the coral. The coral takes on a white appearance in the absence of the algae and often dies shortly after.
12. The ocean absorbs CO<sub>2</sub>. The CO<sub>2</sub> forms an acid in the water causing the pH of the ocean to decrease. As atmospheric concentrations of CO<sub>2</sub> continue to rise this process has accelerated and is causing the ocean pH to decrease further. This process is called **ocean acidification**. This decrease in pH could impact the ability of coral and other organisms that form calcium carbonate shells to exist.
13. The number of frost free days per year is increasing throughout the United States. This is impacting the natural cycles of plants. This could lead to a mistiming between the flowering of plants and the seasonal arrival of the plants' pollinators.
14. In the last fifteen years, Plant Hardiness Zone maps have been redrawn to accommodate changes in temperature and precipitation in the United States.
15. In the western United States, fire season has increased significantly over the last 20 years, and the number of large fires has increased. This is most likely due to changes in precipitation. Forest fires are also occurring at higher altitudes than previously recorded. This is most likely due to decreased snow pack in the mountains.
16. The ranges of some pest species have expanded as average temperatures have increased. This could result in dramatic losses for agriculture, and the increased incidence of disease as vectors, such as mosquitoes, are able to thrive in new areas.

While it appears that there are significant changes occurring in our atmosphere we are left with two simple, but very important, questions. What does climate change mean for us, and what, if anything, can we do about it? First we will address some of the potential effects of a changing, or warming, climate.



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## **Potential Disadvantages of a Changing Climate**

Ice caps, glaciers, and permafrost will continue to melt. The large amount of CO<sub>2</sub> that is currently sequestered in the permafrost could be released into the atmosphere.

As regional climates shift, living organisms will struggle to adapt to their new environments. This will almost certainly lead to a further decrease in biodiversity.

It is possible that the size and strength of storms in some areas will increase in a warming climate.

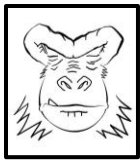
A warming climate will lead to new health concerns as diseases, and their vectors, are able to spread into parts of the globe where cooler climates previously prevented their infiltration.

As climate shifts occur, it will become more difficult to produce crops in areas that currently supply large portions of our food. Conversely, there will be some areas that are productive where they were not before.

## **What Can We Do About It?**

Here are some potential actions that could be taken to reduce the impact of climate change.

1. Continue to improve the efficiency of our homes and transportation. More efficient living means less fossil fuel consumption and the emissions that go along with it.
2. Continue the shift to established renewable energy resources such as wind and solar power.
3. Diversify energy production by using local resources to produce electricity.
4. Increase the efficiency of existing coal-fired power plants.
5. Reduce deforestation. Cutting down trees not only removes the trees carbon sequestering ability, but prematurely releases the carbon that was stored in the tree.
6. Use more natural gas to replace coal in energy production.
7. Use conservation tillage on a greater percentage of croplands.



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8. There are several options for sequestering CO<sub>2</sub> that is already in the atmosphere. These methods include planting more trees, injecting CO<sub>2</sub> into the deep parts of the ocean, and chemically removing CO<sub>2</sub> from automobile and factory exhaust.

### **The Fine Print**

The **Kyoto Protocol** is an international treaty that is designed to reduce the emission of greenhouse gases with the goal of reducing the impact of climate change. The U.S. initially signed the treaty, but then failed to ratify the treaty in the U.S. Senate.

The **Intergovernmental Panel on Climate Change (IPCC)** is an international panel whose task is to evaluate the impact of climate change. The panel is responsible for the IPCC report which is an ongoing evaluation of climate change.

### **Ozone Depletion**

The ozone layer in the stratosphere helps block UV light from reaching the surface of the Earth. This is particularly important because UV light is detrimental to living organisms. Increased UV radiation, resulting from a thinning ozone layer, has been implicated in increases in human skin cancer, and in the decline of amphibians worldwide. There is a seasonal thinning of the ozone layer that occurs over the poles. The thinning over Antarctica is the most significant. This seasonal thinning is not what we are primarily concerned with when we discuss Ozone depletion.

A group of chemicals called chloroflourocarbons (CFCs), along with other ozone depleting chemicals (ODC's), has slowly been breaking down the stratospheric ozone layer since CFCs were first put into use prior to World War II. CFCs were widely used as propellants and refrigerants in everything from hairspray cans to automobile air conditioners. CFCs are persistent in the environment. Other ODCs include methyl bromide, hydrogen chloride, and halons.

UV light reacts with CFCs to break a chlorine molecule off of the CFC. The chlorine then "steals" an oxygen from ozone (O<sub>3</sub>) The chlorine binds with the oxygen leaving O<sub>2</sub> which does not block UV light! Free oxygen atoms then "steal" the oxygen from the remaining CLO leaving chlorine alone to go steal another oxygen from an ozone molecule.

### **Negative Impacts of Ozone Depletion**

With a thinner ozone layer, more UV light will pass through the atmosphere resulting in increased incidence of skin cancer, cataracts, and sunburn.



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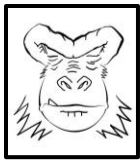
There will be increased incidence of photochemical smog as more UV light is available to react with fossil fuel emissions.

Some populations of aquatic organisms particularly susceptible to UV radiation will experience a decline in numbers.

## **The Fine Print**

In 1987 the **Montreal Protocol** was passed. This is an international treaty to drastically reduce CFCs prior to the year 2000.

In 1992 The **Copenhagen Protocol**, another international treaty, was adopted. The goal of the Copenhagen Protocol was to phase out other Ozone Depleting Chemicals as well as CFCs. The two treaties have played a major role in the reduction of ODC emissions.



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## Climate Change and Ozone Review Questions

1. Ozone in the stratosphere blocks UV radiation. Which of the following chemical compounds has been implicated in the breakdown of the ozone layer?

- A) Chlorofluorocarbons
- B) H<sub>2</sub>O
- C) Carbon Dioxide
- D) CH<sub>4</sub>
- E) C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>

2. Which of the following international treaties attempts to reduce the levels of carbon dioxide in the atmosphere?

- A) Montreal Protocol
- B) Copenhagen Protocol
- C) Kyoto Protocol
- D) The Lacey Act
- E) CITES

3. Ozone depletion has been associated with which health impacts?

- I. Skin cancer
  - II. Sunburn
  - III. Cataracts
  - IV. Heart Disease
- A) I only
  - B) II only
  - C) I and III only
  - D) I, II, and III only
  - E) I, II, III, and IV



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4. As carbon dioxide in the atmosphere increases more  $\text{CO}_2$  dissolves into ocean water causing a decrease in the pH of the ocean. This process can be detrimental to organisms with calcium based shells. This process is known as

- A) Ozone depletion
- B) The greenhouse effect
- C) Coral bleaching
- D) Ocean Acidification
- E) Cultural eutrophication

5. Different substances on the surface of the Earth reflect, or absorb, sunlight differently. This reflectivity of the surface of the Earth is known as

- A) Albedo
- B) Specific heat
- C) The greenhouse effect
- D) Turbidity
- E) The Kyoto Protocol

### **Free Response**

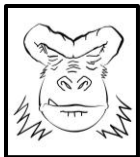
1. Ozone depletion has been linked with several negative impacts on human health and the environment.

A. Describe the role of chlorofluorocarbons in ozone depletion.

B. Identify and describe the two international treaties that address Ozone depletion.

C. Identify the layer of the atmosphere that contains the beneficial ozone layer.





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## Multiple Choice Scoring Guidelines

1. A	3. D	5. A
2. C	4. D	

## Free Response Scoring Guidelines

1.A. (1pt total) 1point for correctly describing the role of CFC's in ozone depletion. CFC's react with UV radiation, chlorine breaks off of the CFC molecule, Chlorine then removes an oxygen atom from ozone leaving behind O<sub>2</sub>.

1.B. (4pts total) 1 point each for each correct identification and description of the Montreal and Copenhagen protocols. In 1987 the **Montreal Protocol** was passed. This is an international treaty to drastically reduce CFCs prior to the year 2000. In 1992 The **Copenhagen Protocol**, another international treaty, was adopted. The goal of the Copenhagen Protocol was to phase out other Ozone Depleting Chemicals as well as CFCs. The two treaties have played a major role in the reduction of ODC emissions.

1.C. (1pt total) one point for the correct identification of the stratosphere as the layer of the atmosphere that contains the ozone layer.

Multiple choice points earned + Free response points earned/11\*100 = Quiz average

( \_\_\_\_\_ + \_\_\_\_\_ )/11 \* 100= \_\_\_\_\_ Quiz grade