SPQ Module 8 – A hole in the Ozone

Have you ever sunburned the roof of your mouth? There are reports of polar explorers, dragging heavy sledges, their mouths open as they gasp for air at high elevation on the Antarctic Plateau, burning the roofs of their mouths with sunlight reflected off the snow. According to Kevin Vallely this is not an uncommon for mountaineers. "It has happened to me climbing Mount Rainier in Washington State."

Sun protection is a very important consideration for polar explorers, particularly in the Antarctic. In fact if you are looking for a place to get a sunburn, the Antarctic is one of the best locations to choose. This is accounted for by three main factors:

- **There are 24 hours of sunlight during the summer months.**
- **Antarctica is 98% covered in white snow and ice, which is very efficient at reflecting sunlight, including ultraviolet light. This effectively doubles one's exposure to solar radiation, from above and from below.**
- **There is a hole in the ozone layer that forms over the Antarctic continent during the spring months allowing more harmful ultraviolet rays to penetrate through to the continent.**

British scientists discovered the hole in the ozone layer over Antarctica in 1985. Ozone is a simple molecule composed of three oxygen atoms: O_3. (The oxygen we breathe is made up of two oxygen atoms: O_2). Ozone is a minor component of the Earth's atmosphere making up less than 1% of the gases.

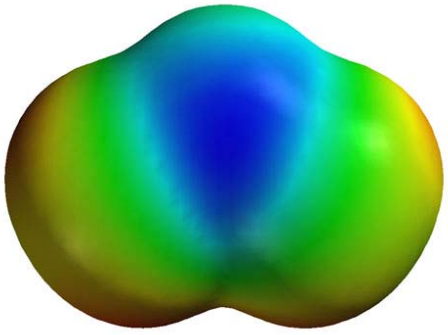

Figure1: Three-dimensional ozone molecule (Source: Wikimedia commons, Benjah-bmm27).

Despite its relative lack of abundance ozone is essential to life on Earth. The ozone layer functions to absorb harmful ultraviolet rays, preventing them from reaching earth. Ultraviolet radiation is harmful to life because it can enter cells and damage the genetic code (DNA) that directs cell function. Cells with damaged DNA can malfunction and may become cancerous. That is why significant exposure to the sun and ultraviolet radiation, predispose people to skin cancer.

Did You Know?

The earth's atmosphere is composed of:

- 78% nitrogen
- 21% oxygen
- 1% argon
- Minute traces of other gases including ozone

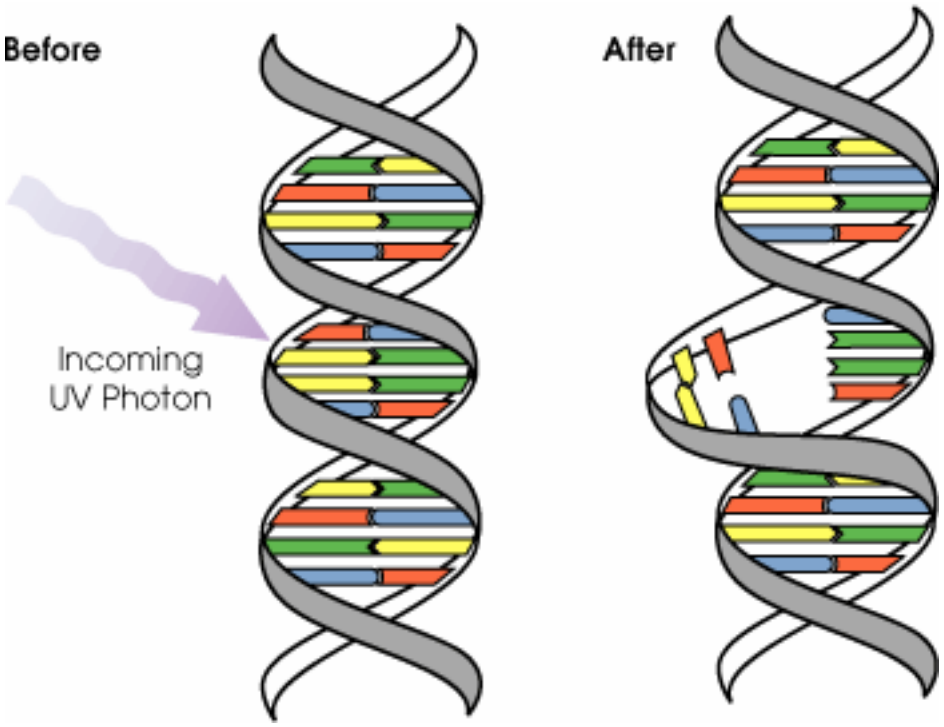

Figure 2: Ultraviolet (UV) photons harm the DNA molecules of living organisms in different ways. In one common damage event, adjacent bases bond with each other, instead of across the "ladder." This makes a bulge, and the distorted DNA molecule does not function properly. (Source: NASA)

However, the danger from ultraviolet radiation is not restricted to human beings, but can affect most forms of life. For example, birds and whales that come to feed in the waters off Antarctica have witnessed a decrease in their food source because of the depletion of ozone. Plankton, a small ocean dwelling organism that lives on carbon, light, and elemental nutrients is sensitive to high levels of ultraviolet light. Studies have found that high ultraviolet radiation decreases

populations of plankton, which in turn adversely affected the population of krill that feed on them. Birds and whales that feed on krill in turn find their main food source reduced. Thus long-term depletion of the ozone layer will disrupt the fragile balance of life on earth in many ways.

Figure 3: Ultraviolet light (source: Wikimedia commons Self-published work by Tatoute)

The Earth's atmosphere is separated into 5 distinct layers: the troposphere, the stratosphere, the mesosphere, the thermosphere, and the exosphere. . Most of the ozone in the atmosphere is concentrated in the second layer, or stratosphere that is 10 to 50 kilometers above the earth's surface. The ozone layer itself is found in the middle of the stratosphere, about 20 to 30 kilometers above the Earth. The layer of ozone acts as a veritable sunscreen that envelopes the planet allowing life forms to flourish in an environment with tolerably low levels of ultraviolet light. However in the past 30 years this envelope of ozone has been globally depleted and two seasonal holes in the layer have developed off the poles. The largest hole in the ozone layer lies over Antarctica.

Since its discovery in 1985, significant energy has been dedicated to understanding why the Antarctic ozone hole has occurred. Ozone is a fragile molecule that can be destroyed when exposed to certain volatile molecules such

Did You Know?

If you compressed all the ozone in the earth's atmosphere at sea level temperature and pressure it would form a layer of pure ozone approximately 3 mm thick

as chlorofluorocarbon (CFC). CFCs have been used principally in aerosol sprays and to cool refrigerators. Although natural occurrences such as volcanic activity can lead to the creation of molecules that destroy ozone, up to 85% of ozone damage is the byproduct of human activity. Although CFC's and other damaging chemicals are produced all over the industrialized world it is the atmosphere over the poles, and particularly Antarctica, that has been most sensitive to ozone depletion. This is because of unique climactic conditions that concentrate ozone-destroying molecules in the atmosphere over the Antarctic continent. Due to the climate changes the ozone hole is seasonal, growing over the spring months and shrinking over the autumn.

The ozone hole over Antarctica has steadily grown larger since it was first discovered in 1985. The largest recorded hole was in 2006 when it covered an area of about 27 million square kilometers, which is about the size of the North American continent.

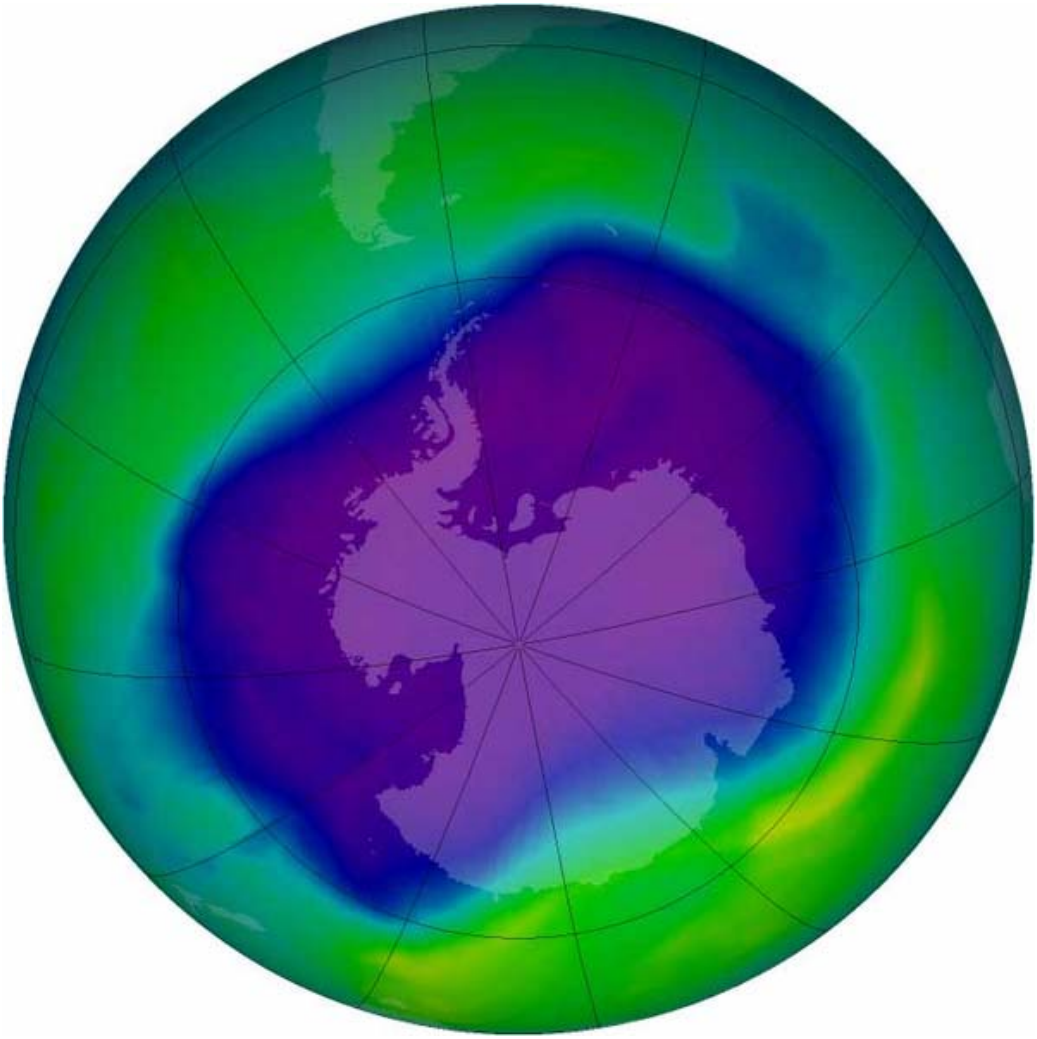

Figure 4: The Antarctic ozone hole on September 24 2006. This was the record single-day largest area of 11.4 million square miles (29.5 million square kilometers) equaling that reached on Sept. 9, 2000 (source: NASA)

Recognizing the global risk to life by ozone depletion, delegates from around the world met in September of 1987 in Montreal and signed a protocol calling for the reduction and ultimate elimination of the production and use of CFC's. Although this protocol has been observed, scientists feel it will take many years for the Ozone layer to recover.

Certainly the ozone hole over Antarctica has not been repaired in time for the South Pole Quest team. Consequently, recognizing the risk that they face from solar radiation, Richard and Kevin will be taking significant precautions against skin injury by wearing full facial coverage for the duration of their trip. Ray says he isn't interested; he's going for the tan!

Figure 5: Richard Weber wearing the custom made face protective gear that will be worn on the expedition to the South Pole. (Photo: Ewan Affleck)