Chapter 14

Sorting Out Ozone

One evening before bedtime, Russell began to cry. He was worried about the ozone layer that surrounds and protects the earth. His father had told him that the air conditioner in the family car had chemicals that "eat" the ozone when they evaporate. Russell, a second-grader in Forest Hills, New York, felt hopeless.[1] But his father urged him to do something about it. And he did.

Russell started an environmental club at his school. His group, Kids Save the Ozone Project (Kids STOP), lobbied the mayor and city council in New York City to pass a law requiring chlorofluorocarbons (CFCs) in auto air conditioners to be recycled. The group even lobbied the president to urge him to support a worldwide ban on CFCs.

Russell became concerned about the ozone layer because it troubled his father, but many children learn in school that the thin layer of ozone in the stratosphere is being "eaten away" by man-made chemicals, primarily CFCs. Without ozone to protect us, students are told, the sun's ultraviolet (UV) rays will damage crops, cause skin cancer, and injure our eyes. One science book says that "'CFCs . . . are 'eating' holes in the ozone layer,"[2] and one children's book even shows little PacMan-like creatures eating the ozone molecules.[3]

Concern about ozone depletion has a basis in science. It is, in fact, a more genuine environmental worry than global warming or species extinction. But, fear of ozone loss is exaggerated. There is no ozone crisis.

Ozone: The Simple Version

Ozone depletion is a complicated scientific issue. But in our children's textbooks and other literature, the message is simple.

- "Without Earth's sunscreen, we'd be in big trouble," says the children's book *Earthcycles and Ecosystems*. "Farm crops would be damaged by the radiation and would produce less food. People would be plagued with skin cancer and eye diseases, caused by the increase in ultraviolet rays."[4]

- "The increase of ultraviolet light can threaten human and plant life," says *The Green Classroom*. "Ultraviolet light harms our eyes and immune systems . . . [and] can increase the occurrence of skin cancer."[5]

- The science text *Challenge for Change* says: "Since ozone absorbs the ultraviolet rays, any reduction in its amount could lead to a greater degree of ultraviolet rays reaching the earth's surface with harmful effects. It is known that exposure to ultraviolet rays causes skin cancer, and the radiation may be harmful to other animal tissue and plant life."[6]

- Too many ultraviolet rays "can cause skin cancer and eye diseases. They can do terrible damage to crops and other plants—especially some of the ocean plants that sea creatures depend on for food," says a book for children.[7]

To understand this issue, we should start with oxygen. The normal oxygen that we breathe is composed of two atoms of oxygen (O_2). Ozone is a molecule composed of three atoms of oxygen (O_3). It is found in extremely small quantities high above the earth, most of it in the stratosphere, the atmospheric layer between ten and thirty miles up. Because most ozone is found there, the stratosphere is sometimes called the "ozone layer." But the amount of ozone is so small that if all the bits of ozone in a column of space in the stratosphere were compressed together, the ozone would be about one-eighth of an inch thick.[8]

This thinly scattered ozone absorbs some of the sun's ultraviolet rays, preventing them from reaching the atmosphere close to the Earth. These rays are invisible components of sunlight. Ozone absorbs only very short rays, which scientists call UV-B radiation.

The major worry is not stratospheric ozone itself but, rather, the radiation that is normally blocked by ozone. If ozone declines, more UV-B rays will reach the earth on a clear day. Too much of this radiation can cause sunburn, irritation of the eye's cornea, and skin cancer.

Ozone: Two Complex Issues

There are two ozone depletion issues. (And we're only talking about the ozone that exists many miles up in the stratosphere! Ozone close to ground is part of smog.)

First, scientists have been trying to figure out if the worldwide layer of stratospheric ozone is thinning. And, second, they have been trying to figure out the cause of what is known as the "ozone hole" above Antarctica. These are separate questions, although the textbooks tend to mix them up, creating confusion.

- "Unfortunately, the ozone layer is in danger. Little by little we are destroying it," says Beth Savan's children's book *Earthcycles and Ecosystems*, referring to the worldwide layer of ozone.

- It continues: "There's already a big hole in the ozone layer over Antarctica . . . We destroy the ozone layer by producing chemicals that eat it up."[9]

The Global Ozone Issue

Let us begin with the question of the worldwide thinning. Ozone is an unstable molecule. It can break apart, forming oxygen and a free-floating oxygen atom. This is what "ozone depletion" means. Natural forces that break ozone apart include trace gases such as hydrogen oxides, nitrogen oxides, and chlorine.

But ozone is also constantly created. Sunlight reacts with oxygen, breaking the oxygen molecule (O_2) into free-floating oxygen atoms. When a loose oxygen atom joins an oxygen molecule, O_3 is formed again. Creation and destruction of ozone go on all the time. The ozone layer is not a solid that is "eaten away" by chemicals. It is not a fabric that is being "torn."

Natural fluctuations of ozone are very large. Over a few months, the amount of ozone can vary by 50 percent over parts of North America.[10] From day to day, the amount of ozone can vary by 25 percent.[11] Because these changes occur naturally, they arouse little concern. And because these fluctuations are so large, it is difficult for scientists to know whether the ozone layer is thinning over time or, if it is, what is causing the thinning.

The Antarctic Ozone "Hole"

In 1985, British scientists reported that during the period between August and October of 1984, the amount of ozone over Antarctica had dropped dramatically—by more than 40 percent from what it had been some years before. This loss extended over an area broader than the entire Antarctic continent. This reduction in stratospheric ozone became known as the "ozone hole."

In the textbooks, it is pretty scary. "In 1984, about 30 percent of the ozone was gone; in 1985, 50 percent; in 1987, 60 percent," says

The Kids' Environment Book. "On October 5, 1987, scientists recorded a level that was barely one-third of normal. By then the hole was bigger than the continental United States and as deep as Mount Everest is high."[12]

Our children are rarely, if ever, told that this thinning of the ozone layer over Antarctica is temporary—that is, it lasts for only a short period of time each year—or that it probably reflects conditions unique to the South Pole. And there is no ozone hole over the North Pole, even though people have predicted one from time to time, and some loss of ozone has occurred over the North Pole late in the winter.[13]

CFCs: Cause of It All?

Now, enter the supposed villains: CFCs. Many scientists believe that these chemicals are both thinning ozone and directly contributing to the ozone "hole." Let's see why they think this.

CFCs contain chlorine. In addition, they have an unusual property: they are inert. That is, they don't react easily with other chemicals. This makes them nontoxic and nonflammable.

Because they are so safe, they have been widely used, especially for cooling in refrigerators and air conditioners, but in other ways as well. They were found in aerosol propellants at one time, but their use in Canada was banned in 1980 after concerns about ozone loss first surfaced.[14] They were also used in the production of some plastic foam products such as Styrofoam cups, plates, and fast-food containers, a point that some books emphasize.

Because these chemicals don't break apart easily, they stay in the atmosphere a very long time. Gradually over many years, they float up to the stratosphere, where they are finally broken apart by sunlight, and their chlorine atoms are released.

These chlorine atoms, through complex chemistry, can change two ozones (O_3) into three oxygens (O_2). Scientists theorize that a single chlorine atom can break apart up to 100,000 ozone molecules.[15] In the atmosphere, however, other chemical reactions interfere, slowing but not stopping the process.

Are CFCs causing ozone to thin around the globe? And are they causing the ozone "hole"? Let us look at each ozone issue again.

The Global Ozone Issue

Scientists aren't sure how much the ozone is thinning. A panel of scientists convened by the National Aeronautics and Space Administration (NASA), the Ozone Trends Panel, reported in 1988 that ozone levels above the Northern hemisphere had declined by between 1 percent and 3 percent per decade.[16] These figures were later refined, updated, and published by a group headed by NASA scientist Richard Stolarski.[17]

In 1991, the U.S. Environmental Protection Agency (EPA) went further, announcing that the ozone layer above the United States had decreased by 4 to 5 percent between 1979 and 1990. However, this statement was based on an oversimplified analysis of satellite data. For one thing, there was an upturn after 1986. Second, the eleven and a half years of records may not be enough to distinguish human-caused decline from the natural sunspot cycle, says S. Fred Singer, the scientist who designed the instrument used on satellites to measure ozone.[18]

Further, the sun's eleven-year sunspot cycle affects the amount of ozone depletion. When the sun is at its strongest, there is more UV radiation in the stratosphere to break apart oxygen molecules, and more ozone is formed. When the sun is at its weakest, less oxygen is broken apart and less ozone created. One study concluded that "73 percent of the global O_3 declines between 1979 and 1985 are due to natural effects related to solar variability . . ."[19]

Sorting out the "natural effects" is an enormous challenge. While chlorine from CFCs appears to be combining with ozone molecules to deplete ozone, the impact of natural forces on the increase and decrease of stratospheric ozone is also tremendously important. The most recent studies, taking into account chlorine, solar cycles, and volcanoes, can still only explain part of the loss of ozone that has been calculated for the period between 1979 and 1994.[20]

The Ozone "Hole"

Scientists have determined that the Antarctic ozone hole is related to a natural weather pattern. The vortex, a circular wind pattern around Antarctica, keeps warmer air from the tropics out during the winter, a time when the air temperature above Antarctica falls to minus 80 degrees Celsius or lower. It is so cold that ice clouds can form in the stratosphere (which, during the winter, is completely dark).

When the sun becomes visible above Antarctica in early spring, the sun can trigger chemical reactions involving the ice crystals, ozone, and chlorine. The source of most of the stratospheric chlorine is CFCs, although there are some natural sources of chlorine, too.

Chemicals that have been "holding" this chlorine release it. The chlorine reacts with ozone, depleting it. As the season progresses, however, the vortex breaks up and the ozone layer is replenished with a fresh supply of ozone-rich air from the tropics.[21] So, it appears that the direct cause of the ozone "hole" is chlorine in the stratosphere. But natural conditions play an important part, too.

The Big Fear: Cancer

If the ozone is thinning, will more UV radiation reach the Earth? And, if so, will it increase skin cancers?

In theory, the answer to both questions is yes. But, as we have seen, we aren't sure there is depletion or, if so, how much. More important, there is little evidence that UV radiation is increasing.

In fact, some scientists have measured just the opposite. The major study of UV radiation reaching the United States showed a slight decrease in UV radiation between 1974 and 1985. While this was a limited study, it shows the opposite of what one would expect if the ozone were thinning.[22] A more recent study showed an increase in UV radiation at a station in Toronto, but the study was based on only four years of measurements, and for two of those years there were problems with the information.[23]

A National Oceanic and Atmospheric Administration scientist reports that UV rays have decreased by between 5 and 18 percent during this century (possibly due to increased clouds and haze).[24] These studies suggest that the danger from ultraviolet radiation, at least in parts of North America, may be lessening rather than increasing.

Skin cancer rates have been increasing since World War II, probably due to changes in lifestyle. Just 50 years ago, people still wore bathing suits that covered much of their bodies. Dr. Frederick Urbach, a Temple University dermatologist, says that recent increases in skin cancer rates "are due to people spending more time outside, not more UV."[25] Fortunately, this type of skin cancer is easily treated. The death rate from nonmelanoma skin cancer is less than 1 percent.

As for melanoma, a very dangerous cancer of the skin, its relationship to sun exposure isn't clear.[26] A study by Richard B. Setlow of Brookhaven National Laboratory and his colleagues concluded that the effect of sunlight on melanoma was almost entirely through either visible light or the UV-A part of the light spectrum, not the very short UV-B wavelengths that are blocked by ozone. In other words, ozone and melanoma appear to have little to do with each other.[27]

UV Radiation: In Perspective

The most important fact that the textbooks fail to mention is that ozone depletion, if it is occurring, is similar to increasing one's exposure to ultraviolet light by moving closer to the Equator or higher up a mountain. There, the angle of the sun is more direct and people are exposed to more ultraviolet light.

- If the ozone level above North America has decreased by 4 or 5 percent, as the U.S. EPA estimated (but rather carelessly) in 1991, the effect would be about the same moving about 100 kilometres (sixty miles) south, say from Vancouver to Victoria. Moving south increases one's exposure to UV radiation about the same amount as a 4 or 5 per cent decrease in ozone.

- A scientific paper pointed out that a person who moves from Oslo, Norway, to San Francisco experiences an increase in UV exposure of 100 percent and increases his or her risk of skin cancer by 250 percent.[28]

What about Crops?

Another worry is that plants could receive too much UV radiation. But Alan Teramura, a leading expert on the effects of UV radiation on plants, points out that plants are remarkably adapted to withstand changes in UV exposure. Even if ozone declined by 20 percent, he says, we "wouldn't see plants wilting or fruits dropping unripened from their vines."[29] Although some plants could be damaged, others would be unaffected or produce greater crop yields.

What about Algae?

When there is an ozone "hole" over Antarctica, the amount of UV radiation does increase significantly there. Some textbooks suggest that plankton, the tiny algae in the water around Antarctica, may not be able to cope with so much radiation. Since other animals feed on these algae, their loss could affect the entire food chain.

Osmund Holm-Hansen, director of polar research at the Scripps Institute of Oceanography, studied these algae. He and his colleagues concluded that the ozone hole would decrease their growth by less than 4 percent while the hole was overhead, and would reduce annual growth by only 0.2 per cent (two-tenths of a percent) at most.[30]

What about Birds?

Keep in mind that when the ozone "hole" occurs in the spring, levels of UV radiation rise to about what they are in the Antarctic summer. This is the level of UV radiation that most migratory animals experience, anyway. Summer is the time that most migratory animals are there.

Ban CFCs, Raise Risks

Textbooks insist that drastic measures were needed to avoid further loss of ozone, and they applaud the Montreal Protocol, the 1987 international agreement to phase out CFCs. Canada was the first country to sign the updated protocol in 1990, which required the phase-out of CFCs by the year 2000. The Canadian government beat this deadline and by the end of 1997, the production and importation of CFCs officially ended, except for essential uses.[31]

The costs and risks of eliminating CFCs are rarely mentioned.[32] Most texts imply that the task will be easy and will have no harmful effects. They omit some important facts:

- CFCs are nontoxic chemicals that have saved lives and improved our standard of living. They keep our food safe and our homes, cars, and factories comfortable.

- Substitutes are less efficient. Refrigerators and auto air conditioners must use more energy to produce the same amount of cooling. This means burning more fossil fuels and more pollution. Hardly an ideal solution for the environment!

- Rapid adoption of substitutes makes the chance of serious problems more likely. One substitute known as HCFC 123 caused tumors in rats. The tumors were not cancerous, but it led one producer of industrial refrigeration systems to hold off on using it until it had been tested further.[33] Several substitutes produce a substance, TFA, that is toxic to plants, and some scientists worry that it could accumulate in wetlands.[34]

- Because substitutes cost more and do not work as well, there is now a multi-million-dollar black market in Freon (the best-known CFC). According to the *New York Times,* Freon is being smuggled into the United States, where CFCs were banned in 1996.[35]

- Maintaining auto air conditioners will be costly, because they will have to be retrofitted to use the substitutes.

Canada, the United States, and other industrial countries may be able to cope with more expensive refrigerators and troublesome car air conditioners. But developing countries, which are supposed to phase out CFCs early in the next decade, will experience more severe problems.

- Lack of refrigeration is already a serious health problem in many countries. If refrigeration becomes more costly, more people may unknowingly eat contaminated food. And more people may go hungry because food cannot be safely preserved.

- The most difficult problem in providing children with life-saving vaccines is keeping them cold. Lack of CFCs makes the job even harder.[36] Many countries still use kerosene fuel for portable refrigerators.[37] It will be more difficult to replace such dangerous refrigerators with cheap, safe ones.

- Old methods of food preservation, such as salting and smoking meats and fish, add potentially cancer-causing substances. These could put people at risk for cancers more dangerous than the skin cancer cited in the textbooks as a risk from ozone depletion.[38]

Talking to Your Children

Responsible scientists still have more questions than answers about ozone. But we do know some things about it. Here are some questions that you can answer now.

- Is the ozone layer disappearing?

  No, it is not disappearing. Scientists think that there may be a decline in ozone caused by some chemicals, but this decline is so small that it is hard to distinguish from natural changes.

- What happens if the ozone layer thins?

  A thinner ozone layer means that more ultraviolet radiation will reach the Earth on a clear day. However, a significant increase in ultraviolet radiation hasn't been measured, except temporarily over Antarctica due to the ozone "hole." And keep in mind that people increase their exposure to the sun's ultraviolet rays voluntarily by moving closer to the Equator and moving to higher altitudes. These changes are often much greater than any increase in exposure that may have been caused by ozone loss.

- What is the ozone hole?

  The ozone hole is a large thinning of ozone above the Antarctic. It occurs each year in the Southern hemisphere's spring, when the winds of the polar vortex keep out ozone-rich air. As the season progresses, and the vortex dissipates, the “hole” closes up again. It is not permanent. When it occurs, more ultraviolet radiation reaches the South Pole and the surrounding area.

- What are CFCs?

  CFCs or chlorofluorocarbons are chemicals that have an unusual property. They are inert, which makes them very safe. However, it also means that they don't break apart easily. Scientists have found that gradually over time they float up into the stratosphere, where sunlight breaks them apart, releasing chlorine. Scientists believe that the chlorine reacts with and depletes stratospheric ozone.

Activities for Parents and Children

As you can see, ozone issues are complicated. Here are some activities that will help your children understand these issues better.

Changes in Exposure

People make far greater changes in their exposure to ultraviolet rays than any change that may be caused by ozone depletion. Exposure to ultraviolet radiation changes as people move from north to south (in the Northern Hemisphere) and as they move to higher elevations. Your children can compute the changes in exposure to ultraviolet radiation.

For every hundred kilometres (sixty miles) traveled south, UV exposure increases by 5 percent. If your family travels from Edmonton to Calgary, which is about 300 kilometres south, how much will UV exposure increase? *UV exposure will increase by 15 percent. No one thinks that human exposure to UV radiation exposure has gone up anywhere near this much as a result of ozone loss.*

For every 45 metres (150 feet) of elevation, UV exposure increases 1 percent. If your family travels from Halifax, Nova Scotia, which is at sea level (32 metres), to Denver, Colorado, which is at an elevation of 1609 metres (5,280 feet), how much will your UV exposure increase? *Exposure will increase by more than 35 percent. Again, this is far more than any estimate of increased exposure to humans that may have occurred through ozone loss.*

Your Summer Vacation

Ask whether the family would be willing to give up a vacation trip to the mountains or to the beach because of the danger of increased UV exposure. This could lead to a discussion of trade-offs and choices.

If they aren't worried about increased UV radiation exposure by traveling, how much should they worry about the current state of the ozone? There is no definite answer here. The point is to think about the choices we make.

Children should be aware that regardless of the state of the ozone, basking in too much sunlight is not a good a thing. Physicians say that children should avoid sunburns by sunbathing less and by wearing sunscreen lotion whenever they are in the sun.

Alternatives to CFCs

Discuss the pros and cons of spending huge sums of money to convert to CFC substitutes. Air conditioners and refrigerators will become more expensive. This might not bother Canadians too much, but what about people in poorer nations? Should their ability to have refrigeration and air conditioning be restricted? Would your family be willing to give up those things?

Notes

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