Repairing the Hole in the Sky

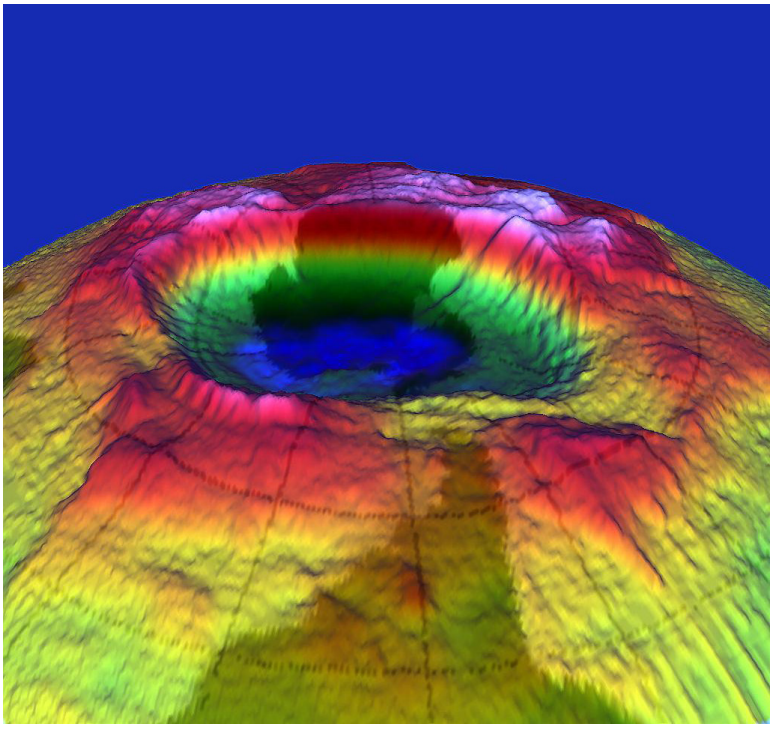
Did you know that there is a giant hole in the sky? That is, there is a "hole" in one important layer of Earth's atmosphere—the ozone layer. Fortunately for everyone on Earth, atmospheric chemist Mario Molina, along with two other scientists, helped figured out how humans were causing it, and how they could eventually repair it.

A Planet in Peril

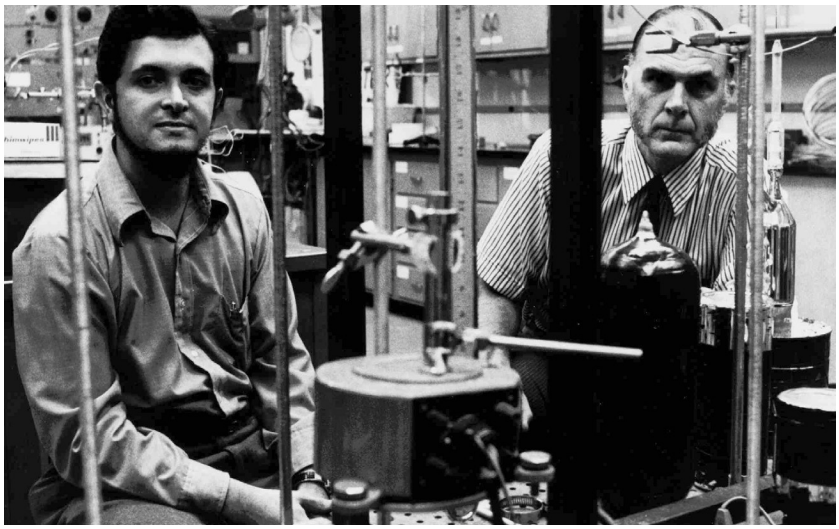
You cannot see it without special satellite photography, but the "hole" in the invisible ozone layer hovers over Antarctica. Why is the hole in the ozone layer a problem?

The ozone layer plays an important role in Earth's climate and its ecology. Located between 10 and 50 km above Earth's surface, the ozone layer is a thick layer of the atmosphere that has high concentrations of ozone gas (O_3), a form of oxygen. Ozone molecules have one more oxygen atom than the oxygen molecules in the air you breathe. The ozone layer keeps some of the sun's damaging ultraviolet (UV) light from reaching Earth's surface. Without the ozone layer, UV rays can quickly damage the cells of humans and other living things. A hole in the ozone layer causes more UV rays to hit Earth and the living things on it.

The ozone layer is a thick layer of ozone that protects Earth from the damaging effects of UV rays from the sun. This image from NASA shows a three-dimensional model of the ozone layer above Antarctica. The different colors represent how thick the ozone is. The green part shows where the atmosphere is thinning, and the blue part shows where there is a hole in the ozone layer.



What caused this ozone hole, and what is making it grow? Scientists now understand that some of the damage is caused by chlorofluorocarbons, also called CFCs. CFCs are human-designed chemical compounds made up of carbon, chlorine, and fluorine. These chemicals used to be quite common in a variety of useful products, including refrigerators and air conditioning systems. These chemicals were thought to be safe because they are nontoxic and nonflammable. However, scientists discovered that they cause damage to the ozone layer. One of the scientists who discovered CFCs' effect on the ozone layer was Mario Molina.



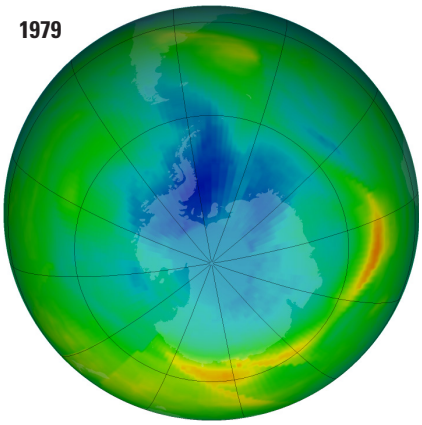
Mario Molina studied very hard to become a scientist. In the 1970s, Mario Molina (left) and Sherwood Rowland (right) started to work together in a laboratory where they studied CFCs.

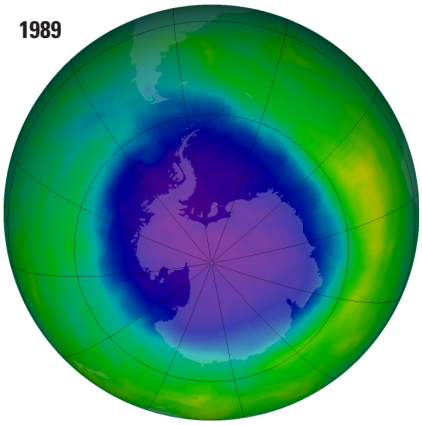
A Scientist Since Childhood

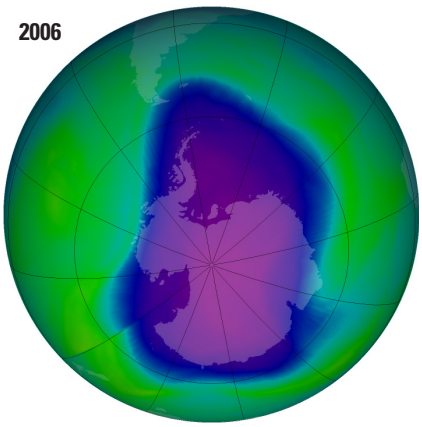
Mario Molina was born in Mexico City, Mexico in 1943. From a very young age, Molina was fascinated by science. Even before he was a teenager, he began investigating the natural world. He even converted one of the family's bathrooms into a home laboratory! Using a toy microscope and hobbyist chemistry sets, he performed experiments and analyzed materials around the house. Using his microscope, he observed organisms too small to be seen with human eyes. "I still remember my excitement when I first glanced at paramecia and amoebae through a rather primitive toy microscope," said Molina. His aunt, who was a chemist, helped him carry out more advanced experiments, the kinds that college students might perform as freshmen—and this was when he was only 10 and 11 years old!

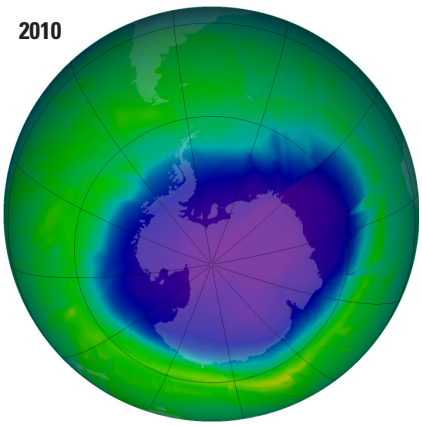
Molina wanted to be a physical chemist when he grew up. Physical chemists use physics to study chemical systems. He studied chemical engineering at the *Nacional Autónoma de México*, or National Autonomous University of Mexico (UNAM). After finishing his undergraduate degree, Molina wanted to obtain an advanced degree known as a Ph.D. in physical chemistry. However, he felt that he was still not good enough in mathematics and physics to study physical chemistry. He moved to Europe and spent two years researching physical chemistry and several months studying mathematics.

Afterwards, Molina earned a Ph.D. in physical chemistry from the University of California at Berkeley. In the 1970s, he began working with a chemist named Frank Sherwood Rowland. At their laboratory in Irvine, California, they started looking into what happens to CFCs once they have been released into the atmosphere.









Nobel Prizewinning Research

When Mario Molina and his colleagues first started their research on CFCs, they did not know whether these compounds had any effect on the environment. They simply wanted to find out how nature breaks down human-made compounds that collect in the atmosphere. They discovered that CFCs may be relatively nonreactive near Earth's surface, but they have a huge effect on the atmosphere. CFCs do not break down until they reach the stratosphere, the layer of the atmosphere where airplanes fly. When CFCs do break down, one of the products is highly reactive chlorine atoms. These atoms are catalysts that cause ozone to break down faster. As a result, the CFCs can deplete the ozone layer.

Their discovery gained world-wide attention in the 1980s as atmospheric scientists studying the ozone using satellite imagery noticed the hole that was forming over Antarctica. Using computer simulations, scientists modeled what would happen if CFCs continued to be produced and escaped from the machines in which they were used and into the atmosphere. They predicted that by 2065, only about a third of Earth's ozone layer would remain and there would be a matching hole in the ozone layer over the North Pole!

After their discovery, many people, including scientists like Molina, fought to put laws in place that regulate the use of CFCs. In 1987, representatives from several countries signed a treaty called the Montreal Protocol, which promised to phase out the use of CFCs and other substances that attack the ozone layer. In 1995, Mario Molina, along with Sherwood Rowland and Dutch chemist Paul Crutzen, won the Nobel Prize in Chemistry for their discoveries about how chemical compounds affect the ozone layer.

Such efforts seem to be working. Looking at satellite data since these laws went into effect, people saw that the hole in the ozone layer has stopped growing and is recovering. At this rate of repair, the ozone layer is even predicted to return to its 1980s thickness by the middle of the 21st century, or even sooner! This is great news for Earth and its inhabitants.

Satellite data shows the hole in the ozone layer, shown with dark blue and purple colors in these diagrams. The data shows the hole growing from 1979, but it stopped growing in the 1990s. Scientists credit this more recent change with laws that regulate the production of ozone-destroying CFCs.

Advocating for Change and Curiosity

Since winning the Nobel Prize, Mario Molina became involved with more than scientific research. He also worked hard to make sure his research has been applied towards international and local policies that protect the environment. He served on the boards of environmental organizations as well as the U.S. President's Committee of Advisors in Science and Technology. In 2013, President Barack Obama awarded him with the Presidential Medal of Freedom for his contributions to both science and society.



In 2013, Mario Molina received the Presidential Medal of Freedom for his contributions to both science and society. Mario Molina does not just work as a scientist, but he also encourages young people of all backgrounds to pursue science.

Molina became a mentor for young people and encouraged students to become part of scientific communities. As a member of the Society for the Advancement of Chicano and Native American Scientists, he advised Hispanic students on their academic goals. With this work, he hoped to inspire children from all different cultures to pursue science. Said Molina, "Many Latino kids should become scientists because we need scientists all over the world from all different backgrounds. We have many tough problems, and we need everybody's help to solve the problems."

Molina also suggested that in addition to taking science class, kids should do science experiments, just as he did as a child. "There are excellent TV programs and very interesting things on the Internet and in museums," he said. "If it is supervised at home, it's safe, and if it's interesting, then it's okay. I did not play with explosions or anything dangerous. I didn't have any poisonous chemicals. You can do very safe experiments." With the right amount of curiosity, anybody can do science, and that science can help the world. He certainly set a good example, given that he started as a 10-year-old who experimented in his bathroom laboratory and eventually contributed to a world-wide effort to patch a giant hole in the sky! ◆