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Polar Ozone Depletion: Mario J. Molina

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POLAR OZONE DEPLETION

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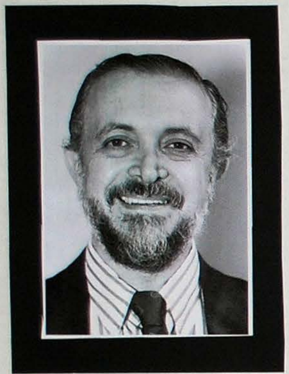

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Mario J. Molina

Mario Molina received the Nobel Prize in 1995 along with two other chemists, Paul J. Crutzen and F. Sherwood Rowland, for their research in atmospheric chemistry, especially in regards to the formation and decomposition aspects of the ozone layer.

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Born in Mexico City on March 19, 1943, Mario Molina always wanted to become a chemist from the time he was a boy. At age 11, he attended boarding school in Switzerland because, at the time, it was believed that understanding the German language was very important. After returning to Mexico, he pursued a chemical engineering degree. Later on, he continued his research in Europe, as well as in Berkley, California. That was where most of his important work was completed, and was where he discovered that freons harm the ozone layer. As of today, Mario Molina still works in California as well as in Mexico. He is married to Guadalupe Alvarez and has a son named Felipe. He received the Nobel Prize, along with his colleagues for their research in atmospheric chemistry, specifically about how chlorofluorocarbons (CFCs) were destroying the ozone layer, which is the thing that protects life on Earth from the harmful ultraviolet radiation coming from the sun. The ozone layer is made up of a compound containing three oxygen atoms and lies in the stratosphere, which is the second major layer of Earth's atmosphere. This "shield" of ozone is very fragile and has been significantly affected by human activities resulting in the accumulation of chlorofluorocarbons (CFCs) into the stratosphere.

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Atmospheric and Environmental Chemistry

Chemists, as well as chemical engineers, in the field of atmospheric and environmental chemistry, want to be able to understand the chemical composition and behaviors of Earth and the things in it, whether it be plants, rivers, oceans, or the atmosphere. Understanding the complex relationships between Earth's natural systems and human activity will make it easier to understand the potential consequences on the environment that may result from those interactions. If scientists understand what those consequences are, they can have a greater chance of preventing damage to the environment around us. As a whole, society should be aware of the potential affects products can have, not just on ourselves, but on the environment as well. Back in 1995, Mario Molina and his colleagues discovered that some products that were in use at the time were very harmful to the environment. In particular, the ozone layer.

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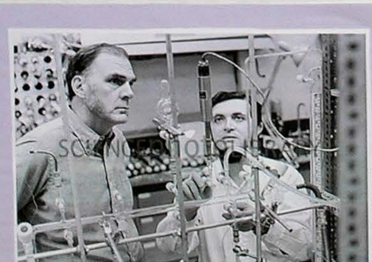

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Polar Stratospheric Clouds

Discovering Ozone Depletion

Molina and his colleagues specifically discovered the effect of freons on the atmosphere, especially the ozone layer. Chlorofluorocarbons (CFCs) are industrial compounds which have been used in refrigerants, solvents, propellants for spray cans, manufacturing of plastic foams, and more. They are useful because they can be quickly transformed from liquids into vapors, and they are generally non-toxic and non-flammable. However, it was discovered that these CFCs were accumulating in the earth's atmosphere and that they were not being destroyed by earth's natural cleansing mechanisms (rain, or oxidation by hydroxyl radicals) that rid the atmosphere of most pollutants. Because these CFCs are long living molecules that are not destroyed in the atmosphere, they eventually rise up into the stratosphere. In the stratosphere, where they are exposed to the Sun's ultraviolet radiation, they are then broken down and release chlorine atoms that continue to destroy the ozone molecules little by little.

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$$ClONO_2 + HCl \rightarrow Cl_2 + HNO_3 \quad (23)$$

$$ClONO_2 + H_2O \rightarrow HOCl + HNO_3 \quad (24)$$

$$HOCl + HCl \rightarrow Cl_2 + H_2O \quad (25)$$

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Further research led to the discovery of the "Antarctic ozone hole", which is where more than a third of the ozone column disappeared during the spring months over the Antarctic continent, and was becoming more severe as time went on. The question then arose, was it a natural, recurring phenomenon or was it caused by human activity? To answer this, more research was done in regards to polar stratospheric clouds (PSCs), which form seasonally over Polar Regions like Antarctica, and evaporate during the summer months. These PSCs form two types, Type I and Type II. The Type II clouds are more prevalent in Antarctica because of the lower temperatures compared to the Arctic. However, the type I clouds are observed more frequently due to temperatures slightly above the frost point of water. From laboratory experiments and thermodynamic considerations, they concluded that the Type I PSCs are composed mostly of nitric acid trihydrate (NAT) which leads to the formation of these clouds. They found that chemical reactions that occur in PSCs play a central role in ozone depletion, causing "chlorine activation and nitrogen deactivation" effects. First, during "chlorine activation", the chlorine is transferred from the HCl and ClONO into forms (mostly Cl) that can be quickly photolyzed (broken down by photons). Second, during "nitrogen deactivation", the nitrogen oxides are removed from the gas phase through combining nitric acid into PSCs. This prevents the $ClONO_2$ compound, which interrupts the catalytic chlorine cycles, which destroy the ozone, from forming. Reactions (24) and (25) are in fact, increased by PSCs, therefore setting the stage for increasing ozone depletion over the Antarctic.

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Since the discovery of this, the production of CFCs were discontinued through the Montreal Protocol, and as of recent discoveries, the levels of ozone-destroying chlorine particles have been decreasing, therefore the ozone hole is also decreasing as a result. As Molina said "the stratospheric ozone issue has shown us that mankind is quite capable of significantly affecting the atmosphere on a global scale" and that as a whole, society can work together to find a solution, like the Montreal Protocol, that can prevent these issues from happening in the future.

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