The Nobel Prize in Chemistry 1995
Paul J. Crutzen, Mario J. Molina, F. Sherwood Rowland

# Award Ceremony Speech

Presentation Speech by Professor Ingmar Grenthe of the Royal Swedish Academy of Sciences

*Translation of the Swedish text*

Your Majesties, Your Royal Highnesses. Ladies and Gentlemen,

About thirty years ago, for the first time, we humans were able to view our planet from space. We saw white cloud formations, blue oceans, green vegetation and brown soils and mountains. From space, we could view and study the earth as a whole. We have come to understand that we influence and are influenced by our biosphere, our life zone. One of the tasks of science is to describe and explain how this happens. In their research on the chemical reactions occurring in the earth's atmosphere, the 1995 Nobel Laureates in Chemistry - Paul Crutzen, Mario Molina and Sherwood Rowland - have adopted this global perspective.

The sun is the engine of life. Solar radiation is the source of energy for nearly all living organisms. But only some of the sun's rays are beneficial. It also emits ultraviolet radiation that harms living beings. Many of us have painful experience of excessive sunbathing. Life in the forms we are familiar with is the result of photosynthesis in green plants, which transforms the carbon dioxide in the air into biomass and oxygen. It has taken hundreds of millions of years for the biosphere to develop the atmospheric composition we have today. In the upper atmosphere, or stratosphere, solar radiation can transform oxygen into ozone. The highest ozone concentrations are found at an altitude of between 15 and 50 km. This ozone layer absorbs the sun's ultraviolet radiation very effectively, thereby reducing hazardous radiation on the earth's surface. This, in turn, makes efficient photosynthesis possible. Here we see an example of a feedback mechanism between the chemistry of the biosphere and the atmosphere. If it is disrupted, there may be serious consequences for life on our planet.

This year's laureates have made a series of major contributions to our knowledge of atmospheric chemistry. This has included studying how ozone is formed and decomposes and how these processes can be affected by chemical substances in the atmosphere, many of them the result of human activity. In 1970 Paul Crutzen demonstrated that nitrogen oxides, formed during combustion processes, could affect the rate of ozone depletion in the stratosphere. He suggested that dinitrogen monoxide, popularly known as "laughing gas" and formed through microbiological processes in the ground, could have the same effect. He has also studied the formation of ozone in the lower atmosphere. Ozone is one ingredient of "smog," which is formed by the influence of solar radiation on air pollutants, especially exhaust gases from motor vehicles and other combustion systems. Whereas stratospheric ozone is a prerequisite for life, tropospheric ozone is strongly toxic and harmful to most organisms, even in small quantities.

In 1974 Mario Molina and Sherwood Rowland showed that chlorine compounds formed by the photochemical decomposition of chlorofluorocarbons (CFC or "Freon" gases) could decompose the stratospheric ozone. They presented detailed hypotheses on how these complicated processes occurred.

The discoveries of the three researchers have an unusually close connection with the consequences of modern technology. Supersonic aircraft release nitrogen oxides in the stratosphere. Motor vehicles and stationary combustion plants release the same substances into the lower atmosphere. CFC gases from refrigerators and air conditioners, and in the form of aerosol spray propellants - combined with a "throwaway culture" - result in large-scale emissions of chlorine compounds into the atmosphere. The findings presented by this year's laureates in chemistry have had an enormous political and industrial impact. This was because they clearly identified unacceptable environmental hazards in a large, economically important sector. Their models were also subjected to very rigorous examination which eventually confirmed the main features of their original hypotheses. One obvious result is an international agreement known as the Montreal Protocol, which regulates the manufacture and use of CFCs.

Perhaps the most spectacular observation of changes in the stratospheric ozone content was made in 1985 over Antarctica by Joseph Farman and his colleagues. They observed a rapid and dramatic depletion of ozone in the polar region when sunlight returned after the polar night. The ozone content then built up to more normal levels during the subsequent polar summer and winter, after which the process was repeated. This recurring "ozone hole" was completely unexpected. Eventually a scientific explanation was found, mainly through the research of Susan Solomon, with important contributions from this year's laureates in chemistry as well.

Professor Crutzen, Professor Molina, and Professor Rowland,

You have demonstrated the importance of homogeneous and heterogeneous chemical processes in the earth's atmosphere. You have developed models that combine these data with knowledge of the large-scale transport processes in the atmosphere, and how these models can be utilized as a forecasting tool to evaluate the consequences of emissions of anthropogenic substances of various kinds. You have thereby not only created a clearer understanding of fundamental chemical phenomena, but also of the large-scale and often negative consequences of human behavior. In the words of Alfred Nobel's will, your work has been of very great "benefit to mankind." It is a privilege to congratulate you on behalf of the Royal Swedish Academy of Sciences, and I now ask you to receive your Nobel Prizes from the hands of His Majesty the King.

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