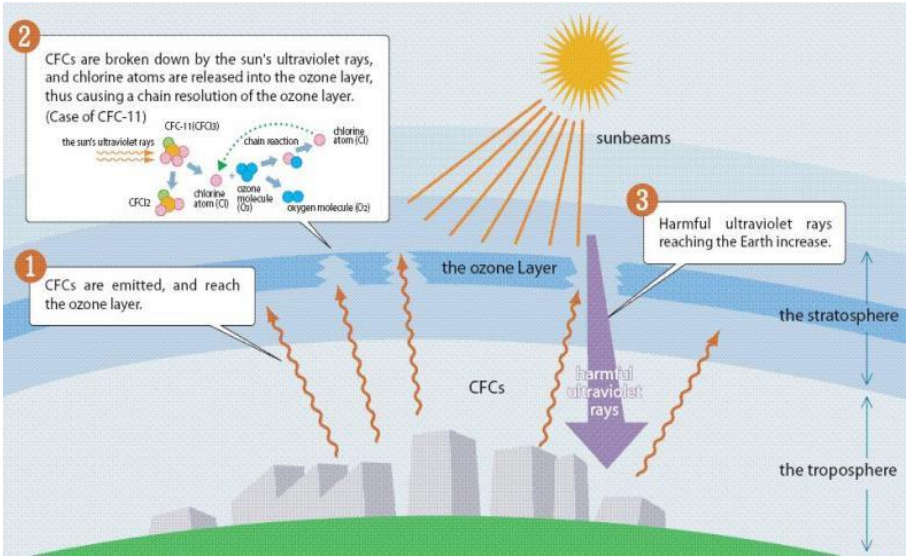
TEACHER BACKGROUND:
THE CHLOROFLUOROCARBONS

Refrigerators from the late 1800s until 1929 used the toxic gases, ammonia (NH_3), methyl chloride (CH_3Cl), and sulfur dioxide (SO_2), as refrigerants. Several fatal accidents occurred in the 1920s because of methyl chloride leakage from refrigerators. People started leaving their refrigerators in their backyards. A collaborative effort began between three American corporations, Frigidaire, General Motors and DuPont to search for a less dangerous method of refrigeration. In 1928, Thomas Midgley, Jr. aided by Charles Franklin Kettering invented a "miracle compound" called ***Freon***.

Freon represents several different ***chlorofluorocarbons***, or ***CFCs***, which are used in commerce and industry. They are a group of organic compounds containing the elements carbon and fluorine, and, in many cases, chlorine and hydrogen. CFCs are colorless, odorless, nonflammable, noncorrosive gases or liquids and highly stable compounds that were used as propellants in spray cans and in refrigeration units. They are several organic compounds composed of carbon, fluorine, chlorine, and hydrogen. CFCs are manufactured under the trade name ***Freon***. The 3 most widely used CFCs include ***CFC-11*** (trichlorofluoromethane - CFCl3), ***CFC-12*** (dichloro-difluoromethane - CF2Cl2), ***CFC-113*** (trichloro-trifluoroethane - C2F3Cl3),



CFCs have been found to pose a serious environmental threat. Studies undertaken by various scientists during the 1970s revealed that CFCs released into the atmosphere accumulate in the stratosphere, where they had a harmful effect on the ozone layer. Stratospheric ozone shields living organisms on Earth from the harmful

effects of the Sun's ultraviolet radiation. Even a relatively small decrease in the stratospheric ozone concentration can result in an increased incidence of skin cancer in humans and in genetic damage in many organisms. In the stratosphere the CFC molecules break down by the action of solar ultraviolet radiation and release their constituent chlorine atoms. These then react with the ozone molecules, resulting in their removal.

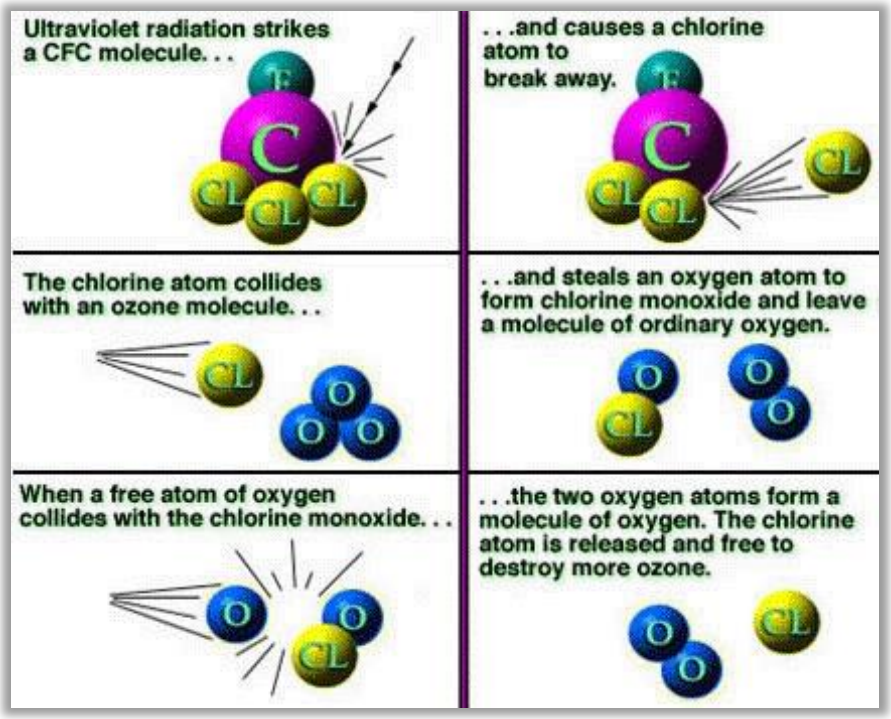


Figure 1:Ozone destruction by CFC molecules.

CFCs have a lifetime in the atmosphere of about 20 to 100 years, and consequently one free chlorine atom from a CFC molecule can do a lot of damage, destroying ozone molecules for a long time. Although emissions of CFCs around the developed world have largely ceased due to international control agreements, the damage to the stratospheric ozone layer will continue well into the 21st century. In 1978 ***The Montreal Protocol*** was adopted as a framework for international cooperation regarding CFC control.

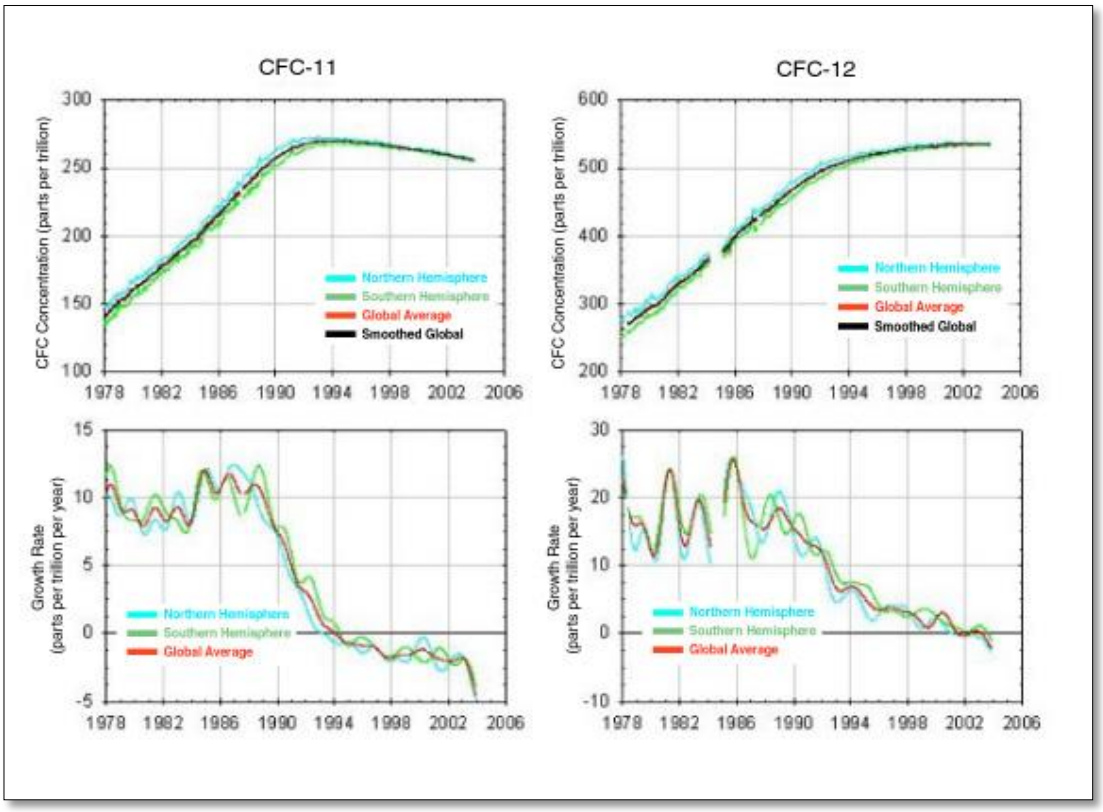


Figure 2: Atmospheric concentrations of CFC-11 and CFC-12 in both the Northern and Southern Hemisphere

Chlorofluorocarbons, as well as their replacements, are exceptionally strong greenhouse gases as well as being responsible for the destruction of stratospheric ozone. The most publicized of these compounds are those used as coolants in refrigeration and air conditioners, as propellants in spray cans and similar products, and as solvents for industrial purposes. Chlorofluorocarbons are far less abundant than carbon dioxide in the atmosphere, but they are 10,000 times more powerful as a greenhouse gas and can remain in the atmosphere for more than 45 to 100 years.

The science that became the basis for the Montreal Protocol resulted in the 1995 Nobel Prize for Chemistry. The prize was awarded jointly to Professors F. S. Rowland at University of California at Irvine, M. Molina at the Massachusetts Institute of Technology, Cambridge, and Paul Crutzen at the Max-Planck-Institute for Chemistry in Mainz, Germany, for their work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone.