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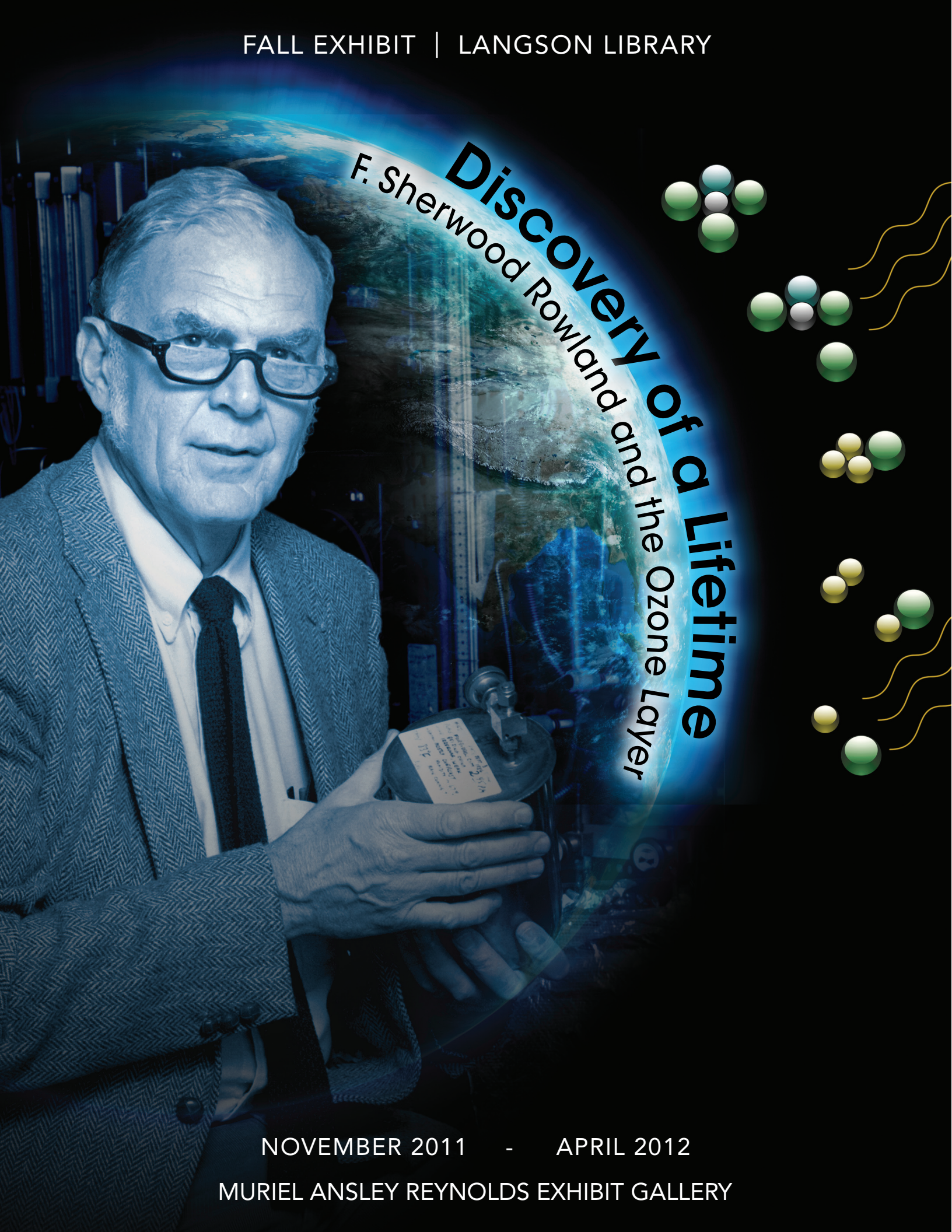

Discovery of a Lifetime

F. Sherwood Rowland and the Ozone Layer

NOVEMBER 2011 - APRIL 2012

MURIEL ANSLEY REYNOLDS EXHIBIT GALLERY

Discovery of a Lifetime

F. Sherwood Rowland and the Ozone Layer

An exhibit in the
UC Irvine Langson Library
Muriel Ansley Reynolds
Exhibit Gallery

November 2011 - April 2012

Curated by

Mitchell Brown
Research Librarian for Chemistry and Earth System Science

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Welcome to the UC Irvine Libraries' fall 2011 exhibit, **Discovery of a Lifetime: F. Sherwood Rowland and the Ozone Layer**. This exciting exhibit celebrates the research contributions of world-renowned atmospheric scientist and Nobel Prize winner F. Sherwood "Sherry" Rowland, and explores his role in bringing worldwide attention to the impact of human-contributed greenhouse gases on a planetary scale. Mitchell Brown, Research Librarian for Chemistry and Earth System Science is curator. The exhibit was inspired by Professor Rowland's generous donation of personal papers to the UCI Libraries. These rich materials are now available for scholarly research in the Libraries' Department of Special Collections and Archives.

We are honored to have Dr. Ralph J. Cicerone, President of the National Academy of Sciences, and UCI Chancellor Emeritus as the featured speaker for our exhibit opening on November 18.

I hope you enjoy the exhibit and return to view others in the future.

Lorelei Tanji
Interim University Librarian

Discovery of a Lifetime

F. Sherwood Rowland and the Ozone Layer

Discovery of a Lifetime celebrates the research contributions of world-renowned atmospheric scientist F. Sherwood "Sherry" Rowland, 1995 Nobel Prize winner for Chemistry, and UCI Donald Bren Research Professor of Chemistry in Earth System Science.

The exhibit traces Dr. Rowland's ground-breaking work as one of the first scientists to warn that chlorofluorocarbons (CFCs) released into the atmosphere were depleting the Earth's vital ozone layer. His research, conducted along with postdoctoral colleague Dr. Mario Molina, contributed to the passing of the 1987 Montreal Protocol to eliminate CFCs from aerosols, and brought worldwide attention to the impact of human-contributed greenhouse gases on a planetary scale. Along with Dr. Paul Crutzen, they were all three awarded the 1995 Nobel Prize in Chemistry "for their work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone."

Since 1978, the Rowland-Blake group has been monitoring global atmospheric trace gases. As with the study of the ozone depletion capability of the CFCs, one cannot always know until well into the work whether the research is about exposing global environmental problems or simply an interesting scientific puzzle. A current and long term research subject of the Rowland-Blake group is the global increase of greenhouse gases, including methane and carbon dioxide.

Dr. Rowland is internationally recognized not only for his research in the laboratory, but also for his efforts to inform other scientists, the public, and policymakers about threats posed to Earth's atmosphere by chemical pollutants. In clearly synthesizing the message of his research, Dr. Rowland developed a effective relationship with the media and learned to play his role as both a scientist and national advocate for the environment. Dr. Rowland epitomizes the important role of the scientist in explaining science and important global climate issues to the public.

1. "**The Man Who Knew Too Much**." Edward Edelson. *Popular Science*. January, 60-65, 102. 1989.

2. "**The Man Who Saved the World**." Edward Humes. *Orange Coast Magazine*. February, 68-70. 1996.

3. "**How to Win a Nobel Prize**." Steve Thomas. *OC Metro*. May 18, 2000.

4. **Photograph of F. Sherwood Rowland and a collection of maps.** Circa 1940.

"In several summers of my early teens, the high school science teacher entrusted to me during his two week vacations the operation of the local volunteer weather station, an auxiliary part of the U.S. weather service-maximum and minimum temperatures and total precipitation. This was my first exposure to systematic experimentation and data collection."

F. Sherwood Rowland

Source: F. Sherwood Rowland, From *Les Prix Nobel*. The Nobel Prizes 1995, Editor Tore Frängsmyr, Nobel Foundation: Stockholm, 1996.

5. **Photograph of the F. Sherwood Rowland Papers in Special Collections and Archives**. University of California Irvine Special Collections, 2011.

The *Rowland Papers* consist of more than 310 archival boxes. The collection documents Dr. Rowland's professional career in radiochemistry and atmospheric science. The material documents his research, awards, professional service, and his global efforts to educate the public and policymakers about stratospheric ozone depletion, global climate change, and related environmental issues. Included are audiovisual recordings, speeches, lecture notes, slides, manuscripts, correspondence, notes, reports, drafts, publications, clippings, and photographs.

6. "**Photograph of F. Sherwood Rowland swinging a bat as a child**." Circa 1937. (Rowland Papers).

7. "**Photograph of F. Sherwood Rowland as a baseball player**." Circa 1950. (Rowland Papers).

During Dr. Rowland's first year in graduate school at the University of Chicago in 1948, he played both basketball and baseball for the University teams. He continued to play baseball for the University during the spring for two more years. He also spent summers playing semi-professional baseball for a Canadian team in Oshawa, Ontario.

8. **Baseball photograph**. *The Daily Times-Gazette*, Oshawa Ontario, October 16, 1951.

Dr. Rowland won G. M. Trewin Memorial Trophy Batting Trophy, batting .397 in the 1951 regular season with the Oshawa Merchants.

"How are a Nobel-prize winning chemist and a baseball player alike? They are both outstanding in their field."

Prof. Ken Janda, UC Irvine

9. **Photograph of Willard F. Libby**. Nobelprize.org. 2011.

Dr. Willard Libby was Dr. Rowland's thesis advisor at University of Chicago. He received the Nobel Prize in Chemistry in 1960.

"I see you made all A's in undergraduate school. We're here to find out if your are any dammed good."

William Libby

"A scientist should always keep busy – and have lots of interests."

William Libby

10. **Photograph of F. Sherwood Rowland as an undergraduate**.
Circa 1952-54.

"In 1950, he played for and managed the Oshawa Merchants a championship semipro team in Canada. How did all this sit with Libby? "He thought I was lazy, and with respect to chemistry that was probably true." Rowland admits. "I lead a busy life."

F. Sherwood Rowland

11. **The Epithermal Reactions of Recoil Atoms by F. Sherwood Rowland, Ph.D.**
The University of Chicago. 1952.

Dissertation with acknowledgement to advisor Willard Libby. "The author wishes to thank Dr. W. F. Libby for his guidance and encouragement throughout the course of this work, and especially for introduction to the true scientific spirit."

12. **"Hot atom" chemistry research**.

In 1956, Dr. Rowland moved to an Assistant Professorship at the University of Kansas, which had just completed the construction of a new chemistry building, including special facilities for radiochemistry. Dr. Rowland's early work in "hot atom" chemistry was concentrated on the application of radioisotopes to chemical reactions, using tritium and radioactive tracer isotopes.

a. "Radioassay by Gas Chromatography of Tritium and Carbon-14 Labeled Compounds." F.Sherwood Rowland, and Richard Wolfgang. *Analytical Chemistry* 35(8):903-906, 1958.

b. "Proportional Counter Assay of Tritium in Gas Chromatographic Streams." J. K. Lee, et al. *Analytical Chemistry* 34(7):741-747,1962.

13. **Various clippings from local press about the UCI Chemistry Department**.

UC Irvine & Research

F. Sherwood Rowland arrived at the Irvine campus of the University of California in August 1964, as Professor of Chemistry and the founding Chairman of the Chemistry Department (1964-70). Dr. Rowland said, "I have deliberately followed a policy of trying to instill some freshness into our research efforts by every few years extending our work into some new, challenging aspect of chemistry…" Dr. Rowland expanded his work from "hot atom" chemistry to environmental chemistry, expanding his research group in 1987 to form the Rowland/Blake group. The research group has been heavily involved in a series of regional and global research projects, often involving aircraft-based atmospheric field research.

14. **UC Irvine Chemistry Department Brochure and Flier.**

    a. Graduate Program in Chemistry, 1965-1966.

    b. UC Irvine Chemistry. January 1966.

15. **UC Irvine Chemistry Faculty standing at balcony outside library**. *Los Angeles Times*. May 23, 1965.

    This photo depicts the first faculty in the Department of Chemistry, UC Irvine 1965. Pictured from left to right are: Conway Pierce, David Brant, Marjorie Caserio, F. S. Rowland, Robert Taft, Don Bunker, Edward Lee, Harold Moore.

16. **UC Irvine Staff ID Card for F. Sherwood Rowland**. 1964. (Rowland papers).

    An early UCI ID card signed by Chancellor Daniel G. Aldrich, Jr.

17. **TRIGA Mark 1 Reactor diagram**. *Safety Analysis for New Nuclear Reactor Facility*. March 1968. (Rowland papers).

    The UCI Nuclear Reactor is a 250 kilowatt steady-state power Mark I TRIGA research reactor, located underneath Rowland Hall. It has been in operation since November 1969. As Department Chair, Rowland was instrumental in bringing the reactor to UCI.

    The reactor was most famously used to analyze bullet fragments from the assassination of President John F. Kennedy, which determined that all the fragment were from the same bullet. Other research areas where the reactor has been used include the analysis of moon rocks collected by Apollo astronauts, the chemical composition of meteorites and tiny bits of sculpture, mosaics or photographs for the J. Paul Getty Museum.

18. **Photograph of F. Sherwood Rowland and Ivan Hinderaker.** 1963.

Vice Chancellor of Academic Affairs Ivan Hinderaker and F. Sherwood Rowland reviewing campus construction drawing.

19. **Photograph of F. Sherwood Rowland with early construction of Physical Sciences I in the background.** Circa 1964.

Built in 1968, the six-story structure houses the School of Physical Sciences, with research and teaching laboratories, classrooms, and offices.

20. **Photograph of Physical Science I under-construction.** March 1968.

Physical Science I was renamed Rowland Hall in 1998.

21. **F. Sherwood Rowland standing in front of Physical Sciences I now renamed Rowland Hall.** (October 9, 1998). *OC Metro*, May 18, 2000.

22. **Research Gas Canister (cylinder) and Research Gas Canister (sphere).**
On loan from the Rowland-Blake lab.

These gas cylinders (or "cans") are used to collect atmospheric gases to be analyzed.

23. **Photograph of Rowland teaching.** Circa 1975-76.

24. **Presentation Materials**. (Rowland papers).

Rowland used slides and transparencies in presentations to illustrate the change in atmospheric concentrations of CFCs and their effects on global stratospheric ozone.

a. Transparancies. Methyl chloroform levels compared with CFC-11 and CFC-12 (F-11 and F-12) concentrations, 1979-1987.

b. Slides from presentations.

26. **Photographs of F. Sherwood Rowland in laboratory with group members.**

a. left to right: Rama Iyer, Nun-Yi Wang , Donald Blake, Sherwood Rowland, Nichola Blake. Photograph by Kerry Klayman: UC Irvine, 1991. (Rowland papers).

b. "The Rowland/Blake group" of graduate students, research staff, and faculty. Circa 1984. (Rowland papers).

27. **Photograph of Rowland holding a research gas canister in Kaikoura, New Zealand during a trip to collect trace gas samples.** 1978. (Rowland papers).

    Since 1978 the Rowland-Blake group has collected air samples at surface locations every three months in Pacific regions, from northern Alaska to southern New Zealand. These canisters are brought back to the laboratory for analysis and determination of selected trace gas concentrations.

28. **List of sites for sampling.** 1978. (Rowland papers).

29. **Photograph of Rowland and Donald Blake in aircraft with headphones.** September 1991. (Rowland papers).

    Drs. Rowland and Blake travelled all over the world to obtain trace gas samples.

30.

    a. **Letter to Brian Toon of NASA from Drs. Rowland and Blake regarding atmospheric research using DC 8 flights.** PEM-West 1991. (Rowland papers).

    b. **Sample worksheet for research gas canister collection.** March 1992. (Rowland papers).

    c. **Flight plan for atmospheric testing flight path.** March 1992. (Rowland papers).

CFC Research

Since 1973, the work of Dr. Rowland's research group has progressively involved more atmospheric chemistry and less radiochemistry, but with the important use of radioisotopes directed toward problems associated with atmospheric chemistry. The research work has been conducted at the University of California, Irvine by a strong, hard-working group of postdoctoral and graduate student research associates, together with several able technical specialists. In 1973, working with postdoctoral researcher Dr. Mario Molina, Dr. Rowland posited that the presence of CFCs in the stratosphere was not just a challenging and interesting scientific question, but a potentially grave environmental problem involving substantial depletion of the stratospheric ozone layer. Drs. Rowland and Molina have continued to focus on threads from this original problem.

Ozone (O_3), which plays a vital part in protecting biota from excess UV, is constantly created and destroyed in the stratosphere. Chlorine and bromine atoms alter the balance, leading to destruction.

> "A single chlorine molecule will, on average, remove between 10,000 and 100,000 molecules of ozone before it randomly moves down into the troposphere or is removed by reaction with molecules such as NO_2 or methane, hence the ozone depleting effect of CFCs. Other ozone-depleting substances include pesticides such as methyl bromide, halons used in fire extinguishers, and methyl chloroform used in industrial processes."
>
> http://www.apis.ac.uk/overview/pollutants/overview_CFCs.htm

A second, but perhaps less publicized, reason for discontinuing CFCs is that they can act as greenhouse gases, contributing to the forcing of climate change. The global warming potential (GWP) is a metric that compares the ability of a particular gas to trap heat in the atmosphere relative to a reference gas, carbon dioxide, on a kg to kg basis. Most CFCs have GWPs several thousand times greater than CO_2, over a 100 year time horizon.

31. **Correspondence between Ralph J. Cicerone and F. Sherwood Rowland.**

    a. Letter to Ralph J. Cicerone. January 29, 1974. (Rowland papers).

       Dr. Rowland sent a preprint of his Nature article to Cicerone prior to publication in 1974.

    b. Reply from Ralph J. Cicerone to Rowland. January 30, 1974. (Rowland papers).

       Cicerone was interested in the direction of Dr. Rowland's research and they began corresponding about gases in the atmosphere.

32. **"Stratospheric sink for chlorofluoromethanes: chlorine atom-catalysed destruction of ozone."** M. J. Molina, and F. Sherwood Rowland. *Nature* 249 no. 5460 June 28, 1974.

Rowland and Molina hypothesized that the chlorine buildup from CFCs would spell severe trouble for the ozone layer. According to their predictions, each chlorine atom could destroy 100,000 ozone molecules, meaning that decades of CFC use could cause substantial declines in the concentration of stratospheric ozone. The stratosphere is the layer of the atmosphere, which extends from an altitude of approximately 10 km to as high as 50 km.

"When asked how the work was progressing, Rowland later recalled, 'There was no moment when I yelled "Eureka!" I just came home one night and told my wife, "The work is going very well, but it looks like the end of the world."

F. Sherwood Rowland

Source: Jackson, Robert B. *The Earth Remains Forever: Generations at a Crossroads*. Austin: University of Texas Press, 2002. p. 72

33. **Photograph of F. Sherwood Rowland and Mario Molina in the laboratory.** Circa 1974-75.

34. **Photograph of Mario J. Molina and F. Sherwood Rowland in lab.** 1973.

35. **Cartoon.** "It's none of our business but did you know there's a hole in your ozone layer?" Hoest, artist. Circa 1980's.

36.

a. **Daily maximum ozone hole for October 3, 1979.** *NASA Ozone Hole Watch.* National Aeronautics and Space Administration. 2011.

Measurements of atmospheric gases over Antarctica show variation in level of ozone, where blue identifies lower levels during the spring months (August-December) that last for many weeks at a time.

b. **Daily maximum ozone hole for October 15, 1985.** *NASA Ozone Hole Watch.* National Aeronautics and Space Administration. 2011.

A British research team in Antarctica confirms that the loss of ozone created a hole between September and December, 1985. Ozone had decreased over all of Antarctica.

37. **Slide from Rowland's Chaffee lecture concerning Lovelock's data.** (Rowland papers).

In 1972 the chemist James Lovelock discovered that CFCs were present in both hemispheres of the Earth. To Dr. Rowland, this raised a challenge. Here was a new compound that had not been in Earth's atmosphere before, and the question was, "What will happen to it?"

38. **"Graphic of Halley Bay O3 - Halley Bay Monthly Means."** J. C .Farman, B.G. Gardiner, J.D. Shanklin. *Nature* 315: 201-210, May 16, 1985.

A British team, which had measured ozone levels over the Antarctic coast since 1956, first began noticing the phenomenon of decreasing ozone in the early 1980s.

39. **"Fluorocarbons – impact on health and environment."** *Congressional Hearing 1974, 93rd Congress. HR 17577 and HR 17545.* Dec. 11-12, 1974. Subcommittee on Public Health and Environment of the Committee on Interstate and Foreign Commerce, House of Representatives. (Rowland papers).

40. **Cover.** *New Times.* March 17, 1975.

41. **Cartoon.** "Little Ozone Annie." Scott Willis, artist. 1992.

42. **Cartoon.** "So that's the one most likely to get us." Bill Maudlin, artist. *Chicago Sun Times.* 1974.

43.

a. **Refrigerant 12 for Auto Air Conditioners.**

A Chlorofluorocarbon (CFC) is an organic compound that contains carbon, chlorine, and fluorine. CFCs are also commonly known by the DuPont trade name Freon. The most common CFC is dichlorodifluoromethane (R-12). Many CFCs were widely used as refrigerants, propellants (in aerosol applications), and solvents, but now banned under the Montreal Protocol.

b. **Style Hairspray.**

Note that the label states, "Environmentally safe aerosol" and "Contains no fluorocarbons."

44. **"Stratospheric Ozone: Earth's Fragile Shield."** F. Sherwood Rowland. *Yearbook of Science and the Future, Encyclopedia Britannica, Inc.,* 170-191. 1979.

Essay on the ozone layer and its role in protecting the Earth from solar radiation.

45. **The Ozone War.** Lydia Dotto and Harold Schiff. Garden City, New York: Doubleday, 1978.

Book about the role of aerosol sprays, supersonic aircraft, the Space Shuttles, and nitrogen-rich fertilizers as ozone-destroying compounds.

46.

a. **Cartoon.** "Credibility Hole." Andrew Birch, artist. Circa 1980's.

DuPont, the world's largest CFC producer, with 25 percent of the market share at the time, began phasing out production of CFCs after 1988.

b. **Cartoon.** "True, the fluorocarbon industry's threat to the ozone layer may every well be serious, but the ozone layer's threat to the fluorocarbon industry is equally serious." Sidney Harris, artist. Circa 1980's.

47. **"Science Answers the Ozone Critics: 'Here are some of the most frequently raised objections to ozone concerns, and the scientific responses to them."** *Popular Science*. October 1997.

Scientific responses to frequently raised questions about objections to the science of ozone depletion.

"So, a plausible, but fallible, hypothesis subsequently disproved by stratospheric observation has been elevated into major error by successive conversion of the failed hypothesis into purported fact and then into gross exaggeration of the faulty conclusion."

F. Sherwood Rowland

Source: "President's Lecture: The Need for Scientific Communication with the Public" F. Sherwood Rowland
Science, New Series, Vol. 260, No. 5114 (Jun. 11, 1993), pp. 1571-1576

48.

a. **"Attack on Ozone Science: Nobel Prize-caliber scientists conclude years ago that CFCs damage the ozone layer. So why is the debate still raging?"** *Popular Science*. 72-78. October, 1997.

b. **Cover.** *Popular Science*. October 1997.

Statesman and Communicator

The chlorofluorocarbon-ozone problem became a highly visible public concern in late 1974. With it came many new scientific experiments, legislative hearings, extensive media coverage, and a much heavier travel schedule for Dr. Rowland. Dr. Rowland was elected President of the American Association for the Advancement of Science (AAAS) in 1992 and served as National Academies of Science (NAS) Foreign Secretary (1994-2002), traveling worldwide to speak at scientific meetings and events. In 1995, he created, with Professor Prakesh Tandon of India, the InterAcademy Panel (IAP), a global network of the world's science academies, now representing more than 100 national academies. They felt the scientist has a role in communicating the message of their work to worldwide audiences, and that it is the responsibility of scientists to translate the message of science so that all audiences can understand it.

49. **Photograph of F. Sherwood Rowland holding gas canister in UCI laboratory.** Circa 1985.

50.

a. **F. Sherwood Rowland at the Nobel Prize award ceremony.** January 1996.

Seated to the left of Rowland is Molina, Crutzen, and UC Irvine Professor Frederick Reines the Nobel Prize winner in Physics the same year.

b. **F. Sherwood Rowland receiving the Nobel Prize from King Carl XVI Gustaf of Sweden.** January 1996.

51.

a. **"Stratospheric Ozone Depletion."** *Hearings before the Subcommittee on the Upper Atmosphere of the Committee on Aeronautical and Space Sciences, United States Senate*. 94th Congress. September 18, 19, and 23, 1975.

b. **Handwritten notes by F. Sherwood Rowland about his presentation to the Congressional hearing.** September, 1975. (Rowland papers).

These hearings led to what became the Montreal Protocol. The notes say: "I was the first witness, to be followed immediately by Ralph Cicerone and Jim Anderson."

52.

a. **Photograph from *The Infinite Voyage*, Episode #110, Crisis in the Atmosphere.** 1989. (Rowland Papers).

b. **Poster promoting *The Infinite Voyage*.** 1989. (Rowland Papers).

The Infinite Voyage ran for five seasons from 1987 to 1992 for a total of 20 episodes. It was a public television program co-produced by the National Academy of Sciences. Rowland served on the advisory board. Topics covered the entire spectrum of science, from physics and astronomy to biology and medicine.

53.

a. Invitation to F. Sherwood Rowland from the Department of the Environment, Ministry for Housing Environment and Countryside to present to the conference, "Saving the Ozone Layer." March 1989. (Rowland Papers).

b. **Photograph of UK Prime Minister Margaret Thatcher, F. Sherwood Rowland, Joan Rowland.** 1989.

c. **"Maggie Attacks Charles on Ozone."** *Daily Standard* placard. 1989.

Prime Minister Margaret Thatcher challenged the UK to act on ozone-destroying compounds.

54.

a. **White House meeting on Global Climate Change.** July 24, 1997. (Rowland Papers).

President Bill Clinton, Vice President Al Gore, and Rowland at the roundtable.

b. **"Global Climate Change (An East Room Roundtable)."** The White House. July 24, 1997. (Rowland Papers).

"Is it enough for a scientist simply to publish a paper? Isn't it a responsibility of scientists, if you believe that you have found something that can affect the environment, isn't it your responsibility to actually do something about it, enough so that action actually takes place?" Rowland concluded the lecture by answering a question about his move from the lab into advocacy: "If not us, who? If not now, when?"

F. Sherwood Rowland

55. ***The CFC-Ozone Puzzle: Environmental Sciences in the Global Arena.*** December 7, 2000. (Rowland Papers).

The John H. Chaffee Memorial Lecture on Science and the Environment National Council for Science and the Environment.

56.

a. List of memberships.

Rowland served as the Foreign Secretary of the National Academies of Science from 1994 to 2002. The Foreign Secretary, elected by the membership of NAS, heads the Office of International Affairs to serve as the official representative of the NAS to other international science academies and organizations. The foreign secretary provides leadership and coordination on international programs and helps draw on the full range of capabilities of program units in developing international activities.

b. **InterAcademy Panel (IAP) on International Issues pamphlet.** *Science and Technology and the Future of Cities: A Statement by the World's Scientific Communities*. June 1996. (Rowland Papers).

Seventy-two of the world's scientific academies signed the IAP Habitat II Statement. IAP was established in 1993 with its primary goal to help member scientific academies work together to advice citizens and public officials on the scientific aspects of global critical issues. Dr. Rowland was a founding Co-chair of the IAP.

57.

a. ***Handbook for the Montreal Protocol on Substances that Deplete the Ozone Layer.*** Ozone Secretariat, United Nations Environment Programme. 8th edition. 2009.

Montreal Protocol on Substances That Deplete the Ozone Layer adopted in 1987 to ban worldwide production of CFCs.

b. **Letter from Representative Henry A. Waxman to F. Sherwood Rowland.** December 27, 1989. (Rowland Papers).

Representative Waxman invited Rowland to testify before the subcommittee on Health and the Environment for HR 2699, on the health and environmental impacts of ozone depletion.

c. ***Stratospheric Ozone Protection Act of 1989 HR 269.***

Introduced to the 101th Congress by Rep. Jim Bates [D-CA44], but not enacted. "To amend the Clean Air Act to require the Environmental Protection Agency to take certain steps to protect the stratospheric ozone layer from depletion resulting from chlorofluorocarbons, and for other purposes."

58. **Cartoon.** "499 year planning committee." Tom Toles, artist. Circa 1986.

59. **"As Nations Delayed, the Danger Rose."** Graphic from article: "Who Lost the Ozone?" Eugene Linden. *Time*. 141(19):56-58. May 10, 1993.

Production of CFCs remained steady, declining worldwide only after signing of the Montreal Protocol in 1987.

60. **"Climate Change and its Consequences: Issues for the New U.S. Administration."** F. Sherwood Rowland. *Environment.* 32(3):28-34. March 2001.

"The world is a very complex system, the amount of information we have about it grows exceedingly rapidly, keeping up requires great effort, but I know of no easy way: you just have to do it. Meanwhile, the combination of some but not enough intelligence, plus considerable amounts of both ignorance and arrogance, can easily lead to being badly wrong in full voice and, worse yet, with a considerable following."

F. Sherwood Rowland

"President's Lecture: The Need for Scientific Communication with the Public." F. Sherwood Rowland. *Science*, New Series, Vol. 260, No. 5114 (Jun. 11, 1993), pp. 1571-1576.

"In response to climate change, we need to do it now because the development of long-term solutions will require decades to develop and decades to put into action."

F. Sherwood Rowland

61.

a. ***An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do About It.*** Al Gore. Emmaus, PA: Rodale Press, Melcher Media. 2006.

b. **Photograph of Al Gore, Joan Rowland, and F. Sherwood Rowland.**

Signed "To Joan Rowland. With Appreciation, Al Gore." Circa 1990's.

c. **"The CFC Success Story" from *An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do About It.*** Al Gore. Emmaus, PA: Rodale Press, Melcher Media. p. 294. 2006.

Chart of CFC production worldwide from the movie *An Inconvenient Truth*.

CFC Chemistry

Chlorofluorocarbons (CFCs) were used as refrigerants in air conditioners and refrigerators / freezers, as propellants in hair spray, perfumes, oven cleaners, underarm deodorants, cleaners, room deodorizers, furniture polishes, and more. They were also used as blowing agents in the production of styrofoam, foam rubber, and packing materials. CFCs are responsible for the progressive thinning of the ozone layer, which shields us from the sun's ultraviolet radiation. Nature also contributes chlorine to the atmospehre, but 82% of the chlorine bearing molecules in the upper atmosphere are man-made.

62. **1995 Nobel Prize in Chemistry poster.** 1995. (Rowland Papers).

63. **Moltek models.** Molymod. Springer Enterprises Ltd. 2011.

64. **How Ozone is Destroyed.** "The Heat Is On." Michael D. Lemonick. *Time*. Oct. 19, 1987.

    "A thin layer of ozone molecules shields humans and other living things from the sun's ultraviolet radiation, which can cause sunburns, skin cancers, and other problems."

65. **Persistant Destruction.** "Attack on Ozone Science: Nobel Prize-caliber scientists conclude years ago that CFCs damage the ozone layer. So why is the debate still raging?" *Popular Science*. 72-78. October, 1997.

66. **Into the Ozone.** "UCI's Sherry Rowland was right about the Ozone Layer." *OC. Register*. June 5th, 1988.

Nobel Prize Diploma and Medal

F. Sherwood Rowland is the Donald Bren Research Professor of Chemistry and Earth System Science at the University of California, Irvine. In 1995, he shared the Nobel Prize in chemistry with Mario Molina and Paul Crutzen, "for their work on atmospheric chemistry, particularly concerning the formation and decomposition of ozone." He has been internationally recognized with numerous awards and honors, not only for his groundbreaking work in the laboratory, but also for his efforts to inform other scientists, the public, and policymakers about threats posed by chemical pollutants to earth's atmosphere.

67. **"Two UC Irvine Scientists Win Nobel Prizes."** K.C. Cole. *Los Angeles Times*. October 12, 1995. (Rowland papers).

    "Let me say, also, it helps very much to have people believe in what you're doing."

    F. Sherwood Rowland

68. **Invitation and collateral materials for a White House Reception.** November 1, 1995. (Rowland papers).

69. **Joan Rowland, F. Sherwood Rowland and First Lady Hillary Clinton.** Photograph. November 15, 1995. (Rowland papers).

70. **Itinerary for Nobel Ceremony.** 1995. (Rowland papers).

71. **Manuscript of Rowland's Nobel Lecture to the Royal Swedish Academy of Sciences.** December 8, 1995. (Rowland papers).

72. **King Carl XVI Gustaf of Sweden presenting Nobel Prize in Chemistry to Rowland.** December 10, 1995. (Rowland papers).

73. **Nobel Medal.** 1995.

    a. Nobel Medal on presentation box.
    b. Nobel medal in case.

74. **Nobel diploma.** 1995.

The Nobel Prize in Chemistry 1995 was awarded jointly to Paul J. Crutzen, Mario J. Molina, and F. Sherwood Rowland "*for their work in atmospheric chemistry, particularly concerning the formation and decomposition of ozone*."

Each Nobel diploma is a unique work of art. The Literature diploma is written on parchment, i.e. specially treated leather, using largely the same technique as those of medieval book illustrators. The diplomas given to the other Laureates are produced on specially ordered handmade paper, each with individual designs related to the particular Laureate. The artists have tried to summarize something about the atmosphere and character of the work of each Laureate.

75. **Manuscript of Rowland speech to Nobel Dinner.** 1995. (Rowland papers).

76. **Photograph of Nobel Dinner reception.** 1995. (Rowland papers).

77. **Rowland with Queen of Sweden Queen Silvia.** 1995. (Rowland papers).