Special Lecture in Memory of Glenn Theodore Seaborg [19 April 1912-25 February 1999]
Glenn T. Seaborg's Multi-Faceted Career

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Abstract

Glenn Theodore Seaborg (1912-1999) was a world-renowned nuclear chemist, a Nobel Laureate in chemistry in 1951, co-discoverer of plutonium and nine other transuranium elements, Chairman of the U. S. Atomic Energy Commission from 1961-71, scientific advisor to ten U. S. presidents, active in national and international professional societies, an advocate for nuclear power as well as for a comprehensive nuclear test ban treaty, a prolific writer, an avid hiker, environmentalist, and sports enthusiast. He was known and esteemed not only by chemists and other scientists throughout the world, but also by lay people, politicians, statesmen, and students of all ages. This memorial includes a brief glimpse of Glenn Seaborg's early life and education, describes some of his major contributions to nuclear science over his long and fruitful career, and highlights his profound influence on nuclear science, both in the U. S. and in the international community.

Opening Remarks

It is a pleasure and great honor for me to be asked to present this special lecture in memory of Glenn Theodore Seaborg. I believe that almost everyone in attendance at this conference has been influenced by him in many ways just as I have been—as a teacher, mentor, scientist, international statesman, lecturer, colleague, sports enthusiast, avid hiker, and loyal friend.

Glenn T. Seaborg was a world-renowned nuclear chemist, educator, scientific advisor to ten U. S. presidents, humanitarian, and Nobel Laureate in Chemistry. He is probably best known for his leadership of the team that accomplished the first chemical separation and positive identification of plutonium in 1941, and his "revolutionary" actinide concept (1944) in which he placed the first 14 elements heavier than actinium in the periodic table of elements as a *5f* transition series under the lanthanide *4f* transition series rather than in the main body under groups 4, 5, 6, 7, etc. He went on to be co-discoverer of nine elements beyond plutonium, culminating in 1974 in the production of element 106, later named ***seaborgium*** in his honor.

Seaborg was also well known as an educator and for his tireless efforts to improve U. S. science education at all levels. He served as Chancellor of the University of California at Berkeley from 1958 until 1961 when he was called by President-Elect John F. Kennedy to Chair the U. S. Atomic Energy Commission, a position that he held until 1971. Seaborg led the negotiations resulting in the limited nuclear test ban treaty prohibiting the testing of nuclear devices in the atmosphere or under the sea, approved by the U. S. Senate in 1963. He strongly supported the use of nuclear energy as a source of electricity, and led delegations to some 63 countries, including the USSR, promoting the peaceful uses of atomic energy.

In an attempt to place some of Glenn T. Seaborg's major accomplishments in perspective, I have picked a few highlights from each of the six major time periods of his long, productive, and multi-faceted career shown in Table 1 below.

Table I. MULTI-FACETED CAREER OF GLENN T. SEABORG

1. Childhood and Early Education: 1912-34
2. Berkeley Days: 1934-1942
3. Manhattan Project "Met" Lab: 1942-46
4. Berkeley: 1946-61
5. Washington, DC: 1961-71
6. Return to Berkeley: 1971-99

1. Childhood and Early Education (1912-1942)

Glen Theodore Seaborg was born on April 19, 1912, of Swedish ancestry in Ishpeming, Michigan, a small iron-mining town on the Upper Peninsula of Michigan. His only sibling,

Jeanette, was born two years later. Even at an early age Glen appeared to be very tall. He attended grade school there until 1922 when his family moved to Home Gardens, CA now a part of South Gate, near Los Angeles. (At this time he changed the spelling of his name from "Glen" to "Glenn".) This move to California was made primarily because his mother wanted to broaden her children's horizons beyond the limited opportunities available in Ishpeming.

But Glenn never forgot his roots in Ishpeming and was always very proud of his Swedish ancestry. Unlike in Ishpeming, where his father would have been guaranteed employment for life as a machinist in the iron works, in California his father never found permanent employment at his trade, and the family finances were in rather poor condition. Glenn early on earned his own spending money by taking paper routes, mowing lawns, and performing other odd jobs.

Glenn attended high school in the Los Angeles suburb of Watts and developed a special interest in chemistry and physics, which he attributed to his inspiring high school chemistry and physics teacher, Dwight Logan Reid. Seaborg graduated as valedictorian of his class in **1929**. He first obtained work in a warehouse as a stevedore and then found summer employment as a night laboratory assistant in the Firestone Tire and Rubber Co. to earn money for his freshman year at the University of California at Los Angeles (UCLA). This made it just barely possible for him to enter UCLA in the depression year of 1929 since UCLA was a tuition free public university and he could live at home and ride with a friend, Stan Thompson, some 20 miles to UCLA. He also worked at a variety of jobs to help earn his way. He decided to major in chemistry rather than physics because he felt it would provide him with more career opportunities if he were unable to find a position as a university teacher. During his last year at UCLA, he became particularly interested in the exciting new developments in nuclear physics and chemistry. After receiving his A. B. in Chemistry in 1934, he stayed on a fifth year 1933-1934 to take a number of courses in physics, which had just that year been started at the graduate (Master's Degree) level.

Because graduate work had not yet been instituted in the Department of Chemistry at UCLA, he then went to Berkeley to pursue graduate work in chemistry there, hoping to work near the great Professor Gilbert Newton Lewis, dean of the college of chemistry, and the rising young nuclear physicist Ernest Orlando Lawrence, who had invented the cyclotron in the early 1930s.

2. UC Berkeley: 1934-1942

Seaborg describes the atmosphere that existed at the University of California at Berkeley (UCB) when he entered as a graduate student in August 1934, as "exciting and glamorous" and he took formal courses in chemistry from many eminent professors. Seaborg earned his Ph. D. in Chemistry in the spring of 1937 with a thesis on the inelastic scattering of fast neutrons. It was the depth of the Depression and suitable positions were difficult to find, but he was soon asked by Lewis to stay on at Berkeley to serve as his personal research assistant. Together, they published several papers and Seaborg always regarded Lewis as one of the scientific geniuses of our time and often expressed his admiration for him as his great teacher and mentor. During this he collaborated with the physicist J. J. (Jack) Livingood to use the newly completed 37-Inch Cyclotron to produce and discover several dozen new isotopes. Many of these, including iodine-131, are still widely used in nuclear medicine procedures. These experiences as a "radioisotope hunter" led eventually to the exploration of the transuranium elements, his life-long research interest. In 1939 Seaborg became an instructor at UCB and in 1941 he was promoted to Assistant Professor.

Quite unexpectedly, Seaborg's colleagues, McMillan and Abelson, during experiments to study nuclear fission, produced and identified the first "real" transuranium element, neptunium in 1940**.** They chemically separated and identified it as element 93, for which they proposed the name neptunium. McMillan then began a search for the next heavier transuranium element (atomic number 94), but was soon called to wartime research at the Massachusetts Institute of Technology. Seaborg requested and received his permission to continue this search. In February 1941, Seaborg led a team consisting of fellow instructor, Joseph W. Kennedy, and Seaborg's first graduate student, Arthur C. Wahl, in performing the first chemical separation and positive identification of plutonium. It was produced as the isotope plutonium-238 in deuteron bombardments of uranium. Soon after this, the new isotope plutonium-239 was produced and found to be highly fissionable with thermal neutrons. Recognizing the potential applications in nuclear weapons, Seaborg's group voluntarily withheld publication until after the end of World War II, but a secret report was sent to Washington, D. C. describing the chemical properties of elements 94 and 93 and suggesting the names plutonium (Pu) and neptunium (Np) for them. Gilman Hall where plutonium was separated and discovered is now a national historic chemical landmark. During the Fall of 1941 Seaborg also made another discovery. He began dating

Helen Lucille Griggs, secretary to O. E. Lawrence, and they spent Christmas Day, 1941 together in San Francisco, one of the first times Glenn had not returned to spend Christmas with his parents in South Gate, California.

3. University of Chicago—"Met" Lab: 1942-46

These discoveries at Berkeley led to the U. S. decision to undertake a crash program to develop nuclear reactors to produce plutonium to be used in the U. S. atomic bomb project. In April 1942 Seaborg took leave of absence from UCB to go to the University of Chicago Metallurgical Laboratory ("Met Lab") to direct the work on the chemical extraction and purification of the plutonium produced in the reactors.

As soon as the decision was made in March 1942 that Seaborg should move to Chicago for work on the Plutonium Project, he proposed to Helen Griggs and she accepted. The understanding was that he would soon come back to Berkeley and they would be married. In June 1942 Seaborg returned from Chicago to Berkeley. After taking Helen to visit his parents in Southgate, he persuaded her to return immediately with him to Chicago by train, promising her that they would be married en route. They disembarked from the train at Caliente, Nevada and were subsequently married at Pioche, Nevada on June 6, 1942, but not without some interesting "misadventures" which have been charmingly described by Helen Seaborg. (e.g., see Helen's account quoted by Seaborg in his preface, pp. 42-44, to the book, "The Transuranium People: The Inside Story" by D. C. Hoffman, A. Ghiorso, and G. T. Seaborg, Ref. 1.) Helen and Glenn's marriage was to last for more than 56 years and Seaborg often fondly referred to Helen as "his best discovery of all".

Then began Seaborg's national service which was to span the terms of the ten presidents shown in Table 2 below.

Table 2. National Service with Ten Presidents

1. Franklin Delano Roosevelt (1933-45)
2. Harry S. Truman (1945-53)
3. Dwight David Eisenhower (1953-1961)
4. John Fitzgerald Kennedy (1961-1963)
5. Lyndon Baines Johnson (1963-1969)
6. Richard Milhous Nixon (1969-1974)
7. Gerald Rudolph Ford, Jr. (1974-1977)
8. James Earl Carter, Jr. (1977-1981)
9. Ronald Wilson Reagan (1981-1989)
10. George Herbert Walker Bush (1989-1993)

By 1944, the process chemistry for plutonium was essentially worked out, and Seaborg and his co-workers began attempts to produce and identify the next transuranium elements with atomic numbers 95 and 96 (americium and curium). They were unsuccessful until Seaborg came up with the "actinide" concept of heavy element electronic structure in which the 14 elements heavier than actinium (atomic number 89) are placed in the Periodic Table of Elements as a *5f* transition series under the lanthanide *4f* transition series. A new Periodic Table incorporating this concept was published in Chemical & Engineering News in 1945**.** It was viewed as a "wild" hypothesis because at that time it was commonly believed that thorium, protactinium, uranium, neptunium, plutonium, and the following elements should be placed as the heaviest members of groups 4 through 10. But Seaborg postulated that the heavier actinides, like their lanthanide counterparts, would be extremely difficult to oxidize above the trivalent oxidation state. This concept was verified when chemical separations based on separating elements 95 and 96 as trivalent homologues of the lanthanides were successfully used to separate and identify these new elements, element 96, curium in 1944 and element 95, americium in 1945.

4. Back to Berkeley: 1946-61

World War II formally ended in September 1945 and soon after in May, 1946 Glenn Seaborg returned from Chicago to Berkeley as full professor of chemistry, bringing some of his associates with him. In early 1946 the Berkeley 184-Inch Cyclotron was just being converted from wartime use in isotope separation to its original purpose as a cyclotron for scientific purposes. By that time, Seaborg was also beginning to gain nationwide attention and was chosen by the U. S. Junior Chamber of Commerce as one of the 10 outstanding young men of 1947, along with another Californian, U. S. Representative Richard Nixon, who was later to be U. S. president from 1969-1974.

In the following years up to 1958, Seaborg, S. G. Thompson, A. Ghiorso and co-workers, including many graduate students and postdoctoral fellows, went on to synthesize and identify the next six transuranium elements with atomic numbers 97 through 102. The first of these, berkelium (97) and californium (98), were produced at the Berkeley 60-Inch Cyclotron in 1949-50. Shortly thereafter, in 1951, Seaborg and McMillan shared the Nobel Prize in Chemistry for their research on the transuranium elements. **Figure 1** shows Helen and Glenn Seaborg dancing at the ball at the Nobel ceremony in Stockholm, one of my favorite photos of them.

Seaborg was appointed Chancellor at UCB in 1958 and in addition to academic duties he was very interested in improving the football team and actively involved in the program, even

encouraging the hiring of a new coach. Football was his favorite spectator sport and he liked to point out that during his tenure as Chancellor the Berkeley football team went to the Rose Bowl! He rarely missed a game and could remember each one in detail.

Seaborg also began to broaden his horizons to national public service and served on the first General Advisory Committee to the Atomic Energy Committee (AEC) from 1947 to 1950. He was asked to serve as a member of President Dwight Eisenhower's Scientific Advisory Council when it was first formed in 1959. He served as Chancellor at Berkeley until 1961 when president-elect John F. Kennedy asked him to come to Washington, DC to chair the U. S. Atomic Energy Commission.

5. Washington, DC: 1961-71

Seaborg's tenure as Chairman of the AEC from 1961 to 1971 was longer than that of any other Chairman and spanned the presidencies of John F. Kennedy (1961-1963), Lyndon B. Johnson (1963-1968), and Richard M. Nixon (1969-1974). Under Seaborg's guidance, the AEC played a significant role in the negotiation of the Non-Proliferation Treaty and took the lead in instituting national and international safeguards to assure that nuclear materials were not diverted from peaceful uses to weapons purposes. He was a strong advocate of a Comprehensive Test Ban Treaty. Under Kennedy's presidency, Seaborg led negotiations resulting in the limited nuclear test ban treaty (LTBT) prohibiting the testing of nuclear devices in the atmosphere or under the sea, which was approved by the U. S. Senate in August, 1963. Under Johnson, strategic arms limitation treaty (SALT) talks were begun. The non-proliferation treaty (NPT) was negotiated and signed in 1968, and then ratified in the Senate in March, 1969 under Nixon.

Glenn and Helen and their six children are lived Washington D. C. during his tenure as AEC Chairman. Helen was his constant companion and advisor and accompanied him on most of his many trips, faithfully attending the scientific and other symposia in which he was involved.

It seemed that Seaborg traveled almost constantly abroad and within the U. S. In May, 1963 he led a tour of 10 U. S. scientists to the USSR. He and Albert Ghiorso presented a Mendelevium folio to USSR Acad. of Sciences Pres. Keldysh (element 101 had been discovered at Berkeley in 1955 by Ghiorso et al. and named it Mendelevium in honor of Dimitri Mendeleev, the great Russian chemist who formulated one of the earliest versions of the periodic table. On the same trip Seaborg together with A. M. Petrosyants, Chairman of the USSR State Comm. on Atomic Energy) signed a memo on cooperation in the field of utilization of atomic energy for peaceful purposes.

Seaborg was instrumental in implementing awards to scientists in the U. S. and abroad. When Lyndon Johnson became president in late 1963 after the assassination of John Kennedy, Seaborg encouraged him to proceed with the presentation of the Fermi Award of the U. S. AEC

to J. Robert Oppenheimer in December 1963 in spite of the strenuous disapproval of many members of Congress. (Oppenheimer's security clearance had been suspended in 1954 after he had been deemed a security risk.)

As AEC Chairman, Seaborg strongly supported the use of nuclear energy as a source of electric power, and led delegations to some 63 countries promoting the peaceful uses of atomic energy. Examples are visits to: Norway in 1963**;** Japan in 1965 (**Figure 2** shows a photo taken at JAERI, Tokai-Mura). From left to right, Seiri Kawabata, Ryokichi Sagane, Seaborg, and our Actinides 2001 Conference Chairman Keiji Naito; and India in 1967 to visit Prime Minister Indira Ghandi.

In 1966, the Fermi Award went jointly as suggested by Seaborg to three non-U. S. citizens: Lise Meitner, Otto Hahn, and Fritz Strassman for their "independent and collaborative contributions" to the discovery of nuclear fission. Seaborg traveled to Cambridge, England in October 1966 to present the Award to Lise Meitner in person as she was not physically able to attend the original Award Ceremony in Vienna, Austria in August of that year.

The next year he visited Seaborg strongly recommended to President Nixon that special one-time Atomic Pioneer Awards be presented to Vannevar Bush, James B. Conant, and General Leslie R. Groves for their service in running the war-time Manhattan project to build nuclear weapons. Nixon accepted this recommendation and the awards were presented in February 1970.

Seaborg also continued his interest in transuranium element research, and the National Transplutonium Production Program was established at the High Flux Isotope Reactor (HFIR) which went into operation at the Oak Ridge National Laboratory in the 1965. The HFIR and the associated transuranium processing facility (TRU) were essential to the production of rare heavy element isotopes to be used in the synthesis of new heavy elements and in heat sources for space exploration. Other radioactive isotopes for applications in biology, nuclear medicine, and industry were produced. During his tenure the support for basic research in the physical sciences, biology, and medicine nearly doubled.

6. Berkeley: 1971-99

Seaborg returned to Berkeley in 1971 as University Professor of Chemistry, a prestigious appointment by the Regents of the University of California which made him a professor of chemistry at all the UC campuses. He continued to serve as an informal scientific advisor to successive presidents and many governmental bodies. He introduced Vice-President Gerald Ford (1974-77) at the World Future Society Conference in Washington, D. C. in 1974 and spoke with former President Jimmy Carter (1977-81) at the 1984 "Salute to Excellence" dinner of the American Academy of Achievement, where a good photo was taken of him with Carter.

He was a member of the team that discovered element 106 at LBNL in 1974**.** In the photo in **Figure 3**, Seaborg along with Albert Ghiorso and Matti Nurmia are shown together with our Heavy Element Element Nuclear and Radiochemistry Group which confirmed the discovery in 1994**,** thus paving the way for naming it seaborgium (Sg). He taught regularly until 1979, supervising the Ph. D. research of more than 65 students in all. I went to Berkeley in 1984 to be professor of nuclear chemistry at UCB and Sr. Scientist and leader of the Group and although we held our own group meetings, we still attended the famous "brown bag" lunches in his office. Dr. Y.-F. Liu's farewell lunch in 1981 which was attended by the **SHEIKS** (**S**uper**H**eavy **E**lement **I**sotope **K**jemiker**s**) group is shown in **Figure 4a** and a special lunch (1987) honoring Russian visitors Vladimir Perelygin and G. Ter-Akopian is shown in **Figure 4b.**

In 1982, Seaborg founded the Lawrence Hall of Science and became its first director. He served as Associate Director-at-Large of the Lawrence Berkeley National Laboratory until his death in 1999. He was active in many international organizations for fostering the application of chemistry to world economic, social, and scientific needs.

Seaborg maintained and even escalated his interest in better education in science and mathematics at all levels and served on many federal and state committees. President Reagan appointed him to be a member of the Commission on Excellence in Education (NCEE) and they its report "A Nation at Risk" was presented in April 1983. In 1989, Seaborg and the current Secretary of Energy James Watkins hosted a Mathematics/Science Action Conference at the Lawrence Hall of Science that again called for a revitalization of science education in the U. S. Seaborg used the following quote from that report in his address to the Conference. ***"Our Nation is at risk. Our once unchallenged preeminence in commerce, industry, science and technological innovation is being overtaken by competitors throughout the world. If an unfriendly power had attempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war. As it stands, we have allowed this to happen to ourselves. We have in effect been committing an act of unthinking, unilateral educational disarmament."***

In 1989, Seaborg was asked to brief President George H. W. Bush on the "cold fusion" phenomenon and received the Presidential National Medal of Science from him in 1991.

In addition to all of his other activities Seaborg authored a host of books and was exceedingly proficient in explaining and popularizing science to non-specialists and laymen as well as other scientists. A list of some of these "non-technical" books is shown below.

Table 3. Selected "Non-Technical" Books

1958: Elements of the Universe--*Best science book for youth award

1964: Education and the Atom

1971: Man and Atom
1979: Beyond Normalization—Report of UNA-USA National Policy Panel to Study U. S.-China Relations
1981: Kennedy, Khruschchev, and the Test Ban
1987: Stemming the Tide: Arms Control in the Johnson Years
1992: National Service with Ten Presidents of the United States
1993: The AEC Under Nixon: Adjusting to Troubled Times
1994: The Plutonium Story: The Journals of Professor Glenn T. Seaborg, 1939-1946
1994: Chancellor at Berkeley
1996: A Scientist Speaks Out: A Personal Perspective on Science, Society and Change
1997: A Chemist in the White House

How he managed to do all this I will never understand. Our final collaborative effort, together with Albert Ghiorso, resulted in the book entitled "***Transuranium People—The Inside Story"***, which was published in early 2000. Just that one book seemed to occupy all my "spare" time from about 1996 until August 1998. Of course, in typical fashion, Seaborg had his sections completed long ahead of time with appropriate figures and pictures, but Al and I worked long and hard to get all our pictures in and have him read our final texts. Somehow I was obsessed with getting this project completed and we sent it to the publisher just before we left for the August 1998 ACS national meeting in Boston where he suffered the stroke and fall on August 24, 1998 that ultimately claimed his life.

A party celebrating the proposal by the discoverers to name element 106 after him was held at the Seaborg Institute for Transactinium Science at LLNL on March 13, 1994, just before the San Diego ACS meeting at which Ken Hulet announced the proposal to name element 106 as Seaborgium. Seaborg was presented a crystal periodic table during the LBNL Open House on 18 October, 1997, proclaimed Glenn Seaborg Day by the city of Berkeley, California to recognize the naming of element 106 after him. As you know, the name "seaborgium" for element 106 was not officially approved by IUPAC until August 1997, an honor which Seaborg said he cherished more highly than the Nobel Prize.

After the historical session on chemistry of the Manhattan Project on Monday morning, August 24, 1998, we had a photo taken together shown in **Figure 5** that I believe is one of the last photos of him. It was taken on August 24, 1998 just after the morning historical symposium on the chemistry of the Manhattan project for which he had given the introduction and I believe it is probably the last photograph taken of him. That evening while exercising at the hotel he suffered the stroke that resulted in his death on Feb. 27, 1999.

I have often tried to figure out why and how Glenn Seaborg accomplished so much—how he managed to "do it all" and contribute to so many fields—sustaining a high level of achievement right up to the very end of his life. It is true that Glenn was a master administrator of science and knew how to delegate, and that he worked extremely hard and never gave up, but in truth, many people do that! The current periodic table is a tribute to his scientific intuition and perseverance, showing not only the actinide but the superactinide series which he proposed so long ago and which we may yet glimpse. Glenn also had a rare ability, which in current jargon, might be characterized as being a "parallel" processor. He could keep track of a multitude of very important projects all at once, perhaps due to his fabulous memory, reinforced by his lifelong habit of recording everything in his famous journals. Not only was he was able to access this wealth of information, but even more importantly, he was able to apply it as required. His organizational skills were legendary and as long-time collaborator and friend Albert Ghiorso says, "He always kept his eye on the ball and had a knack for doing the right thing at the right time." Certainly a strong factor in his success and productivity was his wife Helen who was his ultimate confidant, "advisor", and in later years his almost constant traveling companion.

In spite of his legendary accomplishments, Glenn Seaborg always had time for family members, colleagues, students, and even non-scientists who wanted to visit with him. We have lost a treasured advisor, colleague, mentor, resource, and friend. But he will live on through his prolific writings and in the cherished memories of the multitude of students, scientists, colleagues, and lay people that he touched in his long and productive life.

I would like to close my remarks in his memory with two quotes. The first was made in the context of the value of fundamental research:

"We cannot very often predict the practical applications of basic science--but we can predict that these applications will occur--to the positive benefit of mankind."

The second is an excerpt from the statement he delivered upon being appointed Chancellor of the University of California, Berkeley in 1958. It is my favorite quote from Seaborg and an appropriate ending for these remarks.

"There is a beauty in discovery. There is mathematics in music, a kinship of science and poetry in the description of nature, and exquisite form in a molecule. Attempts to place different disciplines in different camps are revealed as artificial in the face of the unity of knowledge. All literate men are sustained by the philosopher, the historian, the political analyst, the economist, the scientist, the poet, the artisan and the musician."

Tables.

1. Multi-Faceted Career of Glenn T. Seaborg. Inserted in text.
2. National Service with Ten Presidents. Inserted in text.
3. Selected "Non-Technical" Books. Inserted in text.

Figure Captions.

Attached as Powerpoint files called Fig1, Fig2, Fig3, Fig4, Fig5.

1. Helen and Glenn Seaborg dancing at the Nobel Ceremony in Stockholm, 1951.

2. JAERI, Tokai-Mura, Japan, 1965. From left to right, Seiri Kawabata, Ryokichi Sagane, Glenn Seaborg, and our Actinides 2001 Conference chairman Keiji Naito.

3. LBNL, 1994: Heavy Element Group Members together with Yas Watanabe, and original element 106 discoverers Albert Ghiorso, Glenn Seaborg, and Matti Nurmia.

4. a) Farewell Luncheon for Dr. Y.-F. Liu: Seated, left to right: Diana Lee, Phil Wilmarth, Akihisa Kudo, Bob Welch, Pat McGaughey. Standing, left to right: Rose Marie McFarland, Carol James, Zoe Randolph, Albert Ghiorso, Yuan-fang Liu, Glenn T. Seaborg, Matti Nurmia.
b) SHEIKS meeting honoring Russian visitors. Sitting, left to right: Darleane C. Hoffman, Coreen Casey, Matti Nurmia, GTS, Albert Ghiorso. Standing, left to right: Ken Gregorich, Walter Loveland, Roger Henderson, Robert Chadwick, Howard Hall, Vladimir Perelygin, Gurgen Ter-Akopian, J. Mike Nitschke, Carolyn Gannett, Yuichi Hatsukawa.

5. Glenn T. Seaborg and Darleane C. Hoffman, 24 August 1998. Taken at American Chemical Society National meeting in Boston, Massachusetts, USA.