Conference paper

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The life and contributions to the periodic table of Glenn T. Seaborg, the first person to have an element named after him while he was still alive

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Abstract: Glenn Seaborg was born on Michigan's Upper Peninsula in 1912. At age 10, he moved to southern California, where his high school chemistry and physics teacher, Dwight Logan Read, sparked his interest in these fields. Seaborg was the first person to have an element named after him while he was still living. The only other person to have an element named after him while he was still alive was Yuri Oganessian.

Keywords: actinide series; Mendeleev 150; periodic system; periodic table; Seaborg.

Early life

Glenn Theodore Seaborg was born in Ishpeming, on Michigan's Upper Peninsula, in the United States, on April 19, 1912. His parents were Swedish Americans, and he spoke Swedish before he spoke English. He was proud of his Swedish heritage for his entire life. Ishpeming was rural. It has a cold climate similar to that of Sweden, which is why Seaborg's paternal grandfather and mother each moved there from Sweden. The snow was so high in winter that he skied out of the second story window of his modest house. In his 10 years in Ishpeming, he never talked on the phone or heard the word "radio". He never forgot his roots in Ishpeming, and visited it throughout his life.

The Seaborg's friends Bob and Ruth Engstroms had moved to Southern California and wrote a letter urging Glenn's parents to join them. Glenn's mother wanted to move to California because she thought it would give her children more opportunity. Glenn had one sibling, a younger sister, Jeanette. Glenn and Jeanette are shown when Glenn was four years old in Fig. 1. The Seaborgs moved to South Gate, a suburb of Los Angeles, in 1922, when Glenn was ten. Bob Engstrom was a carpenter and helped them build their house.

Seaborg went to David Starr Jordan High School in Watts, a neighborhood in southern Los Angeles. He liked history and English, had an aptitude for math, and had no interest in science and knew little about it. As he planned his junior year, a school counselor told him that he needed at least one science class with laboratory sessions to fulfill college requirements. He wanted to go to college. So he signed up for the science class offered in his junior year, which was chemistry.

This class was taught by Dwight Logan Reid with an unusual enthusiasm. He did not teach chemistry; he preached it. His eyes would light up as he told stories that animated the subject. He caught Glenn's interest in chemistry's controversies in a way that made him want to know the answers. He also encouraged Glenn, which was very important to him. It was this fantastic teacher who sparked young Glenn's interest in chemistry and physics, and without him, Glenn would probably not have made the discoveries he made.

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Fig. 1: Glenn Seaborg, age 4, and his sister, Jeanette, age 2, in 1916, in Ishpeming, Michigan, where Glenn Seaborg spent the first 10 years of his life.

Seaborg's father had a difficult time finding employment in South Gate, and so the family was poor. Glenn went to the University of California at Los Angeles, which had no tuition at the time, and which was close enough to his home to allow him to live at home and save rent money. It was his only chance, and he resolved to do whatever it took to succeed. Mr. Reid taught physics in Glenn's senior year in high school, and it interested him even more than chemistry. But he believed chemistry had more job opportunities, so he majored in it in college.

Scientific contributions

In graduate school at the University of California at Berkeley, where he obtained his PhD in chemistry, he collaborated with Jack Livingood on discovering many new radioactive isotopes. The first were new radioactive isotopes of tin with unremarkable properties, but they were immeasurably important to Seaborg, for they opened the door to his future. They discovered iron 59, which was used by others for breakthroughs in our understanding of iron metabolism and blood formation. At one point, Seaborg had a conversation with Joe Hamilton, a pioneer of nuclear medicine. Hamilton was using an isotope of iodine to study thyroid function. Iodine is crucial in manufacturing thyroxine, a growth-regulating hormone made by the thyroid gland. He told Seaborg the isotope he was working with had a half-life of only 25 min, too short for it to progress through the body. Seaborg asked what Hamilton would prefer for a usable half-life. He replied about a week, and Seaborg said he would try to find one of that stability. Hamilton was absolutely amazed when Seaborg came back with iodine 131 [1], with a half-life of 8 days, almost exactly the time period he asked for! Iodine 131 turned out to be of great significance in diagnosing thyroid gland problems and locating brain tumors. It is used to treat hyperthyroidism, certain goiters, and some thyroid cancers. It can diagnose kidney and liver

disease, screen for pulmonary emboli, and determine cardiac output and blood volume. Amazingly, iodine 131 treated Glenn's mother's hyperthyroidism, and saved her life! This of course was personally very satisfying to Glenn.

The great chemist, G. N. Lewis, summoned Seaborg to his office two weeks after Seaborg's fellowship at Berkeley expired, and asked him to be his personal laboratory assistant. Surprised, Seaborg asked if Lewis thought he could handle the job. Lewis smiled and said he would not have asked him if he did not think so. This was a huge opportunity. Lewis deserved a Nobel Prize, but never received one. One cannot get the prize by lobbying, but it helps to network at conferences, give visiting lectures, and other activities to bring one to the attention of the establishment elite. Lewis did not do any of these activities, and had a gruff personality. The result was that he was probably the greatest scientist to never win a Nobel Prize. Seaborg learned a great deal from Lewis. The systematic approach of Lewis taught Seaborg how to break a large problem down to solvable component parts, and this helped him in his later work on the Manhattan Project. Lewis put Seaborg on the faculty as an instructor starting in July, 1939, saying it was time to move on from being his lab assistant, and that he was "taking up too much" of Seaborg's time.

In 1940, Seaborg received an unexpected offer from UCLA to be an assistant professor, a tenure-track position that would have been an important promotion. But he wanted to stay at Berkeley, and he told Lewis of the offer while trying to convey that he would gladly accept an equivalent offer from Berkeley. When Lewis asked when Seaborg would give his answer to UCLA, Seaborg said he would call them after seven that night, when the phone rates went down. This was a ploy to give Lewis more time to think and give an offer if he so chose. I regret that it never occurred to me, while my father was still alive, to ask him how anyone would be in at UCLA after seven, and so this story will forever have an unexplained portion. At this time, Seaborg and Lewis lived in the Faculty Club. At about seven that evening, Seaborg's heart was pounding as he slowly walked to the phone in the main lounge of the faculty club. Lewis was there, long after he usually departed, a good sign. He motioned Seaborg over to him. He said that although he could not guarantee that the university president would approve it, he would recommend him for an appointment as an assistant professor after one more year as an instructor. He then asked Seaborg if he still was going to call UCLA. Seaborg replied yes, but to tell them he would not accept their offer because he would accept that from Lewis. He was ecstatic to be staying at Berkeley. He began the research that would change the course of his life there by the end of that summer. This was where he co-discovered plutonium with three other researchers [2].

When Seaborg's team discovered plutonium at UC Berkeley, they considered naming it ultimum because they thought it would be the last element on the Periodic Table (PT). It amazed them to have an element two places higher than uranium, the last naturally-occurring element, so they thought additional elements improbable. However, after several years of experience with it, they found it was stable, with a very long half-life, suggesting heavier elements were possible, even probable. Seaborg and his team did not name plutonium after the Greek and Roman god of the underworld, Pluto, because of its nefarious properties, as some uninformed people have stated. Seaborg knew too little classical mythology for this idea to even occur to him. Neptunium, element number 93, is named after the planet Neptune. Pluto was considered the next planet beyond Neptune at the time, and the newly-discovered element was number 94, following neptunium. Hence, they named it after the planet Pluto. Seaborg was delighted when he met the discoverer of Pluto, Clyde Tombaugh, late in his life. It is ironic that Pluto was later demoted from its planetary status, and we now have an element named after a Kuiper Belt object. Seaborg never knew of this demotion, since it occurred after his death. Following convention, the symbol for plutonium would have been its first two letters, Pl. But Seaborg had a sense of humor, and chose the symbol Pu, which in English is an expression used to indicate a bad odor. This pun did indeed refer to plutonium's ominous properties.

In the summer of 1944, at the Metallurgical Laboratory in Chicago, which he headed at the time as part of the Manhattan Project to develop an atomic bomb, which helped end World War II, Seaborg conceived his actinide concept [3, 4]. This is the only major revision of the PT since Mendeleev conceived it.

Figure 2 shows Seaborg at a Geiger counter at U. C. Berkeley, and Fig. 3 shows him teaching chemistry in a classroom on this campus.

Fig. 2: Seaborg listening for counts from a Geiger counter, 1941, at the University of California at Berkeley. This is this paper's author's favorite photo of Glenn Seaborg.

Fig. 3: Seaborg with chemical apparatus in front of a classroom where he is teaching chemistry, in about 1941, UC Berkeley.

Seaborg's team suspected new elements heavier than plutonium were being formed in the reactors as by-products of the reactions that created plutonium. But there were many fission products. The team tried, but could not isolate the unknown radioactive products. They required some knowledge of their chemistries to be able to isolate and identify them. The best way to accomplish this was to be able to predict their chemistry on the basis of their positions on the PT. That way, they would be able to deduce the reagents that would likely combine with them, so they could isolate them. However, the traditional, accepted arrangements where those elements were to be placed was not working, nor was a proposed new, alternative one. Seaborg concluded their lack of success was a result of the arrangement of the PT itself.

Furthermore, new elements neptunium and plutonium did not have similar properties to the elements above them in their assigned columns at the time. In fact, Edwin McMillan and Philip Abelson proposed a "uranide" series of related elements, including neptunium and plutonium, analogous to the lanthanides.

The key to understanding the lanthanide series and that it formed a row separate from the main body of the PT had been the discovery that its elements all contained an inner electron shell. It is the outer shell electrons that form chemical bonds and thus molecules with other atoms, defining an element's chemistry. Since the outer shells of the lanthanides all contained the same number of electrons, they shared similar chemical properties.

As he learned more about plutonium, Seaborg saw that the success he and his colleagues had in separating it as if it were like uranium was largely a result of luck. Neptunium and plutonium resembled the lanthanides more than uranium. The uranide concept was not holding up. Seaborg thought there had to be a better theory.

Seaborg thus came up with the actinide concept, a radical idea proposing a complete rearrangement of the PT. It was the only major revision of the PT since Dmitri Mendeleev conceived it in 1869. Before the actinide concept, the heaviest elements were placed on the main body of the PT, since it was thought they and any additional elements to be discovered in their row would resemble the elements in the last complete row on the main part of the table at the time, which began with element number 72, hafnium, and ended with element 86, radon.

Seaborg challenged this idea in 1944, when he proposed that these heaviest elements, which would be called the actinide series, ranging from atomic number 89 (actinium) to 103 (lawrencium), would resemble the lanthanide series. The actinides would thus be placed under the lanthanides, separate from the main portion of the PT. This was his actinide concept.

Element number 89, actinium, would be placed directly below lanthanum, because there was yet another inner electron shell being filled, causing the actinides to resemble each other and the lanthanides. This required the most radical change in the PT since Mendeleev formulated it. While the uranide concept merely necessitated the change in position of only newly discovered elements, this concept required moving three elements already on the PT with fairly well established chemistries. In later theoretical work, Seaborg also proposed the transactinide series, ranging from element 104 (later discovered; now Rutherfordium) to 118 (now Oganesson), to be placed on the main body of the table under elements 72–86. Seaborg further hypothesized the superactinide series, approximately spanning elements 122–153 or higher, possibly up to 157. The chemistry is complex, but it appears this series would resemble and hence be located under the lanthanides and actinides.

The actinide concept was not accepted at first. Renowned chemist Wendell Latimer, who played a prominent role in Seaborg's career, warned him that such an outlandish proposal would ruin his scientific reputation. Seaborg later joked that this was no deterrent, for at the time he had no scientific reputation. So he proposed the concept and presented evidence supporting it in a Metallurgical Laboratory report.

The actinide concept allowed Seaborg's team to discover more elements. Before this theory, they thought the new elements would be like plutonium and thus isolated by being oxidized to the VI oxidation state. But Seaborg's idea meant this would fail, and it was not likely they could be oxidized above the III state. Elements 95 and 96 were soon discovered as a result. Element 95 was under europium on the PT, so was named americium, and 96 was under gadolinium, named for a Finnish chemist who had done a great deal of work on the lanthanides, so was named curium after Pierre and Marie Curie. These two elements demonstrated

the accuracy of the actinide concept, which guided the discovery of yet more elements. The concept lead to the last rearrangement of the PT. Because of that and its helpfulness in discovering new elements, Seaborg considers it his greatest contribution to basic science.

Seaborg co-discovered ten elements on the PT. They are: plutonium (94), the most important element he co-discovered, used in the atomic bomb, instrumental in ending World War II, in which Russia and the USA were allies, and in nuclear reactors; americium (95), used in smoke detectors; curium (96); berkelium (97); californium (98); einsteinium (99); fermium (100); mendelevium (101); nobelium (102); and seaborgium (106), the element named after him [5]. In addition, Seaborg and his colleagues are responsible for the identification of more than 100 isotopes of elements, including 80% of those used in medicine in his time, although this percentage no doubt decreased as others found more such isotopes. He is a pioneer in nuclear medicine and one of its most prolific discoverers of isotopes [6]. Therefore, Seaborg revised Mendeleev's PT by both altering its structure and adding to it. Seaborg used the cyclotron, invented by Ernest O. Lawrence, to make many of his discoveries. Figure 4 shows Robert Oppenheimer, Seaborg, and Lawrence at the controls of a cyclotron in 1946.

In 1951, Glenn Seaborg shared the Nobel Prize in chemistry with Edwin McMillan for their "discoveries in the chemistry of the trans-uranium elements". The Nobel committee did not recognize them for the discovery of transuranium elements. The committee adopted this careful wording because Enrico Fermi received his Nobel Prize in 1938 for the discovery of transuranium elements. The committee did not want to award two prizes for the same discovery. Of course, Fermi's discovery turned out not to be transuranium elements, but nuclear fission, itself worthy of a Nobel. He rightly received the prize, but for the wrong reason.

Figure 5 shows Seaborg and McMillan together. Figure 6 shows Seaborg receiving the Nobel Prize from the king of Sweden, and the Nobel Prize Medal.

Seaborg does not hold the record for most elements discovered. That record is twelve, and is a tie between his co-worker, Albert Ghiorso, and an Armenian and Russian nuclear physicist, Yuri Oganessian. The latter is also the only other person to have an element named after him while still living. That element is Oganesson (118), symbol Og, at the very end of the current final row of the main body of the PT, and the element with the highest atomic number at the time of this writing.

Fig. 4: Left to right: Robert Oppenheimer, Glenn Seaborg, and Ernest Orlando Lawrence, at the controls of a cyclotron, in 1946. The cyclotron was being converted from its wartime use of producing atomic bomb material to its original purpose as a research tool.

Fig. 5: Seaborg and Edwin McMillan, who shared the Nobel Prize in 1951. Taken in about 1951.

Fig. 6: Left: Seaborg receiving the Nobel Prize in chemistry from the king of Sweden, in Stockholm, Sweden, on December 10, 1951. Right: The Nobel Prize medal. All medals made before 1980 were struck in 23 carat gold. The chemistry medal displays Alfred Nobel in left profile and the years of his birth and death on the obverse. The reverse of the chemistry medal shows two classical figures of people in the center, has writing in Latin, and has the winner's name and year won in Roman numerals at the bottom.

Amusing stories

Seaborg was the scientific advisor to ten Presidents of the United States. He became well acquainted with the three he served as Chairman of the Atomic Energy Commission. They were John Kennedy, Lyndon Johnson, and Richard Nixon. He found Kennedy smart and very curious and interested in science. Johnson once called him into his office. Seaborg assumed it was for business. It turned out Johnson liked Seaborg a great deal and was lonely. He wanted someone to talk to. They spent the afternoon in social conversation. Seaborg found Johnson to be one of the most effective people he ever met in the art of persuasion. He tended to make

decisions based on ethics and what was right. In fact, he would often ask, “Is that the right thing to do?” He would tend to do the action if Seaborg or whoever he asked replied in the affirmative. Figure 7 shows Seaborg with President Kennedy, and Fig. 8 shows him with President Johnson.

Glenn and his wife Helen Seaborg had six children, in this order of birth: Peter, Lynne, David, Steve, Eric, and Dianne. My birth was unusual, exceptional, and special. My mother started having labor cramps on a Friday night in April, 1949, at my parent’s house in Berkeley, California. My father positioned the car at the bottom of the front porch steps to have it ready to go to the hospital, and went to help my mother down from

Fig. 7: Seaborg holding a model of a nuclear reactor as he explains nuclear energy to President Kennedy, in about 1961.

Fig. 8: Seaborg and President Johnson in the Oval Office of the White House, in 1964.

the upstairs bedroom. She was in obvious distress, and upon reaching the front porch, she announced that she was not going any further. She said she was going to have the baby right then and there. I was thus born on the wooden front porch of my house on Ellsworth Street, about ten blocks from the University of California at Berkeley campus. I came out very quickly. My father caught me and made the delivery. My parents told me that if my father did not do so, I would have hit the porch and been injured or killed. This was at about 11:50 PM, on April 22, 1949. April 22 is Earth Day. I am an active, nature-loving environmentalist, so my early arrival leading to an Earth Day birthday was fortuitous. My father announced that it was a boy. He went into the kitchen to put some water on to boil, because they always told the father to do that in books and movies; he did not know why. When the doctor arrived in a mere few minutes, my father teased her about the ease of making the delivery himself, saying, “Boy, am I wise to your racket!” An ambulance that the doctor had called whisked my mother and me to the hospital, with my umbilical cord still attached. I was born with the caul unbroken, which my mother later told me means a lucky life, which I have had.

When Seaborg was at the dinner honoring Nobel Prize winners in Stockholm, Sweden, that December, as part of the ceremonies when he won the Nobel Prize, the king gave his toast to my father, as he did to all Nobel Prize winners. My father, who was raised in America by Swedish parents, spoke Swedish before he learned English. His mother was from the south central Swedish province of Dalarna, famous for wooden horses usually painted orange as its iconic folk art. So he toasted the king back in Swedish. The next morning, a Swedish newspaper had this headline, which I am translating from Swedish: “Seaborg answers king in ringing Dalarna accent.”

In about 1961, when I was about 12 years old, I answered the phone at our house in Lafayette, California. The woman on the line asked for Dr. Seaborg. I looked for my dad, but did not see him. Being a 12-year-old, I forgot about the call, and played baseball in the lot our family owned next to our house. After I finished playing, I saw my father walking by, and was reminded of the phone call that had by now occurred a half an hour ago. I said, “By the way Dad, you are wanted on the phone”. He went and took the call. He returned five minutes later, and said, “Dave, do you know who you kept waiting on the phone for half an hour?” I said, “No, who?” He said, “President Kennedy!” He thought it was funny and did not punish me for my error.

Kennedy had called to appoint my father to be Chairman of the Atomic Energy Commission, which necessitated moving our family to Washington, D. C. He held this position from 1961 to 1971. It is now the Department of Energy, a cabinet level agency. During this time, Seaborg, Kennedy, and Soviet Premier Nikita Khrushchev were instrumental in the negotiation and signing of the Limited Nuclear test Ban Treaty of 1963, which prohibited tests of nuclear weapons in the atmosphere and sea, limiting nuclear weapons tests to being performed underground. This is probably the first major environmental treaty in history.

During Seaborg’s tenure as Chairman, the Atomic Energy Commission had to lay off a number of machinists at the Oak Ridge National Laboratory in Tennessee. One of the Senators from that state, Al Gore, Sr., the father of the Democratic Presidential candidate in 2000 and winner of the Nobel Peace Prize for his work on climate change, called my father to testify before Congress to explain the layoffs. Seeing an opportunity to gain popularity with his constituents in his state, Senator Gore asked my father, “Dr. Seaborg, just what do you have against machinists?” My father replied, “Senator Gore, I do not have anything against machinists. My father was a machinist. My grandfather was a machinist. My great grandfather was a machinist. And I would have been a machinist too if I’d had any talent in that area.” Everyone in the hearing room broke into laughter, including Senator Gore.

After Seaborg’s return to UC Berkeley, his team used the heavy ion linear accelerator (HILAC) to bombard californium, element 98, with oxygen, element 8, to produce the new element 106. This was named after him. He had named element 99 einsteinium after Albert Einstein and 100 fermium after Enrico Fermi when these two great scientists were still living, but the names were not approved until after their deaths. Thus, the names were not official until the two were deceased. Thus, when Seaborg’s co-discoverers of this element proposed naming it after him, there was opposition from some people on the International Union of Pure and Applied Chemistry, which must approve names of chemical elements for them to become official. Some people on this committee felt that no person should have an element named after themselves while still alive. Thus, a long struggle between opposing sides resulted in some time passing before element 106 was officially

approved with the name seaborgium, symbol Sg. An editorial supporting naming element 106 seaborgium argued that one should not hold it against Seaborg for not dying at a convenient time. Seaborg joked that the committee said he was still alive and they could prove it. Glenn Seaborg is the first person to have an element named after him while he was still alive.

Fig. 9: Glenn Seaborg in his office on the hill at the Lawrence Berkeley National Laboratory in Berkeley, California; age about 80; about 1992.

Fig. 10: David Seaborg, third child of Glenn Seaborg, author of this paper, evolutionary biologist, with American Kestrels.

Conclusion

Figure 9 shows Glenn Seaborg in his office in the Lawrence Berkeley National Laboratory in about 1992, at about age 80. On August 24, 1998, when in Boston to attend a meeting of the American Chemical Society, and while jogging up the stairs of his hotel to get exercise, Seaborg suffered a stroke, which led to his death 6 months later on February 25, 1999, at his home in Lafayette, California. An autobiography written by Glenn Seaborg with his son, Eric, is a source of much additional information on Seaborg's life and work [6].

The International Year of the Periodic Table (2019) also marks 20 years since the great Glenn T. Seaborg passed away. I sincerely hope that the present paper helps to draw more attention to the life and contributions of Glenn Seaborg, the only person to make a major revision to the PT since Dmitri Mendeleev conceived it, the man who added ten elements to the PT, and the first person to have an element named after him while he was still alive.

I am the third-born of his offspring, David. I gave the eulogy in front of hundreds of his admirers after his death, in Zellerbach Hall on the UC Berkeley campus, in 2000. I gave an oral paper with information similar to that found in this paper at the Fourth International Conference on the Periodic Table endorsed by IUPAC, also called Mendeleev 150, because it commemorated the 150th anniversary of Mendeleev's invention of the PT. It was held July 26 to 28, 2019, in Saint Petersburg, Russia, where Mendeleev formulated the PT. I was the keynote speaker, and spoke for 50 minutes on my father's life and contributions to chemistry and the PT. Figure 10 shows me in Saint Petersburg with a male (on my head) and female American Kestrel (*Falco sparverius*) supplied by a person who owned them and photographed them on me for a fee.

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