Oral History of

Gustaf Olof Svante Arrhenius

Interview conducted by Laura Harkewicz

11 April 2006

TABLE OF CONTENTS

ABSTRACT:

Gustaf O. Arrhenius was interviewed in his home on April 11, 2006. Arrhenius was born in Stockholm, Sweden in 1922. Prior to moving to the United States in 1952, he participated in two Swedish deep sea research expeditions—the Skagerak Expedition in1946 and the Albatross Expedition around the world from 1947 to 1948. The Albatross Expedition provided him with research materials to do his doctoral work. In 1953, he received his Ph.D. in natural sciences from the University of Stockholm. He came to Scripps Institution of Oceanography (SIO) in 1952 as a visiting research oceanographer. In 1956, he joined the faculty at SIO as associate professor of biogeochemistry. In his long and distinguished career, he has held a variety of professional and advisory appointments in addition to his positions at SIO, including: director of the Interdepartmental Laboratory of Space Science at the University of California, San Diego (UCSD) (1962 – 1963), associate director of the Institute for the Study of Matter at UCSD (1966 – 1970), associate member of the Department of Applied Physics and Information Science (presently, Electrical and Computer Engineering) at UCSD (1967 – present), member of the NASA Lunar Sample Analysis Planning Team (1970 – 1972), member of the NASA Advisory Committee on Comet and Asteroid Exploration (1973 – 1975), member of the Ocean Science Board of the U.S. National Academy of Sciences (1977 – 1981), and staff member of the NASA Specialized Center of Research and Training in Exobiology of the California Space Institute at UCSD (1991 – present). The interview stressed Arrhenius' many years at SIO, especially his association with Roger Revelle and how the institution has evolved over the years. We also spoke about Arrhenius' familial ties to science and his career progression from oceanography and geochemistry to biogeochemistry to research into solid-state and space chemistry, origin and evolution of life and beyond.

INTERVIEW HISTORY: The interview took place on a sparkling Southern California afternoon in the home of Gustaf and Jenny Arrhenius in La Jolla, California—just across the canyon from Scripps Institution of Oceanography. The Arrheniuses served me tea and snacks on Danish porcelain prior to our interview. Their pleasant living room furnishings were highlighted by artwork including a portrait of Arrhenius' Nobel prize-winning grandfather, Svante Arrhenius. Mrs. Arrhenius sat quietly and listened throughout our interview—Dr. Arrhenius told me she was interested in our discussion because of its relations to her father's (George de Hevesy) work with radioisotopes. We talked for approximately two hours. The tape was paused twice: once while Arrhenius retrieved a photograph from a party held at Roger and Ellen Revelle's home that we discussed at length, and a second time when Arrhenius took a phone call. A persistent beeping, which is due to Arrhenius' phone answering machine, may be detected in the background on the audio tape.

Laura Harkewicz
Oral Historian, SIO/UCSD
July 27, 2006

In a playful moment, Gustaf Arrhenius (left) about to spike Roger Revelle (wrapped in cables) on-board ship, Capricorn Expedition, 1953. Scripps Institution of Oceanography Archives, UC San Diego.

INTERVIEW WITH GUSTAF ARRHENIUS: 11 APRIL 2006

Harkewicz: ## [1]. . . 2006.[2] This is Laura Harkewicz. I'm in the home of Dr. Gustaf Arrhenius in La Jolla, California. Good afternoon, Dr. Arrhenius.

Arrhenius: Good afternoon.

Harkewicz: So, what we wanted to talk about today is about your experience at Scripps. What made you choose a career in oceanography?

Arrhenius: That was pretty much predestined by my upbringing in a family of scientists for many generations. So, that was really clear, but one of my earliest experiences in oceanography was in school when, in summertime, you had to do an independent scientific study. I think I was thirteen or fourteen. Since we lived at a beautiful fjord that had a very interesting hydrological structure, I chose to make an investigation of the whole run-off area with the lakes, rivers and brooks that drained into the fjord, and of the fjord itself, the physics and chemistry of it and the biological properties. That experience wetted my appetite for oceanographic ventures. And then something remarkable happened in Sweden. There was a most imaginative Swedish physicist and oceanographer by the name of Hans Pettersson,[3] the son of one of the founders of oceanography, Otto Pettersson,[4] whom Walter Munk[5] could tell you lots about. H.P., as he was informally known, planned to make an expedition around the world utilizing some new tools that had been developed in oceanography, particularly a coring device with which it was possible to punch out sediment cores of record length, up to about twenty meters. This instrument, the piston corer, was the brainchild of Börje Kullenberg,[6] a physicist and an associate of H.P. The piston corer, if applied to slowly depositing deep sea sediments, promised to provide an undisturbed record of the history of the Earth over the last few million years and was going to be the main instrument of the expedition. I was lucky enough to be offered a position as geochemist in this enterprise, which developed into the Swedish Albatross Expedition,[7] around the world, 1947 to 1948. Preceding that major effort we had, in 1946, a trial expedition with a smaller ship, the M/S *Skagerak*, down to the Mediterranean to

[1] The symbol ## indicates that the tape or a section of the tape has begun or ended. For a guide to tapes see the final page of this transcript.
[2] The date of the interview was cut off from the original recording. The interview was conducted on April 11, 2006.
[3] Hans Pettersson (1888 – 1966), leader of Swedish Albatross Expedition, professor of oceanography and director of the Göteborg Oceanographic Institute, Sweden.
[4] Otto Pettersson (1848 – 1941), Swedish physical chemist and oceanographer.
[5] Walter Heinrich Munk (1917 -), physical oceanographer at SIO and professor of geophysics at UCSD.
[6] Börje Kullenberg (1906 - 1991), Swedish physicist and oceanographer.
[7] The Swedish Albatross Expedition was the first thorough marine geological core sampling that used the (then) newly developed Kullenberg Coring System, which allows for retrieval of sediment cores from the deep sea up to twenty meters.

try out the equipment. The Skagerak Expedition[8] was an eye-opener and a fantastic emotional and oceanographic experience, cruising and operating in the beautiful Mediterranean right after the war with all harbors opened up again after the war ravages. The Skagerak expedition demonstrated the power of the new coring, seismic, and optical techniques that we set out to test and we could start out a year later on our one and a half year trip around the world.

Harkewicz: One and a half years?

Arrhenius: Yes.

Harkewicz: Wow.

Arrhenius: That's quite a long time. Actually, Hans Pettersson was worried that he would be overrun by applicants for scientific positions on that trip, but practically nobody besides the staff of his institute applied because they knew that we were going to be away for fifteen months from home, away from careers, wives and girlfriends. But being relatively unattached and set on adventure I had nothing against embarking on such a fantastic, though long lasting, expedition.

We were mostly operating between latitudes 15° north and 15° south and those are wonderful tropical regions to work in. We made a large collection of sediment cores, over 200, that carried in them the possibilities for study of the climatic evolution of the Earth in the last million years. In those days that sounded like a tremendously long time for a continuous sedimentary record; it would cover the entire series of Quaternary ice ages and perhaps give a clue to their cause. Nowadays, with deep-sea drilling, one covers time periods up to 300 million years. And in our recent research we work with sediments that have turned into rocks that are as old as 3.8 billion years, the oldest, but fragmentary, sedimentary sequence so far known on Earth. That has been quite a progression.

But then coming home with all this material, it proved extremely difficult to find somebody who could chemically and physically analyze this entire material. To deal with five or ten samples, that people would love to do. But when it came to 20,000 samples, nobody had the facilities, except, luckily enough, my father,[9] who for his research depended on making analyses on a large scale. So he had a whole laboratory set up for that and he gave me access to the entire core material from the East Equatorial Pacific that I had selected for my Ph.D. thesis because it seemed an ideal area just for this climatic recording. During that time, Roger Revelle[10] here at Scripps became interested in the work and the rumor spread about what we were trying to achieve. So he regularly sent emissaries from here to Sweden to come and visit our rural

[8] The Skagerak expedition was in the Mediterranean and eastern Atlantic.
[9] Olof Vilhelm Arrhenius (1896 – 1977), Swedish chemist.
[10] Roger Randall Dougan Revelle (1909 – 1991), SIO director 1951 – 1964.

laboratories and see what was actually going on. Among these guests was Louis Slichter from UCLA,[11] who was a great protagonist for modern geophysics here on the West Coast. There were scientists from Lamont Geological Observatory and Woods Hole, Heinz Lowenstam[12] from Chicago and Fred Phleger[13] from Scripps, who was a specialist on foraminifera, important in deep sea research. They all came through and we entertained them and showed them everything around from the cow stables to my father's wide-ranging ecological and agricultural field experiments, and of course the emerging results from the core analysis—they had lots of fun seeing all these new things developing. And they brought the reports back to Maurice Ewing[14] and to Roger Revelle who was kind enough to invite me to come over and join Scripps in time for the big expedition he was just planning, the Capricorn,[15] that was a follow-up after the nuclear bomb experiments in the Marshall Islands. So I set out without any assurance of specific employment or anything like that; Roger just wrote a letter saying, "You know, why don't you come over?" We thought was the way Americans did it. We bought tickets on a freighter and Jenny[16] and I with our two-year old daughter came over to Baltimore where we bought a used black Pontiac and drove across the country, visiting various scientific institutions on the way: Lamont, Woods Hole, Chicago, UCLA, everything connected by our years of correspondence. Chicago[17] was fantastic, with Harold Urey[18] and Bill Libby,[19] and barnstorming student colleagues like

[11] Louis Byrne Slichter (1896 – 1978) director of the intercampus Institute of Geophysics, which was located at UCLA.
[12] Heinz Adolf Lowenstam (1912 – 1993), professor of paleoecology at Caltech.
[13] Fred B. Phleger (1909 – 1993), professor of oceanography at SIO.
[14] William Maurice Ewing (1906 – 1974), geophysicist. Ewing started his career at Woods Hole Oceanographic Institution (WHOI) in 1935 and founded the Lamont Geological Observatory at Columbia University in 1946. In 1972, he moved to the University of Texas at Galveston.
[15] The Capricorn Expedition took place from September 26, 1952 to February 21, 1953 and involved both the R/V *Horizon* and the R/V *Spencer F. Baird*. Capricorn involved travel to the South Pacific with stops in Suva, Pago Pago, Tonga, Tahiti, and the Marquesas. The Capricorn Expedition was a research cruise with, among other purposes, to study the Tonga Trench, which has depth equivalent to the height of Mount Everest and the East Pacific Rise—at that time a mysterious feature on the ocean floor. Many of the researchers participating in the Capricorn Expedition were also involved in Operation Ivy, the testing of the first thermonuclear device at the Marshall Islands in November, 1953.
[16] Eugenie "Jenny" de Hevesy Arrhenius (1926 -) who married Gustaf Arrhenius in 1948. They have three children: Susanne, Thomas, and Peter.
[17] Arrhenius is referring to the University of Chicago.
[18] Harold Clayton Urey (1893 – 1981). Urey won the 1934 Nobel Prize in chemistry for the discovery of heavy hydrogen. In 1945, Urey moved from his position as Director of War Research, Columbia University to the Institute for Nuclear Studies at the University of Chicago where he became Distinguished Service professor of chemistry. In 1958, he was named first University Professor at the University of California at San Diego, which was founded in 1960.
[19] Willard Frank Libby (1908 – 1980). Libby won the Nobel Prize in chemistry in 1960 for development of the radiocarbon dating technique. He was professor of chemistry at the University of Chicago from 1945 – 1954. Libby's career also included several connections to the University of California system: he was instructor and assistant professor of chemistry at the University of California, Berkeley from 1933 – 1941 and professor of chemistry (1959 – 1976; emeritus, 1976 - 1980) and director of the Institute of Geophysics and Planetary Physics (1962 – 1976) at the University of California, Los Angeles. Libby was also the head of the chemistry division of the

Harmon Craig, Gerry Wasserburg and Sam Epstein.[20] And, we finally arrived here on July 28, 1952.

Harkewicz: It's amazing you remember that exact date.

Arrhenius: Oh, that was a date I'll never forget. I went up to what was indicated as Roger Revelle's office and here was this tall man and he said, "Well, welcome." And he turned around to his secretary and said, "Put him on low-frequency underwater sound." And, I said, "But Dr. Revelle, I don't know very much about underwater acoustics." He said, "Oh, that just an administrative detail." And I realized the very easy-going way in which he financed and carried out all of the projects that he wanted to do. So what we then did was to prepare for the Capricorn Expedition, which I was going to join in January. That's when the bomb tests were over.

In the meantime I flew back to Sweden to defend my thesis, which had been postponed because of my coming over here. At that time Scripps was, of course, very heavily supported by the Navy. It essentially was a military-supported institution.[21] And I myself, being a naval officer from Sweden, I felt very much at home in the Navy atmosphere here. And when you flew somewhere you always traveled by the military air transportation service—MATS,[22] which was later abolished because of what the commercial airlines considered unfair government competition. But at that time we always flew from military bases here to other military bases abroad. So I flew to Sweden by way of the Rhein-Main AFB in Germany. I was there, in Stockholm, for my defense, and then came back again, and flew out to Fiji where I joined the expedition.

The last segment of Capricorn took about another month and a half, I think. We went way down into the South Pacific and over the East Pacific Rise and collected much data that became quite important for understanding deep ocean sedimentation. That was truly a great experience. In the meantime, I had left Jenny in Sweden because she was going to have a baby—we thought you better not have babies in this wild country. So she stayed there while I came back. In the meantime, I was invited to go to Caltech where Harrison Brown, a very imaginative scientist, had started up a new program in Earth Science.[23] I joined

---

Manhattan Project at Columbia University (1942 – 1945) and the chairman of the Atomic Energy Commissioner (1954 – 1959).

[20] Harmon Bushnell Craig (1926 – 2003), Scripps geochemist. Gerald Joseph Wasserburg (1927 -), professor of geology and geophysics at Caltech. Wasserburg is currently emeritus chairman of the Division of Geological and Planetary Sciences at Caltech. Samuel Epstein (1919 – 2001), geochemist and professor of geology at Caltech from 1956 – 1990.

[21] Arrhenius later added that Scripps was "referred to as 'the base.'"

[22] Military Air Transport Service.

[23] Harrison Scott Brown (1917 – 1986). Brown was a geochemist known for his part in the isolation of plutonium for use in the first atomic bombs. He is also known for his work regarding meteorites and their relation to Earth's origins. At Caltech he held a double appointment in the Geology and Humanities divisions.

his staff as a guest researcher for two months—an extremely rewarding experience also because he had assembled a group of some of the most powerful geochemists and radiochemists of the time: Wasserburg, Epstein, Silver[24], who were the young Turks at that time and now are old or gone. So Caltech at that time was fascinating.[25] Then back here to Scripps. I was wonderfully taken care of by Ed Goldberg.[26] Ed Goldberg is one of the most famous geochemist old-timers here. You might be interested in interviewing him. From his Chicago time, he had extensive experience from his Chicago time in radiochemistry, and that was a field I didn't have much experience in at all, so I enjoyed very much to learn from him and to apply that to the material that we had brought back.[27] And then . . .

Harkewicz: From the Capricorn Expedition?

Arrhenius: Yes, the Capricorn. And with those slowly depositing sediments you can get so much time into one meter of sediment that you can study the decay curve of relatively long-lived isotopes. So that was a great learning experience. Other things happened later on. I went on a few more expeditions collecting materials to supplement what we had learned on the Capricorn. And then came an interesting development; the Deep-Sea Drilling Project. It started out based on an idea engineered by Willard Bascom.[28] For a first test, we went on an expedition near the Guadalupe Islands using the *Glomar Challenger*[29] drilling ship. Along on that trip came also John Steinbeck[30] as a narrator, and Fritz Goro as a photographer.[31] He was a star photographer for *Life Magazine*. Of those two great personalities John Steinbeck was a great tease and he continually

---

[24] Leon Theodore Silver (1925 -), professor of geology at Caltech.
[25] Arrhenius later added that Caltech was fascinating "intellectually and had modern instrumentation yet lacking at Scripps."
[26] Edward D. Goldberg (1921 -), professor of chemistry at SIO.
[27] Arrhenius later noted that Goldberg's experience at Chicago was in nuclear chemistry, "a field that I had developed an interest in from my father-in-law [George de Hevesy (1885 – 1966), who invented the radiotracer technique] and from collaboration with Bill Libby, but where I didn't have much practical experience, so I enjoyed greatly to learn from the Master, and to assist him in applying radiochemical techniques to material that we had brought back."
[28] Willard Newell Bascom (1916 – 2000), Scripps oceanographer who led the engineering aspects of the Mohole Project.
[29] Arrhenius' reference to "*Glomar Challenger*" is in error. The name of the ship that was used for the Guadalupe test was the *CUSS*, named for the four oil companies that owned the ship—Continental Oil, Union Oil, Superior Oil, and Shell Oil. The *Glomar Challenger* was the first research vessel specifically designed for drilling into, and taking core samples from, the deep ocean floor. The ship's first expedition was in 1968. It was taken out of active duty in 1983 and later scrapped. Its successor, the *JOIDES Resolution* was launched in 1983.
[30] John Steinbeck (1902 – 1968). Steinbeck was awarded the Nobel Prize for Literature in 1962. Among his books are: *Tortilla Flats* (1935), *East of Eden* (1952), *Of Mice and Men* (1937), *Cannery Row* (1945), *Travels with Charley* (1962), and *Grapes of Wrath* (1939) for which he won a Pulitzer Prize.
[31] Fritz Goro (1901 – 1986). Goro was a science photographer who took photos for popular magazines like *Life* and *Scientific American.* He invented "macrophotography," which made visible the world that is located between the eye and the microscope.

tortured poor Fritz who was a very sensitive person. But, that[32] proved essentially the possibility for drilling and that became a major program which, however, unfortunately, got in the wrong hands in the company of Brown & Root, nowadays part of Halliburton. A huge project thing. And, they of course made the costs go up sky high, sky high, and so finally . . .

Harkewicz: That was the Mohole Project?[33]

Arrhenius: That's right.

Harkewicz: Okay.

Arrhenius: That had to be abolished, finally. But then Mohole gave rise to a more modest and reasonable deep-sea drilling project that is still going on and that has revolutionized the field of marine geology.

But by that time, in the sixties, what became another fascinating development was Roger's idea of creating a new university campus here, and the way he initially visualized it, it would be mainly a research campus—like Caltech was at the time. No undergraduate classes and large administration, pure research involving graduate students, and that was an enormously challenging undertaking. I got involved in recruiting people in various fields like mathematics and history.[34] We brought in the first historians here, and the linguists—the humanities was an interesting field of recruitment. And Roger's principle was to not start out with some low-level faculty who would then make the place gradually develop like UCLA that grew from a teacher's college up to what it is now but rather to start with a bang and get the best people in the world in all departments. And that was an idea that horrified the people administration in Berkeley and UCLA. They didn't strongly encourage the idea, to say the least, but Roger had a Machiavellian way of getting away with what he wanted.

---

[32] Arrhenius clarified the "that" as follows: "The drill successfully penetrated the entire sediment column into basaltic rock proving the feasibility of drilling operation in deep water."

[33] The Mohole Project was first proposed by members of the American Miscellaneous Society (AMSOC)—a combined social and professional group of earth scientists—in 1957. On February 23, 1962, National Science Foundation (NSF) director, Alan Waterman, chose the Texas company Brown & Root, Inc. to serve as operations contractor for the Mohole Project. The selection caused a political uproar because Brown & Root had not rated highly in early evaluations of bids and due to the appearance of conflict of interest—Brown & Root company president, George Brown, had close political ties with Vice President Lyndon Johnson as well as to Representative Albert Thomas—a Texan who chaired the House committee that had oversight responsibility over the NSF budget. As Brown & Root proceeded with plans for the Project, cost estimates escalated from $30 million to $127 million. In 1966, skyrocketing costs prompted Congress to pass legislation abolishing the Project. However, the idea for deep sea sedimentary ocean drilling continues in the Deep Sea Drilling Project and its present-day equivalent, the Ocean Drilling Project. For a scholarly view of the Mohole Project and a history of the origins of the Deep Sea Drilling Project see: David K. Van Keuren, "Breaking New Ground: The Origins of Scientific Ocean Drilling" in Helen M. Rozwadowski and David K. Van Keuren, editors, *The Machine in Neptune's Garden: Historical Perspectives on Technology and the Marine Environment* (Sagamore Beach, Massachusetts: Science History Publications, 2004: 183 – 210.)

[34] During the editing process, Arrhenius noted that Revelle was "mirroring the rise of medieval universities in Europe" and that "Roger was immersed in the reading of The Great Books, fashionable at the time."

[*Laugh*] He appointed the basic first physicist here, Walter Elsasser, as a research oceanographer. Walter was one of the first physics appointments, but he became an oceanographer without knowing it to start with.[35] [*Laugh*]

Harkewicz: Before we get into the UCSD information, I wanted to ask you a little bit about when you first came as a faculty member to Scripps?

Arrhenius: I was a research staff member at the time.

Harkewicz: Well, two things I wanted to ask you before we get into UCSD. First of all, when you were talking about Capricorn, you mentioned that you weren't involved with the Ivy[36] test at all?

Arrhenius: No, not at all, because as a foreigner, I didn't have the necessary level of clearance. As a routine, practically everybody at Scripps who qualified by their background was given a secret clearance, but I didn't have the higher level secret clearance that you needed

Harkewicz: Because of the atomic test?

Arrhenius: And even to have a low level clearance arranged, you had to fill in lots of forms—you had to fill in all your relatives back to the third and fourth generation. And when I had put down that one of my ancestors was a colonel in the Russian Tsarevnas Guard, that put a halt on things for a while until it was discovered that he was one of those who had led the revolution against the Reds in Finland in 1918, then things passed through.

Harkewicz: So you couldn't get the full security clearance because of political stuff? It wasn't so much that you didn't have a scientific purpose in the Ivy part?

Arrhenius: Exactly.[37] I was never attempting to get the secret clearance, but to work at Scripps you had to have a low-level clearance so that you could use military transportation and participate in most activities here; they were much intertwined with civilian projects. I never had a need for any—and nobody asked me to—seek any higher clearance, and there was no reason for me to be

---

[35] Walter Maurice Elsasser (1904 – 1991), theoretical physicist at UCSD, Scripps oceanographer. Arrhenius later added "Elsasser was surprised to find himself in this position but soon made important contributions to the early development of the Earth, rising to the occasion."

[36] Operation Ivy was the testing of the first thermonuclear bomb, *Mike*, at the Marshall Islands on November 1, 1952. Scripps oceanographers were involved in a variety of research activities, especially those related to wave systems, in this military-sponsored mission. Of major concern to Scripps personnel, like Walter Munk, who were involved in the Operation were anxieties that the explosion would be so large that it would trigger an underwater tsunami. Fortunately, their fears were unfounded and no tsunami was triggered; however, military personnel had been evacuated from the Islands prior to the detonation as a precaution. Also see note #15 for information on the non-military, pure research portion related to Operation Ivy (the Capricorn Expedition). Capricorn was funded, through the military, by Scripps participation in Operation Ivy.

[37] Arrhenius later responded, "No, the primary reason for not being asked to participate, besides not being a U.S. citizen, was, of course, that my services in this operation were not needed."

involved in the Ivy test, and my invitation was for joining the expedition after the test was over.

Harkewicz: When Revelle said that you were going to work in acoustics, as you said earlier, and you said you had no background in acoustics, was that some sort of cover, somehow or other for the military, do you think?.

Arrhenius: Well, no, lots of effort went into the physics of submarine detection, and submarine warfare, and one of the sources of funds came from what was referred to as "low-frequency underwater sound." That is officialese for noise from submarine propellers. So the whole Marine Physical Laboratory here was started during the war just for that purpose and it has played an important role for the general understanding of the behavior of sound in the ocean. But Roger, of course, used those funds freely and wisely on a much broader scientific scale, and he pointed out to me that the financial allocation of my appointment was just an administrative convenience.[38]

Harkewicz: I found a letter in your file from when you became a member of the faculty at Scripps, and at the time they had just gotten a Rockefeller Foundation grant that was supposed to be directed towards rejuvenating biology at the institution. So, you were hired as a biogeochemist.

Arrhenius: Biogeochemist. I've returned to that. I'm now again a professor of biogeochemistry.

Harkewicz: Did you run into any kind of conflict with biologists here at Scripps?

Arrhenius: No, on the contrary, it was fascinating. I mean that Roger's idea with that Rockefeller grant was to completely rejuvenate biology at Scripps. Biology at Scripps before was mainly dominated by a few people, namely Claude ZoBell[39] in bacteriology, a very clever bacteriologist. And Denis Fox,[40] who was a specialist in pigments in animals. But they belonged to an older generation and as such they also were politically against Roger's appointment as a permanent director. So the situation at Scripps was what I used to liken to some small German princedom in the 18th century, with the prince and his loyal court around him and people who were plotting against him. And the way Roger went about things in a very dictatorial fashion was very much like the situation in such a political unit.

---

[38] Arrhenius later added, "But I felt obliged, none the less, to learn more about this intriguing subject. One of its mysteries was the strange frequency dependent sound absorption which was solved around that time by the great German physical chemist Manfred Eigen (1927 -) with whom I have had much fruitful interaction much later in our studies of the origin of life.

[39] Claude Ephraim ZoBell (1904 – 1989), professor of marine microbiology at SIO.

[40] Denis Llewellyn Fox (1901 – 1983), professor of physiology at SIO.

So, since much of my interest and work had been focused in biogeochemistry, I felt that it was a perfect situation. And all the new people that he'd brought in here were fantastic people to do it. Ben Volcani, Ralph Lewin,[41] and others.[42] There was a whole group of brilliant scientists who, with the aid of the Rockefeller funds, were put into action here.

Harkewicz: But you didn't find ZoBell and Fox working against you because they were against Roger Revelle?

Arrhenius: No, they were very nice people, very generous and friendly. Like people in general in this wonderful country, they went out of their way to be helpful and hospitable to us as newcomers, and they took an active interest in my work. They invited me to participate in their club meetings and things like that. ZoBell was very, very skilled. He greatly expanded the knowledge in marine bacteriology. He was an interesting man to know.[43]

Harkewicz: Let's talk a little bit about when you and your wife first came here. What was it like in San Diego? What was it like in La Jolla and around Scripps?

Arrhenius: Oh, San Diego was a small place and I thought this was a nice place to be for maybe a year or two as a postdoc, but not the place for the future. But then, before I knew it, twenty years had gone by because of all these fantastic developments. So Scripps and, of course, San Diego were much smaller then: La Jolla had a population of about 25,000. It was a very conservative place where old corn growers from Iowa were retiring and bringing their parents along, it was said. It was politically extremely conservative. For example, when Roger made his whole development, both in biology, and later on, the expansion of the campus, he had very great difficulty because such a prevalence of outstanding scientists were Jewish and there was a conspiracy against selling any real estate to them. There was a "gentlemen's agreement," essentially. So Roger made a major coup. He organized a group of interested staff members and together with them privately bought a tract up here at Scripps Estates,[44] as it's called, and then subdivided it, much to the chagrin of local real estate agents who felt that real estate development should be made by them, not by some interloper. Roger and the Association that was formed then offered parcels to

---

[41] Benjamin Elazari Volcani (1915 – 1999), marine microbiologist at Scripps; Ralph Arnold Lewin (1921 -), professor of marine biology at SIO.

[42] During the editing process, Arrhenius added Scripps biologists, Andrew Alm Benson (1917 -) and Adriano Buzzati-Traverso (1913 – 1983) to the list of scientists that came to Scripps under the funding of the Rockefeller Foundation Grant.

[43] Arrhenius later added, "Both he and Fox were a little pompous, but in a funny and inoffensive way."

[44] For more information on the history of the Scripps Estates Associates (SEA) see: John A. Knauss, "Scripps Estates Associates—the Early History," 2001. Biographical Information Files, Scripps Institution of Oceanography Archives, UCSD. Also see Knauss' discussion of SEA in his oral history available at: http://repositories.cdlib.org/sio/arch/oh/knauss .

all the staff members of Scripps.[45] That development was, of course, what made it physically possible to build the structure that he looked forward to.

Harkewicz: Is this one of the lots from the Scripps Estates?

Arrhenius: No. No. This is separate.[46] We couldn't quite face the idea of living, on an everyday basis, closely merged with our colleagues. So we found this by coincidence, and bought it at the time, when I received my faculty appointment and realized that I would be here for more than a few years. People told us we were crazy to move here and build a house in this desolate area—we would be so lonely. It was at the time far away from everything. There was nothing around here but beautiful wilderness. But we realized what was going to happen, that we wouldn't be lonely for very long.

Harkewicz: You knew that at the time that you were . . .

Arrhenius: Of course, with all the developments taking place here at the campus, Roger already had plans for a campus.

Harkewicz: ` I wanted to ask you one other thing before we talk about UCSD, though. Deborah[47] told me that you were at the meeting at Woods Hole prior to the International Geophysical Year [IGY], when Roger Revelle, Harry Wexler,[48] and Carl Gustaf Rossby[49] were talking about measuring carbon dioxide in the atmosphere? And I know that your grandfather[50] was actually the first person to do carbon dioxide measurements in the atmosphere…

Arrhenius: That's right[51]. He essentially predicted, on the basis of the physics of the atmosphere that the addition of carbon dioxide to the atmosphere would lead to an increase in temperature, world temperature, and he carried out very extensive calculations to establish regional and worldwide effects. So when the planning for IGY came up, Roger and Walter Munk were discussing what Scripps should do. And both of them realized that the carbon dioxide question would be a very

---

[45] Arrhenius later added that "UCSD and eventually Salk [the Salk Institute located near to SIO] and other institutions coming in."

[46] Arrhenius later added that his home was located in a "separate development, actually also initiated by Roger by selling off the southeast corner of the Pueblo Lot that is SIO."

[47] Deborah Cozort Day (1951 -), Scripps archivist.

[48] Harry Wexler (1911 – 1962), meteorologist for U. S. Weather Bureau. Wexler was chief scientist for the American expedition to Antarctica for the IGY (1955 – 1958). He was one of the first scientists to suggest using satellites for meteorological purposes.

[49] Carl-Gustaf Arvid Rossby (1898 – 1957), Swedish-born naturalized American meteorologist who developed the field of atmospheric physics, which explained the large-scale motions of the atmosphere in terms of fluid dynamics.

[50] Svante August Arrhenius (1859 – 1927). Arrhenius won the Nobel Prize in Chemistry in 1903 for his work on the electrolytic theory of dissociation (that compounds such as salt may be separated into ions of sodium and chlorine). Arrhenius is credited as being the first person to investigate the effect that an increase in atmospheric carbon dioxide would have on global climate. He is also known for the "Arrhenius Equation," which calculates the effect of temperature on reaction rates.

[51] Arrhenius later added, "except that he did not carry out extensive measurements."

important thing; Rossby had already started a field program in Sweden. So, he had ideas and insights in the project when this meeting at Woods Hole was set up. That was a historical event when we all got together. Roger invited me because of my interest in the field.[52] Rossby felt that one should utilize modern infrared spectroscopy, and he brought some records from the Swedish analyses that were not very accurate, actually, at that time, but showed that things could be done.[53] It was also agreed that SIO should invite a promising young man from Harrison Brown's group at Caltech who was already developing a sophisticated instrumental program for measuring CO_2. That was Charles David Keeling.[54] But, another characteristic of Roger was that he didn't like the idea of expensive instrumentation. He was very conservative, economically. I remember once Jenny told him that she had just bought a shirt for me for five dollars. And Roger was disapproving that we should buy such expensive things. [*Laughter*]

Harkewicz: Five dollars? Things have changed, haven't they?

Arrhenius: But therefore he was even more disapproving when, as I remember, Charles David Keeling wanted to buy a tremendously expensive infrared spectrometer to serve as the key instrument for his CO_2 measurements—it would cost several thousand dollars, and it took lots of convincing to let Dave go ahead with the purchase.

Harkewicz: Was that his main problem with taking the measurements, you think, because of the cost of the instrumentation or was it more theory that he was . . .

Arrhenius: The analytical technique had to be refined completely. The problem with the Swedish program at the time was that the air sample collection was made on land in Sweden, and of course you've got big fluctuations there due to the growth of plants and big clouds of CO_2 wafting across the fields. Keeling's big idea was to make measurements far away from civilization from high mountains like Mauna Loa in Hawaii, and at the South Pole, so that you really got an idea about the average global atmospheric content of carbon dioxide. But he had a very hard time to convince federal agencies[55] about his strategy and funding needs. He was extremely tenacious. That was his luck. He carried out this program over his lifetime against all odds. He was cut off from funding, sometimes, and had a terrible time, but he did it. He was fantastic in that respect.[56]

---

[52] Arrhenius later noted that "although he did not say so, I think that he hoped that I would take on a responsibility for the SIO part of the program."

[53] Arrhenius later clarified that the results were not accurate because "they proved to be overwhelmingly influenced by local conditions."

[54] Charles David Keeling (1928 – 2005), climate scientist at SIO.

[55] Arrhenius later added, "…and scientific peer reviewers…"

[56] For more information on the background of global warming and the contributions of scientists at SIO see: Charles D. Keeling, "Rewards and Penalties of Monitoring the Earth." *Annual Review of Energy and the Environment* 23 (1998): 25 – 82.

Harkewicz: I want to ask you about something about him, but I just wonder if, in our opinion, you know, being the grandson of Svante Arrhenius and but also being an oceanographer, do you think that oceanographers were the first to, so to speak, ring the alarm about global climate change, or do you think people like your grandfather and Guy Stewart Callendar[57] were the first people?

Arrhenius: [58]Well, my grandfather rang a bell, indeed, and people became extremely interested in it at that time. There was a great flurry of interest in it, but not because of the menace but because it would be so great. He felt that it would be marvelous to have an improved climate in "the northern climes." And in addition, the carbon dioxide would stimulate growth of crops—they would grow better. So he was, he and people at the time were not unhappy about the prospects. They were only sad that in his calculations it would take about 300 years for it to have the marked effect that we now think would happen in something like thirty or forty years. The reason for the discrepancy was that it was not known at the time that the ocean is stratified with a lid of warm water on the cold, and mixing between them is limited. As a result the timescale of the temperature increase was not well known. But once it was established, the interest in the greenhouse effect was lost in the beginning of the 1900s and it was only Callendar who took it up again in the 1930s, again without much alarm, I think, but as an interesting geophysical problem.[59] And Roger wasn't alarmed at all either—he liked great geophysical experiments. He thought that this would be a grand experiment to make, if possible, particularly because of his oceanographic background—to study the effect on the ocean of the increase of carbon dioxide in the atmosphere and the mixing between the ocean reservoirs.

Harkewicz: He did work on that, didn't he?

---

[57] Guy Stewart Callendar (1898 – 1964), British steam and combustion engineer, Fellow of the Royal Meteorological Society. In 1938, in a paper delivered to the Society in London, Callendar claimed that the 10% rise in atmospheric carbon dioxide seen between 1890 and 1938 could be linked to the warming trend observed during that same time period.

[58] During the editing process, Arrhenius wrote: "My grandfather became interested in the subject of circulation of carbon dioxide in nature as a result of discussion in the Physical Society that he had founded, with Arvid Högbom (1857 – 1940) a geologist who had clarified an important link in the system, the transformation of silicate rocks to carbonate by the weathering action of atmospheric carbon dioxide dissolved in rain. Arrhenius saw this effect, together with the input from volcanoes and human sources as a dynamic system that could be subject to variations with time. He coupled this to the phenomenon of selective absorption in the atmosphere of the Sun's infrared radiation by carbon dioxide, methane and water vapor and calculated the global heating effect that was being caused by industrial burning of fossil fuel and cement making. Through his lucid popular lectures both the scientific and the educated lay communities became excited about the subject at that time."

[59] For more information on the history of global warming see: Spencer R. Weart, "The Discovery of the Risk of Global Warming." *Physics Today* 50 (1): 34-40 (January 1997).

Arrhenius: Yes, he worked on that. That was part of this thesis problem.[60] So he regarded that as a major fantastic positive experiment. And the same thing with the nuclear bomb experiments. He thought, like everybody, all geophysicists thought it fantastic to have a spike of activity of radioactive markers, like Jenny's father[61] started to use, injected in the atmosphere and then you can study the decay of it and the mixing into the ocean and the way it went in the biosphere and everything. A marvelous experiment. And Roger never became very convinced about the dangers of fallout.[62]

Harkewicz: It seems like such an odd way of looking at things now, to see an atomic bomb as a great tool. But I guess from your description, I can see it from a scientific standpoint. I mean, how do you feel about the issue, having all this experience? You were there at the time and you had this experience with Roger Revelle's viewpoints, and now you've seen other things happen.

Arrhenius: Well, there were two aspects, of course. Partly the military aspect, which was very menacing. But it seemed at the time, at least in the first years, that we would not need to worry because nobody else was going to master that technology. The Russians weren't sufficiently smart or well organized to do that. Nobody was up to our standards, so there was no reason to worry. And, then came the big competition with the Russians, and the Chinese, and the

---

[60] Revelle's dissertation is: *Marine Bottom Samples Collected in the Pacific Ocean by the Carnegie on its Seventh Cruise* (University of California, La Jolla, California, 1936) and discusses, among other topics, "possible factors affecting the distribution of calcium carbonate in the bottom sediments" (5). Revelle's interest related to ocean uptake, and turnover, of carbon dioxide, which is related to its partial pressure. The partial pressure of carbon dioxide is a function of seawater alkalinity. Revelle's original claim was that the ocean was able to absorb most of the carbon dioxide released into the atmosphere, including that produced by human activities since the industrial revolution. However, years later, scientists realized that, due to the complexity of seawater chemical systems, the ocean is unable to absorb all the carbon dioxide humans add to the atmosphere. In fact, Revelle found that only a small amount of additional carbon dioxide added to the ocean would cause readjustment of the balance of ion concentrations in the surface layer causing the majority of absorbed carbon dioxide to diffuse back into the atmosphere. For more information see: Roger Revelle and Hans E. Suess, "Carbon Dioxide Exchange Between Atmosphere and Ocean and the Questions of an Increase of Atmospheric CO_2 During the Past Decades," *Tellus* 9 (1): 18-27 (1957) and Spencer Weart, note #59, pages 37 – 38.

[61] George Charles de Hevesy (1885 – 1966). De Hevesy received the 1943 Nobel Prize in Chemistry for his conception of the radiotracer technique in which radioisotopes are used to study the behavior of stable atoms. De Hevesy also developed the technique of neutron activation analysis in which an element of interest may be investigated by artificially producing a new radioisotope of that element through neutron bombardment He also discovered the element hafnium.

[62] During the editing process, Arrhenius modified his statement noting that Revelle considered atomic bomb fallout to be, "A marvelous experiment and Roger never became convinced about any general dangers of 'peaceful' fallout except under special circumstances such as when he, during Ivy, experienced the rainout from the mushroom cloud. A year later, during the Bravo shot of Operation Castle more unfortunate Japanese fishermen had a lethal exposure of the fallout." The Scripps ship R/V *Horizon* was exposed to radioactive fallout from the first test of a thermonuclear device, *Mike*, during Operation Ivy. The crew of the Japanese fishing boat, *The Lucky Dragon*, were exposed to radioactive fallout from the Bravo explosion in March 1954. The radio operator of the ship died from complications stemming from this exposure. In addition to the Japanese fishermen, twenty-eight American military personnel and over 200 Marshall Islanders were exposed to potentially lethal doses of radioactive fallout from Bravo. The Marshallese have been part of a medical survey in relation to their exposure that continues to this day.

French, and everybody getting into the act. And that, of course, gave rise to very much concern, particularly from a person who might collaborate in it much later, namely Professor Hannes Alfvén[63] who was one of the great public enemies of nuclear armament.[64] But many of my friends among the scientists who were deeply involved in the Manhattan Project saw it from a technical, scientific and patriotic point of view. Others, like Leo Szilard[65] and Niels Bohr[66] whom I had the privilege to know personally, tried to arrange for political barriers to armament, but that was impossible, of course. Bohr was regarded as a very dangerous person by the U.S. government after the war and Szilard also. So, there was a strong political acceptance from some groups of scientists – particularly in the physical sciences. Then many became concerned from a point of view of use.[67] I think, however, that the way things have turned out is that it's such a scary perspective that it has created an era of peace that has been unparalleled in the history of mankind.[68]

Harkewicz: Do you have any personal views on it one way or the other?

Arrhenius: On which issue, Iran? Israel? What?

Harkewicz: The first atomic tests—since you have worked with it?

Arrhenius: Well, I'm certainly very concerned about the potential use of atomic weapons. And, one should do everything one can to prevent their use. But there's not much you can do in view of the politics of the world. And the obvious effect is that all emerging countries feel that to be on top, to be really somebody, you have to have a bomb.

---

[63] Hannes Olof Gösta Alfvén (1908 – 1995), professor of plasma physics at KTH in Stockholm. He was brought to UCSD as professor of electrical engineering . Alfvén won the Nobel Prize in 1970 for his work in magnetohydrodynamic theory. He also wrote the popular science fiction book, *The Great Computer: A Vision* (London: Gollancz, 1968) under the pseudonym Olof Johannesson.

[64] Arrhenius later noted that "even 'peaceful' developments of atomic energy came under suspicion" by individuals such as Alfvén who "argued vehemently against government-sponsored civilian developments that he considered as hidden sources of weapons material."

[65] Leo Szilard (1898 – 1964). Szilard was a Hungarian-born physicist and member of the Manhattan Project. On March 12, 1934, Szilard filed the first British patent application on the neutron chain reaction. In 1939, he encouraged Albert Einstein to write a letter to President Franklin D. Roosevelt to support research into production of an atomic bomb that led to the Manhattan Project. On June 11, 1945 he co-authored the *Franck Report* (with seven other scientists from the Manhattan Project's Metallurgical Laboratory at the University of Chicago) encouraging demonstration of the atomic bomb before all the nations of the world on a deserted island rather than its use in World War II. Also in 1945, he circulated a petition among Manhattan Project scientists opposing use of the atomic bomb on moral grounds. In 1964, he became Resident Fellow of the Salk Institute in La Jolla, California.

[66] Niels Henrik David Bohr (1885 – 1962), Danish physicist best known for his work exploring the atomic structure and the radiation emitted from it for which he won the Nobel Prize in Physics in 1922. Bohr advocated full openness between nations in regards to the development of nuclear weapons.

[67] Arrhenius later added, "about ethical, social, and suicidal aspects."

[68] During the editing process Arrhenius added, "until World War III was started, initially involving an atomically defenseless but oil rich adversary, considered to be an easy prey. But meanwhile many people have learnt to live with the bomb and love ours—trusting that 'theirs' can be shot down by our superior weapons."

Harkewicz: It's power.

Arrhenius: That's why you had these caricatures in the Danish papers of Mohammed with a bomb on his head.[69] To be in the big league, you have to have nuclear bombs. So it's no wonder with a relatively advanced country like Iran, under the threat by the United States and surrounded by Israel, Pakistan, and India who have atomic weapons that they'd like to have some, too. One can only hope that irresponsible leaders can be scared away from using these weapons. I think that such armaments are an accepted fact of modern history that individuals don't seem to be able to do much about. What do you think?

Harkewicz: I agree, I guess, with you. I was mainly interested in what you thought having actually been part of things more than I was. But, I guess you're still a citizen of the world and you have to look at things from the broader perspective?

Arrhenius: Sure. But at the time, particularly, I completely shared Roger's feeling that one had to utilize this as a unique opportunity, particularly since successful efforts were under way for banning bomb tests in the atmosphere and the ocean. That is a unique opportunity to take care of, take advantage of this spike and study a number of effects that would never later be studied. And, the same thing with the carbon dioxide problem. It's a big spike. It'll come to an end eventually.[70]

Harkewicz: You brought us back to the question that I was going to ask you about. Deborah Day, the Scripps archivist, said that you told her a story at the Keeling Memorial. You had mentioned how he was very driven. The story you told Deborah was that he tried to flag you down once when you were driving. You were driving to the hospital because your wife was in labor and he tried to flag you down to talk about carbon dioxide measurements and you said you couldn't stop right now…

Arrhenius: We engaged in a discussion about carbon dioxide, but after a few minutes Jenny made signs that she really couldn't . . .

Harkewicz: Oh, she was actually in the car with you?

Arrhenius: That's right. Yeah.

Harkewicz: I see.

---

[69] In early 2006, several European newspapers printed cartoons depicting the prophet Mohammad that prompted riots in many cities.

[70] During the editing process, Arrhenius clarified his comments as follows: "The use of this radiation spike to clarify geophysically-important processes also made it possible to evaluate and warn against biological effects that (hopefully) could never later be evaluated. And the same thing with the carbon dioxide problem. It's a big spike. It'll come to an end eventually when we learn how to behave but probably only after global temporary or permanent damage."

Arrhenius: So I told Keeling, “I'm sorry. We're going to have a baby right now, in a few minutes.” [*Laughter*] And then he finally realized he had to pull out of this scientific discussion and waved us off.

Harkewicz: Can you tell me a little bit about him. What was he like as a person? What was he like as a scientist?

Arrhenius: Keeling was a remarkable man. He had a great interest in music and other cultural endeavors, and he was totally dedicated to his science, and he was an extremely stubborn man, which was his luck, without being that he would never have succeeded. Everyone may be excited in the beginning of an important project but, as you know, people have very short-lived interests and after five years of work, something like that evolved, many just lost interest. Even Roger wasn't so deeply involved any longer. So Keeling had to fight to get support. And there were many both political and scientific forces against him. But thanks to his tenacity, he won out. He was also a very wonderful and friendly man, but he was doggedly insistent on extremely careful and detailed work which was necessary for his purposes. But this quality made it difficult for students to work with him because he was so insisting on extreme detail that they eventually became frustrated and gave up. Instead he developed a thoroughly dedicated staff around him, who all understood the importance of careful scientific work, and pursued it until past his death and still today.

Harkewicz: Unfortunately he passed away before I had the opportunity to talk with him. Do you think that he was still struggling—I mean, with the political situation in regards to global climate change as it is today, do you think he would still be struggling today with making people believe what he . . .

Arrhenius: He did it until very recently. And lately, it was easier for him, I think, to get funding. There were some years, a period maybe ten, fifteen years ago which were especially frustrating. But, I have a feeling that at the end it became possible for him to get continuous support that he could rely on without the need to waste energy on fighting for survival. This is because there's been so much interest focused on the climate problem in the last five years and Dave became an icon.

Harkewicz: So you were talking about interacting with him when you were younger, did you find that the scientists tended to socialize a lot together in the early days?

Arrhenius: Roger had a court you know and everybody belonged to that court and always congregated at his house or in other people's homes for serious discussion and fun. There were—if you like to I can show you a historical picture. Would you like to see it?

A party at the home of Roger and Ellen Revelle in April 1957. Front row, left to right: Jenny Arrhenius, Walter Elsasser, Roger Revelle, Shirley Liebermann. Center row: Rhoda Bascom, Helen Raitt, William Van Dorn, unidentified, Leonard Liebermann. Back row: Ellen Revelle, Carl Eckart, Gustaf Arrhenius, Willard Bascom, unidentified, unidentified. Scripps Institution of Oceanography Archives, UC San Diego.

Harkewicz: Sure.[71] We are looking at a picture from a gathering at Roger Revelle's house.

Arrhenius: That's right—it's a typical party. Roger and Ellen[72] were extremely hospitable, and their friends gathered around them for scientific and political discussion mixed with drinking big martinis. It was nice. They were incredible martinis; Roger used to say that a good martini should be prepared with pure gin and you just waft the cork of the vermouth bottle over it. [*Laughter*]

Harkewicz: I see.

Arrhenius: I don't understand how we could consume so much alcohol. But here are some of the major actors at the time. Here's a very important person in the history of Scripps, Carl Eckart,[73] a prominent theoretical physicist who was. . .

Harkewicz: The library is named after him.

Arrhenius: Yes, it's named after him. I don't know if you, have you read much about him. Do you know much?

Harkewicz: Not too much, no.

Arrhenius: He was the director before Roger and was a strong supporter in getting him appointed against the resistance. Carl was a theoretical physicist and is said to have developed the Schrödinger Equation at the same time as Schrödinger.[74] But Carl was such a critical scientist that he didn't quite dare to believe or want to believe in his results until they were absolutely perfected. So I think that's the reason why he was not fully acknowledged for this work. The lady next to Carl is Ellen Revelle.

Harkewicz: She's not the woman with her arms wrapped around Roger Revelle, then?

Arrhenius: That is Shirley Liebermann.

Harkewicz: Ah.

Arrhenius: Shirley, she is really such a beautiful person.

---

[71] The tape was paused while Arrhenius retrieved a photograph from a 1950s era party at the home of Roger and Ellen Revelle. The discussion that follows is in reference to the photograph that pictured a number of Scripps scientists and their wives posing casually.

[72] Ellen Virginia Clark Revelle [Eckis] (1910 -), San Diego philanthropist and great niece of Scripps early benefactor, Ellen Browning Scripps (1836 – 1932).

[73] Carl Henry Eckart (1902 – 1973), director of Scripps from 1948 – 1950, vice-chancellor of UCSD (1965), pioneer in quantum mechanics and underwater acoustics.

[74] The Schrödinger Equation was proposed by Austrian physicist, Erwin Schrödinger (1887 – 1961) in 1925. It describes the space-time dependence of quantum mechanical systems and is of central importance to the theory of quantum mechanics.

Harkewicz: He's got sort of a grimace on his face, doesn't he?

Arrhenius: That's Roger—and that's Shirley's husband. Leonard Liebermann.[75] He came here as a leader of the acoustics program during the war. He's a well known physicist, and is still active. Then, let's see, here is Walter Munk's wife.

Harkewicz: Judy Munk?[76]

Arrhenius: No, not Judy

Harkewicz: His first wife?

Arrhenius: His first, Martha; Martha Chapin Munk. I am afraid that the Capricorn was responsible for triggering the divorce—theirs was not the only case…

Harkewicz: Was that something—especially like the Swedish expedition you went on for a year and a half—was that something that caused a lot of problems, scientific cruises?

Arrhenius: Oh, definitely. I was engaged to Jenny at the time, and when the ship was in the Seychelles Islands I got a telegram from her, she was in England studying at the University of Durham, and it said that she was "tired of being engaged to somebody who was never there." So, goodbye.

Harkewicz: She gave you an ultimatum, then?

Arrhenius: Well, not even that.

Harkewicz: She just said "Goodbye?"

Arrhenius: So, I quickly got on a P&O Steamer to East Africa and flew up to England and appeared there unexpectedly and we got married there. So indeed long absences have their effects. But with few exceptions the people on the Capricorn seem to have had marriages that could withstand the limited strain of such a short expedition or they were happily unattached.[77]

---

[75] Leonard Norman Liebermann (1915 -) professor of physics at UCSD. Arrhenius later added, "As an eminent young physicist he [Liebermann] was the first staff member to be brought into the Marine Physical Laboratory [MPL] in 1946 by Carl Eckart, then director. MPL was created after the war out of the University of California Division of War Research."

[76] Judith Horton Munk (1925 – 2006), artist and architect who married Walter Munk in 1953.

[77] Arrhenius later added, "Fifteen months on the Albatross was a different matter but even so I am not aware of any marital, or premarital, split during that time. Also, after a year, the ladies arranged for a conjugal visit while we made port call at Nice in France, a beautiful and romantic event."

Harkewicz: So we're looking at this picture. Do you know what year this was taken, by any chance?

Arrhenius: Oh, I can guess from the fact that this is Walter Elsasser; he was the theoretical physicist who was appointed by Roger as a research oceanographer in order to start our Physics Department. So it must be shortly after Roger had the idea of that—it must be maybe '57, '58, something like that. That is he. He was an ingenious thinker, but he was obsessed by doubt. When he had some great new fundamental insight like the wave nature of the electron, he worried that it was too good to be true and wouldn't be believed. So he finally had a nervous breakdown and had to leave because he thought things were going so well here that a catastrophe must be approaching.

Harkewicz: Oh, that's terrible.

Arrhenius: But, he was a sensitive and wonderful person with a life marked by disasters. And that is Jenny. And that is Willard Bascom, and his wife Rhoda. Both of them since dead. And I don't know why so many men are missing here, because they might be on an expedition or something, but that is Helen Raitt.[78] You know her?

Harkewicz: Yes.

Arrhenius: Her husband is not in the picture, either. And that is me.

Harkewicz: You have quite a look on your face there, too. [*Laughter*]

Arrhenius: This is Bill Van Dorn,[79] another person who played an important role in oceanography. He was engaged in the physics of the bomb tests. And his wife, Nancy—I don't see her. She must be away somewhere, too.##

Harkewicz: ## We are looking at a photograph from a party in, approximately in 1957, '58 maybe?

Arrhenius: Yes. Something like that.

Arrhenius: So, that's all the personalities shown here, and it's a typical informal gathering of the kind that Roger had.

Harkewicz: This happened often then?

Arrhenius: Quite often.

---

[78] Helen Hill Raitt (1905 – 1976), wife of Russell Watson Raitt (1907 – 1995), marine field geophysicist and professor of geophysics at SIO.
[79] William George Van Dorn (1920 -), research oceanographer at SIO.

Harkewicz: Was there anybody who didn't want to hang out at these parties, any of these scientists that felt like they . . .

Arrhenius: Well, there were some—nobody that didn't want to, I think, but there was a certain exclusion. There was nobody of the old biological school ever involved. The people I mentioned—Fox, ZoBell—they were not so much, I think, heavy martini drinkers, easygoing hedonists. Later on the sixties and seventies turned into the Age of Aquarius when people were so loving and happy, and the martinis were substituted by milder relaxants. And those old-timers were much more conservative, I think.

Harkewicz: I see. So, when did this kind of thing, did these parties stop after Revelle left the directorship?

Arrhenius: Yes. At that time the scientific crowd had become so large that it tended to split up into separate small groups involving many more personalities from the new campus who developed interests and loyalties with Scripps people.

Harkewicz: Let's talk a little bit about the new campus, UCSD. I just want to ask you because in this oral history that you did with Texas A & M in 1976[80] you were talking about how you used the term "convenience of the time," and how a lot of divisions or departments at UCSD were created because of the people that they acquired for the department. Like you mentioned the Space Research Laboratory was set up for Harold Urey's work, and the Institute for the Study of Matter was created to support the solid-state physicist Bernd Matthias.[81] So, was that typical of the way UCSD was put together, divisions were created for people, so to speak?

Arrhenius: Bringing in powerful experimental physicists, chemists, and biologists demanded that they be given instruments, funding for technical staff and graduate students and partly for themselves, and organizational structures to operate with. Departments could not get such funding from federal sources. If a department would ask for research funding from a federal agency, it would suspect that the money would be siphoned off into undergraduate teaching. And therefore the way to draw in federal support is to create an institute. Typically with a leader in his field, like Bernd Matthias—it was easy to get large support at that time—the Air Force had come up as a competitor to the Navy in science support and generously supported research in superconductivity at his specially created Institute for the Study of Matter for twenty years. Then the military agencies by the Mansfield Amendment[82] were forbidden to support civilian

---

[80] Oral History with Gustaf O. Arrhenius, 19 July 1976. *Project on the History of Moden Oceanography: Oral History Interviews, 1975 – 1978*. Interviewed by Robert A. Calvert at Scripps Institution of Oceanography, La Jolla, California. Cushing Memorial Library and Archives, Texas A & M University.

[81] Bernd Theodor Matthias (1918 – 1980), professor of physics at UCSD.

[82] The Mansfield Amendment of 1973 expressly limited appropriations for defense research to projects with direct military application. Such research was administered through the Advanced Research Projects Agency (ARPA), which was later renamed the Defense Advanced Research Projects Agency (DARPA).

research after the government discovered the misdirection of funds intended for warfare.

Harkewicz: Did the same kind of thing happen at Scripps?

Arrhenius: You mean, the people splitting?

Harkewicz: Or that divisions were set up in order . . .

Arrhenius: Institutes or smaller centers were set up most definitely for focusing research interests and drawing in support funds that mostly could not be provided by the University. One Scripps example is Doug Inman's Center for Coastal Studies, working on near-shore processes, is typical of that.[83] And the prize is the Institute of Geophysics that existed at the time at UCLA under Slichter's leadership. Walter Munk started a new and highly successful branch here.[84] Several other branches were started on other campuses but the SIO section has become one of the most important and successful institutes. And then with the rise of space activities in the sixties came the California Space Research Institute led by Jim Arnold of the Chemistry Department.[85] The initiative to start such a State supported research organization was taken by Governor Brown, "Governor Moonbeam" [*laugh*] as he was called.[86]

Harkewicz: Jerry Brown?

Arrhenius: Yes, Governor Brown, Jr. had great aspirations for state-sponsored scientific enterprises and his creation of a space research institute supported by the State of California was very unusual. Most of those institutes were practically entirely federally supported with some seed money from the university offered in the hope that they, with outstanding scientists at the helm, would become magnets for federal grant funds. Jim Arnold had visualized CalSpace as an independent free-standing institute. But our very powerful director at the time, Bill Nierenberg,[87] to Arnold's great surprise decreed, "That will be part of

---

[83] The Center for Coastal Studies was started in the 1980s by Scripps research professor of oceanography, Douglas Lamar Inman (1920 -) and was meant to provide an interdisciplinary approach to coastal studies.

[84] The Institute of Geophysics and Planetary Physics at Scripps was established in 1960 as an expansion of the geophysics program of the University of California system. The intercampus Institute of Geophysics, established in 1946 and headquartered at UCLA, was directed by Louis B. Slichter from 1947 – 1961 and by Willard Libby from 1962 – 1976.

[85] James Richard Arnold (1923 -), professor of chemistry at UCSD, former director of California Space Institute at UCSD.

[86] Edmund "Jerry" Gerald Brown, Jr., was born in San Francisco in 1938. He served as the governor of California from 1975 to 1983. In 1998, he was elected mayor of Oakland, California—a position he still occupies at present although, as of this writing he is running for the office of attorney general of the State of California. Arrhenius later added that Brown was "derisively" called "Moonbeam" because of his intellectual bent, a political liability.

[87] William Aaron Nierenberg (1919 – 2000), physicist and SIO director, 1965 – 1986.

Scripps." So, it was anomalous in a way, but the California Space Research Institute became a part of Scripps.[88]

Harkewicz: So creating these institutes was the way to get federal funding?

Arrhenius: That's right.

Harkewicz: Was it also the way to get big names?

Arrhenius: Well, the big names mostly came first, but we also held out potential institutes as attractive tools while recruiting those people. So it was a combination of both.

Harkewicz: So how did the founding of UCSD affect you personally, or your work at Scripps, or Scripps' work in general?

Arrhenius: It affected me greatly because I got in touch with all of those extremely exciting actors in various fields, and one of the first things that happened was that I joined up with Bernd Matthias and I spent several years in superconductivity working on things that superficially had little to do with Scripps. But I felt that it gave a deeper insight into a field that I didn't know enough about, particularly the electronic structure of materials. And then space physics, at the time when we brought in Hannes Alfvén from Sweden, the founder of modern plasma physics. Together with him I devoted many years to effects in plasma physics that have to do with the solids that form in the space medium and gather into comets and meteorites, materials from which the Earth, planets and satellites have formed and therefore are highly relevant also to Earth science and oceanography. And in that context, the intense space effort that started in the sixties with the lunar exploration also captured me. So I was completely hijacked by all of these new things. And that has made me . . .

Harkewicz: By choice or by . . .

Arrhenius: By—well, it was impossible to avoid because it was so fascinating.

Harkewicz: I see. You were just intrigued?

Arrhenius: And felt the need to broaden my knowledge into these fields.

Harkewicz: So was there any connection in your deep-sea drilling experience to your move into space exploration?

---

[88] The California Space Institute (CalSpace) was a Multicampus Research Unit (MRU) that was hosted at UCSD/SIO until 2005. The first director was James Arnold from SIO, followed by physicist and former NASA astronaut Sally Kristen Ride (1951 -) and then Scripps oceanographer, Wolfgang Helmut Berger (1937 -). The MRU was disestablished in 2005 by the Office of the President of the University of California.

Arrhenius: No. [89]

Harkewicz: They're totally disconnected?

Arrhenius: No, the interest in space physics and chemistry grew at the beginning of the space exploration that was a brand new and fantastically attractive field. So, as another aspect of materials science it was connected to our interest in ocean sediments and in Earth and Moon materials and in the ocean itself.

Harkewicz: Do you think UCSD got into the space field because it was just that time, or do you think . . . .

Arrhenius: Let's see, how that started? First of all it was not possible to get into it until there was a national effort, led by NASA. But locally it was triggered by Harold Urey's longstanding interest and by Jim Arnold's great knowledge in radiochemistry and cosmochemistry. He took the initiative to get grants from NASA to support all of those here that were interested in the field. And in preparation for the manned lunar expeditions that materialized years later a nationwide program was developed to study meteorites as source materials from space, and to develop refined analytical techniques. So, when we finally got materials back from the Moon and from other planets that we would stand prepared to investigate them. Jim Arnold by his initiative and his own work came to play a fundamental role. But then there were also other space scientists brought in, like Carl McIlwain,[90] who worked with Van Allen[91] on the discovery of the Van Allen Belts. And, a whole group in space physics that came in at that time, and still is active on upper campus.[92]

Harkewicz: You mentioned that they set up the program so that they could study materials when they brought them back from space, which reminds me a little bit of the story you were talking about before when you went out on the deep-sea drilling—the Swedish expedition—and they had all the cores to process and nobody knew what to do with them. But in this case they were preparing[93] …

Arrhenius: That's right.

Harkewicz: I see.

---

[89] During the editing process Arrhenius added, "But the gathering of cosmic materials in the slowly depositing deep sea sediments formed a link to space science. And the origin of the ocean is definitely a problem in space physics."
[90] Carl Edwin McIlwain (1931 -), professor of physics at UCSD.
[91] James Alfred Van Allen (1914 - 2006), professor of physics at the University of Iowa.
[92] Arrhenius later noted certain members of this "group": "the Burbidges, famous astrophysicists"—Geoffrey Ronald Burbidge (1925 -), theoretical physicist at UCSD and his wife, Eleanor Margaret Peachey Burbidge (1919 -), professor of physics at UCSD and the first director of the Center for Astronomy and Space Science at UCSD; Laurence E. (Larry) Peterson (1931 -), professor of physics at UCSD; Devamitta Asoka Mendis (1936 -), astrophysicist and professor of electrical engineering and computer sciences at UCSD and Hannes Alfvén.
[93] […for the processing of lunar samples once a lunar landing took place.]

Arrhenius: My work in solid state chemistry had a great deal of influence on my research on ocean related problems since I learned more sophisticated ways of studying materials theoretically and by x-ray- and other radiation techniques that I had been interested in earlier, but now I had a deeper understanding of them.

Harkewicz: So, you don't see a conflict between your interest in space and your interest in oceanography?

Arrhenius: On the contrary. But of course, the danger in doing things like that is that you may become a jack of all trades and a master of none. If your main aim is to get famous in a field, then you have to doggedly pursue it. It must be very boring in the long run. So, I'd rather have fun and not be bored.

Harkewicz: So, try a lot of different things . . .

Arrhenius: As long as they all tie together in one way or another.

Harkewicz: I see.

Arrhenius: Then you get insights from everything related. Oceanography and space, cosmic phenomena, solid state chemistry and biology. A major interest of my early mentor, Hans Pettersson was the influx of cosmic materials that could be recorded in sediments because you can find these little particles in ocean sediments.[94]. So there is a continuous interaction between different fields of science. That was Roger's idea, you know. He felt that one should work in an interdisciplinary fashion and learn various things from different fields and apply them to an integrated picture.

Harkewicz: Is your work in the space field through Scripps or is it through UCSD?

Arrhenius: Well, our work is carried out in both places nowadays, because the way things have developed—originally it was entirely upper campus, and many scientists in Scripps "took a dim view" as Roger used to say, of the development of UCSD. They felt that Scripps should be pure Scripps, not mixed up with all those terrible outsiders coming in. So there was some animosity toward him over UCSD. Particularly, in the beginning, many of the developments in the space field were limited entirely to upper campus. Then it invaded Scripps, in the form of Nierenberg's adoption of the California Space Institute, and also by the applications that we could find in ocean sediments, for example, and in solid-state studies.

---

[94] Arrhenius later added: "Later on that became a big field of interest with collection and analysis of cosmic dust in interplanetary space and its accumulation in glacier ice. And the long standing interest in the chances for propagation of live spores through space and the origin of life."

Harkewicz: So, it's not a direct hijacking of Scripps, so to speak, then? There is an application in the ocean?

Arrhenius: Oh yes. Not of everything of course, but even philosophy and other fields of the humanities. Everything affects you if you participate in it.

Harkewicz: I know that when Revelle first established UCSD he wanted it to be more of an institute, or more of a graduate-type setup, and not have undergraduates.

Arrhenius: Absolutely, that was his goal—he was disturbed by the thought of having undergraduates first. Among other things there was a rule in the University that if you had undergraduates on campus, if you had more than fifty students on campus then you had no right to serve liquor within a distance of, I think, two miles or ten miles, or something like that. That would have had an impact on our lifestyle. But that, of course was not a main reason for concern. Roger visualized a local research university fueled by graduate students, of course, and a powerful research staff. I think I still have a bumper sticker that says "UCLJ," University of California, La Jolla. That was its official name to start with. But then the citizens of San Diego started grumbling that they were paying the taxes for it, too, so it had to be changed to UCSD.

Of course in America the feeling is that everything has to grow and it if doesn't, you will fail. Everything has to grow bigger. And as Roger expanded things he found that originally the administration of the university, including the Regents, had been quite willing to support Scripps as a little enclave that they could show off as an advanced research institute. But if it grew now into something that was quite different, with many disciplines, then you had to admit undergraduates. And for this, you had to have elaborate curricula and a corresponding administrative organization or you couldn't expand. So Roger came to realize that and to accept the thought that we had to have an undergraduate curriculum. But when you do that, then you're not any longer regarded as some little enclave—you get ground between the big powers in the university, all the deans, and top administrators at Statewide, as the UC System was called then. That all led to Roger's downfall because he was not a politician at the educational level. He was a great scientist with inspiring visions. But when you start to deal with all the big university administration, that's purely a political business. And he was not acknowledged by those powers as a capable politician.

Harkewicz: Historically, especially in the postwar period, Scripps was known more as a research institution than as an educational institution, correct?

Arrhenius: Purely.[95]

Harkewicz: Do you think they've reached the proper balance now?

---

[95] Arrhenius later added, "but including, of course, graduate student research."

Arrhenius: We're still in a crisis situation, I think. In the past, for Scripps to grow one had to get more faculty positions. But with the UCSD campus to allocate faculty positions, there had to be teaching positions. Scripps in this new regime got several positions, but the occupants, like their SIO colleagues, came to focus on mostly informal graduate teaching, and that turned into a source of friction with the upper campus.

There's been much pressure recently for expanding the undergraduate teaching from Scripps. And I think right now it's a pretty good situation with a limited undergraduate program—it has always been agreed that oceanography should not be taught at the undergraduate level, since the students first need a foundation in mathematics, physics, chemistry, and biology. So, I think most people in Scripps would agree that we would like to remain a graduate school, but this still doesn't exclude giving general courses, encouraging undergraduate students to explore what there is in such a field so that when they graduate they might . . .

Harkewicz: So they become graduate students in oceanography?

Arrhenius: Right. It is stressed now because there's more pressure for expanded undergraduate teaching but it remains rather relaxed at that level since several faculty members often share a course.

Harkewicz: Well, in the interview for Texas A&M you said something like, "At Scripps there is no border between teaching and research."

Arrhenius: At Scripps, with graduate teaching, of course, there is no border. You don't necessarily give formal courses all the time—there are not enough students for each professor to teach seven courses. There are not enough students to take those courses. And much of the teaching or the learning experience comes from the interaction of graduate students with their mentors in the laboratories. That important form of teaching is not acknowledged in public universities in general, and particularly not in the University of California. The big power here[96] comes from undergraduate teaching—from giving the advantage of basic education to the people, to the sons and daughters of the citizens.

Harkewicz: Of the state.

Arrhenius: That's a very important duty, but it should not be given to a specialized institution, I think.

Harkewicz: Have you taught at the undergraduate level?

---

[96] Arrhenius later clarified, "in the form of operational funds and recognition."

Arrhenius: Well, in two ways. Partly I've been giving popular courses, kind of introductory courses in space origin, things like origin of the universe, origin of the solar system, and things like that. That draws students mostly from upper campus.[97] And secondly, by inviting or allowing qualified upper division undergraduates who have already had chemistry and physics background, to participate in my graduate courses. Those selected young people are often very bright, some of the brightest and most ambitious students I have known. Naturally, they mostly come from the science and engineering departments.

Harkewicz: So you don't have a problem with teaching undergraduates in general, then?

Arrhenius: No. However, I have never taught the really big courses, I've never been involved in teaching the major beginning undergraduate science courses. That's a completely different enterprise. You have five hundred students and lots of TAs, teaching assistants. A very different type of enterprise, and I've never been involved in that.

Harkewicz: And you don't have any grand desire to do that?

Arrhenius: Oh . . .

Harkewicz: That could be another thing you could add to your jack-of-all-trades list.

Arrhenius: I don't know if I would particularly like that. I like to work with small groups of students. That's more satisfying, I think.

Harkewicz: I can understand that.

Arrhenius: Particularly because many of those huge courses are students who want to go to qualify for medical school and they have no interest whatsoever. They just want to qualify to get a grade and they get very angry if they don't get a high grade. And, no dedication, I think. That's why I don't teach them.

Harkewicz: The sixties have been referred to as the "golden age of oceanography." Do you think that's true? You've seen a lot of different things. You've also moved into other fields. So, do you see that time period as something special?

Arrhenius: I think the sixties were great because it was so much fun. With abundant support everybody liked each other, although there were some conflicts between political and personal situations. That was the time of the Vietnam War and enormous amounts of money flowed into military endeavors and therefore, indirectly, also into science. So there was lots of support. Nobody needed to worry about writing proposals all the time. Your peers were very generous in their reviews. All of them had support, so when you sent in a kind of crazy

[97] Arrhenius later added, "Last year, I taught an undergraduate Earth Science core course in optical mineralogy—a big job."

proposal for doing something totally new they mostly said, "Well, interesting idea, you know, probably crazy, but should be supported anyhow." [*Laugh*] So, there was no rancor or jealousy to speak of. No, everybody was supported in doing what he thought would be right.

In oceanography, the way I see it, there has been a "golden age" going on all the time from the 1880s when it started in Norway and Sweden, and all the way since that has been interesting. Well, there have been ups and downs, maybe, and it shifted from country to country, and the forties and fifties were ages of some great expeditions. And the sixties were a time of important instrumental developments. Bill Nierenberg, for example, played a big role in Scripps at that time by supporting the use of computers on shipboard. That made a big push ahead possible in oceanography. Previously, I am sad to say, much of the data collected during expeditions went down the drain because one couldn't treat them all. But now it became possible to record them right away on shipboard and process them and to have them available in a manageable digital form for later work. So that was a big breakthrough. Then Ed Frieman,[98] during his time as director, made it his goal to make Scripps an important center in atmospheric physics.[99] So I think every decade has seen advances, not only at Scripps but nationally and internationally, that made it "golden." I don't have a perspective yet on the nineties and the beginning of this millennium. There you should probably consult people in the field and ask what they think about how "golden" oceanography is now. But lots of new ideas are coming up and people like Walter Munk are always doing new and interesting things.

Harkewicz: So, from what you were talking about some of the former directors who were physicists, from your standpoint you don't see that as a problem? I mean, I've spoken to some other scientists who have sort of felt that maybe funding didn't go to certain divisions because of physicists being in charge?

Arrhenius: That may be partly true—the interest has gravitated. I mean, the interest has gravitated. But that is partly due to the fault of the scientists themselves. I think as long as there are new and exciting ideas, the funding will follow.[100]

Harkewicz: How has your experience with funding gone over the years? Has it gotten more and more difficult for you?

Arrhenius: No, I have always been very generously supported in, particularly in the last two decades when my interests have gravitated more into biogeochemistry and the

---

[98] Edward Allan Frieman (1926 -), physicist, director of Scripps from 1986 – 1998.

[99] Arrhenius later amended his statements to include, "climate science and [Frieman] presided over building up a prominent group of physicists and occasional chemists devoted to related problems that now are taking center stage also in national and international politics. And their results and measurements in or from the atmosphere and space have, of course, given important insights in interactions with the ocean."

[100] Arrhenius later added, "And most recently Charlie Kennel [Charles Frederick Kennel (1939 -), SIO director 1998 – 2006], although, or perhaps because, he is a prominent physicist with broad views, has been instrumental in innovating and strengthening the institutional base in marine microbiology and genomics."

questions of origin of life, which is what we are involved in right now. Both in that field and in space research we've had very generous support, always, from NASA and previously from NSF. This country has been very generous to science. Right now there's a crisis in NASA because of the new presidential proposals on how to change space research toward manned missions to Mars and to the Moon, largely politically motivated enterprises. Scientifically you'd go about this exploration in a more efficient and less costly and risky way by using robotic techniques. In the present situation, NASA has had to restructure its science support system to prepare for these new programs and also for the Space Station, which is an extremely costly enterprise, and with a ceiling on funding, the only place where NASA can cut is in science. That has a devastating effect on postdocs and young people who are just into the field and trying to get support. But everything adjusts itself somehow in the long run.

Harkewicz: So, that's what you meant when you said in that, in the Texas A&M interview, that going to the moon was a publicity stunt?

Arrhenius: Sure. Entirely. But it was a publicity stunt that had great scientific potential at the same time. So it was okay. It was doing something good for science for the wrong reasons—for political reasons.

Harkewicz: But do you think it would have been better if they hadn't worried about sending a man to the moon?

Arrhenius: If they had done it robotically with sample return, I think that would have been much more efficient. Then we would have gotten much further.

Harkewicz: But is that ever necessary to—I mean, you said in that interview, that the public has a limited attention span and so you have to do these things to get public attention. I mean, is public support important?

Arrhenius: Sure. I mean, after all, it's the taxpayers who influence what should be done. So, you have to satisfy the public interests. And in the United States you have a scientifically educated public that is a fair part of the population. Of the rest, many live in superstition. But as soon as people see a worthwhile scientific project they are willing to support it, particularly if it would seem to have economic or military potential. And I'm sure that people, besides glorifying manned spaceflight, would have been approving of robotic exploration of the moon. Since we have the Moon so close by it's not such a big deal to go there. But to send men to Mars at our present state of space technology, I think is foolish.

Harkewicz: Do you think it's appropriate, or do you think it's the role of the scientists, to try to get public support for different programs?

Arrhenius: Yes, because science is supported by the people, it is necessary to have the people be satisfied with what science is doing and not be scared of it. That's a common conflict, that people regard scientists as dangerous people, dangerous eggheads with crazy ideas that might be dangerous, ideologically or economically.

Harkewicz: Do you think that's related to the atomic tests or do you think it goes back farther than that?

Arrhenius: I think the atomic era brought this even more in focus, for sure. It was thought okay to kill your adversaries with atom bombs but you shouldn't leave too much power in the hands of eggheads, because they might do the wrong things and try to stop these applications.

Harkewicz: How do you think changes in society have affected science, or science at Scripps? Things like the Civil Rights Movement, or the Women's Movement? Have you experienced any changes yourself with these kinds of things?

Arrhenius: There's been more acceptance of women in science. There's always an innate resistance. Many men, not me, feel very uncomfortable having female colleagues and this has been the case, very strongly, in seagoing enterprises. The thought of having women aboard an expedition was impossible in the early days. The first breakthrough at Scripps was when Helen Raitt came out to Fiji and joined the Capricorn Expedition—encouraged by Roger, who was a great liberator in that respect. But the sailors were horrified. They thought that would bring bad luck. I remember when I visited Russia when Gorbachev had just gained power and his wife, Raisa, had just inaugurated a ship that was being launched, crushing a bottle of champagne against it, and nobody wanted to enlist as crew members on that ship because it was considered bad luck—the ship would probably go down.

Harkewicz: Because she christened it?

Arrhenius: Yes, she christened[101] it. That kind of inauguration was very dangerous.

Harkewicz: I thought that was as common thing for women to christen ships, though?

Arrhenius: Not in Russia.

Harkewicz: I see.

Arrhenius: It's different. And here, here possibly, as long as they didn't come along at sea. But now, there's no inhibition whatsoever in that respect. So that change has

[101] Arrhenius later pointed out that "christening," with its Christian religious connotations, was not a term that the Soviets would have considered using or thinking.

been very effective. Racially, the same thing.[102] There have been increased efforts to bring in underprivileged minorities into the scientific system but with limited success.[103] One of the great efforts to correct that at UCSD has been the development of the Preuss School.[104] I don't know if you've heard about that? It takes underprivileged but promising children from poor environments and brings them to the school. It's been a great success. But I witnessed great resistance against the idea in faculty meetings. Many of my colleagues said, "This is not our thing to do," and things like that. But now that it's a success everybody, I think, appreciates it.

Harkewicz: So do you see it more directly related to the upper campus . . .

Arrhenius: The upper campus started at Scripps. Scripps is such a small place—but certainly when we have faculty and staff appointments people look carefully to see and encourage women and racial minorities to apply. But then they strongly resist, I think, appointments based only on those criteria—we always take the best. But there's no bias, you see, and there are many outstanding women appointed at Scripps. I don't know if there were fewer in the past.

Harkewicz: You have been on a couple of NASA committees, at least in the seventies. Were they advisory type committee things?

Arrhenius: Yes. They were practically all advisory. Practically all of the initiatives for research projects naturally came from science, for example, much of the work in atmospheric physics. Another was Hannes Alfvèn who was here for many years, and was a great visionary in solar system research. He took the initiative to space missions to comets and asteroids, which are important from a cosmochemical point of view. Because of my interest and activities, most of my services were on related committees and also on lunar sample allocation.

Arrhenius: Jenny, are you tired?

Jenny Arrhenius: Yes.

Arrhenius: Would you like to sit down somewhere else? [*Recording paused*][105]

---

[102] Arrhenius later added, but "not in dangerous professions such as at sea where everybody is accepted, at least in menial jobs."

[103] Arrhenius later added, "largely for practical reasons; the comparatively inferior K–12 education offered."

[104] Preuss School was established on the campus of UCSD in the fall of 1999. The school was named in recognition of a $5 million gift to UCSD from Peter and Peggy Preuss. Peter earned his master's degree in mathematics at UCSD and later founded Integrated Software Systems Corp. (ISSCO)—a San Diego-based software company specializing in computer graphics. Peggy, a former teacher, is currently the vice chairman of the UC San Diego Foundation. Cecil Lytle, professor of music at UCSD and provost of UCSD's Thurgood Marshall College, led the initiative to found the charter school on campus. It's mission is to provide intensive college preparatory curriculum to low-income students in grades 6-12. Preuss School is primarily funded by state and federal revenues based on enrollment and average daily attendance.

[105] Arrhenius was speaking to his wife who sat with us throughout the interview. Mrs. Arrhenius had been injured in a fall and Arrhenius was acting as caretaker for his spouse. Although she appeared tired, Mrs. Arrhenius opted to

Harkewicz: You were talking about the NASA Advisory Committee on Comet and Asteroid Exploration, which you were on from 1973 to '75? Are you still involved in any of these committees—I know you're still working on origin of life issues?

Arrhenius: That's right.[106] My interest has gravitated from the source materials in space to what happens to them when they land on the planet and to what extent and how they can serve as the basis for development of life.

Harkewicz: I see.

Arrhenius: But, also in that field there are lots of committees, conferences, and things like that that I am happy to participate in.

Harkewicz: Is that exobiology?

Arrhenius: Right.

Harkewicz: Do you think that's affected like the way you look at the world somehow? You mentioned in the Texas A&M interview that you were an existentialist…

Arrhenius: Did I?

Harkewicz: Yes. And I thought that was interesting. Because maybe I don't understand existentialism, and maybe you're not an existentialist anymore, but isn't it very subjective? I wondered how you used your subjectivity while remaining the objective, rational scientist?

Arrhenius: Well, existentialism simply implies that our knowledge is so limited that we cannot predict complex processes very far into the future simply for probabilistic reasons. You may know about the first and the second step. Where further events will take us is very hard to predict, and you have to recognize that when you look at the world.

Harkewicz: So, you don't want to make any huge broad statements that you can't prove by experimentation?

Arrhenius: Of course, you have to create general ideas first. You have to say that, say, "Origin of life is a problem that is approachable and that you can do experiments in and you can manage to make scientific progress." But then to make predictions before you've done the experiments, I think, is foolish.

---

continue to sit with us. The recording was paused in order to give her a few moments to decide where she would prefer to be.

[106] Arrhenius later commented, "Those committees do not exist any longer since their work has now developed into actual carrying out of these missions, now with a heavy involvement of engineering."

Harkewicz: So, you want to limit your predictions?

Arrhenius: Yes. But, you have to make some framework for your thinking, thinking what may be possible and then test that.

Harkewicz: You do modeling experiments with your group now, correct?

Arrhenius: Yes. Particularly the question on how life can have arisen from nonliving matter. There are lots of things one can do by modeling in the laboratory.

Harkewicz: So then are they more of a historical type of model as opposed to a predictive type modeling?

Arrhenius: Well, I like Oscar Wilde's statement, "I can predict anything except the future." But, what you try to do in the case of studying the origin of life is to demonstrate that there are processes that you can model in the laboratory that are plausible in nature and that could lead to the crucial overtures for life in the form of RNA. Can one imagine conditions in nature that could generate those, that particularly could generate information? That's the crucial thing. And then you can test your ideas in the laboratory.

Harkewicz: I see.

Arrhenius: We can now see several steps in the making of RNA and its possible precursors occurring in the lab and we have been lucky enough to participate in establishing that. This problem[107] is not solved yet, but pieces of the jigsaw puzzle are being developed.

Harkewicz: I think we're wearing ourselves out here, but I just had a couple more questions. One is how has Scripps affected your life? I know that's a big broad question.

Arrhenius: Yeah. That's a big broad question. It has completely shaped my life. When you live in an institution like Scripps it engulfs you, and inspires you, and creates the background for whatever you do. So, it becomes a universe for you. That's how I feel about Scripps.

Harkewicz: What do you think has made it successful from your standpoint?

Arrhenius: That has made Scripps successful?

Harkewicz: Yes.

Arrhenius: How do you mean "made Scripps successful?" Made Scripps successful for me?

---

[107] Arrhenius later added that the next problem to tackle is that of "molecular coding, and the linking of nucleoside phosphates."

Harkewicz: Well, I guess, well it has to be from your viewpoint, because I'm asking you, but it's sort of a two-part question. The first part is, what do you think has made Scripps successful and then what has threatened its success? So, from your viewpoint what do you think has made . . .

Arrhenius: Scripps successful?

Harkewicz: Yes.

Arrhenius: The idea of bringing together a group of interdisciplinary scientists to work and discuss problems of joint interest. I think that's the essence of Scripps. And to place at their disposal the tools that you need for doing that: ships, instrumentation, and other things that you need like large computing facilities and a central analytical facility. But the people are, of course, the most crucial thing. And there, what is the danger in Scripps is that in creating the next generation, scientists often tend to bring in people who are similar to themselves, to reproduce themselves because they think the most important thing that is being done is what you're doing, and that I see as very dangerous. My friend and colleague Ed Goldberg used to say that, "When you appoint new people you should only bring in people whom you're afraid of." I think that's a very good point. And we are right now into a recruiting process that I'm participating in and I'm trying to see if there are any candidates I would be particularly afraid of. Those I would like to see appointed.

Harkewicz: So you see the biggest threat is in bringing in copies of yourself?

Arrhenius: Yes, and going stale. It's important to develop intellectually. Not necessarily to grow bigger. I think an interesting idea that many people nurture at Scripps is not to have it grow so big. Well, why should you grow so big? Why not keep it at the size we have and develop bigger ideas instead? And you anyhow need to add new people replacing those who retire and die away. And the students that you bring in, of course bring new ideas and new blood.

Harkewicz: Do you think this tendency to bring in copies of yourself is something that has changed over time?

Arrhenius: No, I think it's tied to specific individuals. Some feel that they are so important that they should be reproduced. Others look for new ideas. It's probably always been that way. At the outset, Scripps was at the receiving end of such a conflict—at Berkeley. The founding group of biologists that came here in the early 1900s are said to have left their department in Berkeley when innovators there decided to invite in Jacques Loeb,[108] who was one of the founders of

[108] Jacques Loeb (1859 – 1924), German-born American physiologist and biologist. Loeb is best known for his work in animal tropisms (a reaction to external stimulus) and their relations to the instincts of learning. He extended

modern biochemistry and was described in the famous novel, *Arrowsmith.*[109] I don't know if you know it?

Harkewicz: Yes.

Arrhenius: He was the Rockefeller man there, and the old-timers at Berkeley were terrified. I mean, he was the man who was going to convert real biology into test tube science. And these real naturalists then decided to make an exodus and to create a place where they could in peace and quiet study the organisms in their proper environment. And that is the people who came to start Scripps.

Harkewicz: I see.

Arrhenius: And that attitude persisted until Wayland Vaughan[110] introduced some concepts of biochemistry and a little of contemporary biology. And then the next big push was Rogers' reshaping of biology at Scripps by sidelining the old conservatives and bringing in a whole new set of people who represented the new biology. Now they are old and many are dead. A few are, however, still in full action with brilliant new ideas like Andy Benson,[111] for example. But what we need now is a continuous source of new ideas. It's happening now in genomics, microbiology and biochemistry, fields of expansion in new directions.

Harkewicz: Do you think you have to bring in new people to have new ideas?

Arrhenius: In the long run, yes, experimental science is technology driven and the young people have training that involves mastering of the new techniques and research strategies. But if you want to keep the institution manageable and small, then you have to have renewal, mainly by replacement of staff members who retired, died, or moved elsewhere.

Harkewicz: So, in the fifty-some years that you've been at Scripps and UCSD . . . ##

Harkewicz: ## So, my last question is, "What do you think has been the biggest change at Scripps in the time that you've been here?"

Arrhenius: I can think of two events of particular importance. One is Roger Revelle's revolutionary reshaping of biology at Scripps. By getting a million dollars, bringing in a visionary like Adriano Buzzati Traverso[112] as a leading person.

---

his beliefs to humans through arguing a philosophy in which ethics are an outgrowth of man's inherited tropisms. Loeb was at the University of California, Berkeley from 1903 to 1910.

[109] Sinclair Lewis, *Arrowsmith* (New York: Harcourt Brace, 1925).

[110] Thomas Wayland Vaughan (1870 – 1952), geologist and Scripps director 1924 – 1936.

[111] Andrew Alm Benson (1917 -), professor of biology at SIO.

[112] Adriano Buzzati-Traverso (1913 – 1983), introduced modern molecular biology to Italy. From 1953 – 1956, Buzzati-Traverso directed the division of genetics at SIO. An international symposium in 1953 on "Perspectives in Marine Biology" provided a master plan for the Scripps biology program that was funded by the Rockefeller

They spent a summer inviting the most important biologists in the world to come here and discuss the fundamental questions affecting marine biology. After that was over, all the intense discussions, wining and dining and appointing, then the million dollars was gone very quickly. That injection of money had brought a whole new crew of people and new ideas and that was a fantastic innovation at the time.

The other big change is the impact of the new campus, with all the viewpoints and influences from the new scientists, scholars in the humanities that have had an immense effect on Scripps and also on me personally, very much.

Harkewicz: So, you think that Roger Revelle reshaped *biology* at Scripps?

Arrhenius: That's right.

Harkewicz: That's interesting because I've read a lot about the fact that physical oceanography was stressed in the postwar period, and the time period you're talking about is the . . .

Arrhenius: Physical oceanographers got a major boost from the military interest continuing through the Cold War. So, they got all the funds and infrastructure support they could use to learn about the structure of the ocean from an acoustic point of view, useful for submarine detection.[113] All of that gave a big boost to physical oceanography. But what Roger saw, in addition, was a major need for modern biology in oceanography. He was very visionary in that respect.[114]

Harkewicz: And that's how you got . . .

Arrhenius: That's the way I got into it because he was aware of my biogeochemical inclination.

Harkewicz: Hmm. Interesting. So, you're still working? How often do you still go into Scripps, on a daily basis?

Arrhenius: Currently, daily, in the morning. I have students and a postdoc to take care of and to get the lab work going. But I was retired for one month.

Foundation (at a million dollars over eight years), which led to innovations in marine biology at SIO (including the provision of a tenured faculty position in biogeochemistry for Arrhenius who had been previously hired as a research staff member.

[113] Arrhenius later added, "The Office of Naval Research was, however, at that time extremely open to any kind of basic research that could, by the most extreme stretch of the imagination, serve national defense interests and basic science. So generous ONR support extended way beyond submarine acoustics to cover, in principle, all aspects of oceanography and beyond."

[114] While editing the transcript, Arrhenius added, "But he was, of course, not alone, Woods Hole has also, traditionally, been a progressive force in this field."

Harkewicz: For a month?

Arrhenius: In January. The first time in my adult life that have been unemployed, but I have since been recalled to active duty.

Harkewicz: Well, it sounds to me like you can still have your new ideas.

Arrhenius: Sure, new ideas come from interaction with people and other people's ideas. So, I'm sure as long as I can interact with people, yes.

Harkewicz: When do you think was the last time you went on a scientific cruise?

Arrhenius: That was a long time ago. Well, if you say "cruise," if you mean fieldwork, the last time was about five years ago when I was working up in Greenland to find traces of the oldest life on earth. That was as adventurous and more strenuous as any expedition on the ocean. But on the ocean, that has been quite a while. That was back in the sixties, I think.

Harkewicz: So, do you have any other interests other than . . .

Arrhenius: Oh yes. Sure. I have to attend much to my wife these days. We read a lot, and music is an important thing in our lives, and human interaction, friends, and colleagues, children and grandchildren. That keeps you wishing for more time.

Harkewicz: Is there anything else that you'd like to add that I've left out?

Arrhenius: Well, it has been a long period of my life that we have discussed here. I could talk for days about my impressions of my life, but I think we have covered much of the aspects that you may be interested in.

Harkewicz: Well, I thank you very much for your time. ##

TAPE GUIDE