Donald E. Knuth
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Introduction

This oral history was conducted by the Stanford Historical Society Oral History Program in collaboration with the Stanford University Archives. The program is under the direction of the Oral History Committee of the Stanford Historical Society.

The Stanford Historical Society Oral History Program furthers the Society’s mission “to foster and support the documentation, study, publication, dissemination, and preservation of the history of the Leland Stanford Junior University.” The program explores the institutional history of the University, with an emphasis on the transformative post-WWII period, through interviews with leading faculty, staff, alumni, trustees, and others. The interview recordings and transcripts provide valuable additions to the existing collection of written and photographic materials in the Stanford University Archives.

Oral history is not a final, verified, or complete narrative of events. It is a unique, reflective, spoken account, offered by the interviewee in response to questioning, and as such it may be deeply personal. Each oral history is a reflection of the past as the interviewee remembers and recounts it. But memory and meaning vary from person to person; others may recall events differently. Used as primary source material, any one oral history will be compared with and evaluated in light of other evidence, such as contemporary texts and other oral histories, in arriving at an interpretation of the past. Although the interviewees have a past or current connection with Stanford University, they are not speaking as representatives of the University.

Each transcript is edited by program staff and by the interviewee for grammar, syntax, and occasional inaccuracies and to aid in overall clarity and readability—but is not fact-checked as such. The approach is to maintain the substantive content of the interview as well as the interviewee’s voice. As a result of this editing process, the transcript may not match the recording verbatim. If a substantive deletion has been made, this is generally indicated at the relevant place on the transcript. Substantive additions are noted in brackets or by footnote.
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In this oral history interview Donald Knuth, Stanford University Professor of the Art of Computer Programming, Emeritus, reflects on Stanford University as the setting for his career in computer science. Topics include the early days of the Stanford Computer Science Department, his writing and work process, and the development of the TeX system. He also discusses his campus home, his views on the relationship between science and spirituality, and his recent composition for organ, Fantasia Apocalyptica.

Knuth discusses the emergence in the 1960s of the new discipline of computer science, with its own concepts and language, and describes Stanford’s Computer Science Department (CS) at that time, one of the first in the country. Recruited to Stanford by George Forsythe in 1968, Knuth deferred for one year “to finish writing his book.” He laughingly admits that fifty years later he is still writing that book, The Art of Computer Programming. He speaks warmly about his close collaboration with fellow computer scientist Robert Floyd, who came to Stanford at the same time he did, in a “package deal.”

When CS moved to the School of Engineering in 1986, Knuth says he was one of the main holdouts, as a pure scientist interested in the theoretical aspects of the field. Though he very much enjoyed teaching, he indicates that he retired officially in 1993 because he believed he could contribute more to the world by writing his books, and book sales were already bringing in a sufficient income.

Describing himself as a “geek,” Knuth suggests that geeks, with brains that organize information in a way that resonates with what we now call a computer, make up only a small percentage of the world’s population. A recipient of many honorary degrees and prestigious awards and prizes (including Abel, Turing, Kyoto), he donated the large monetary prizes to charitable organizations.

Knuth discusses his personal experiences with anti-Vietnam War protests on campus in the 1970s and his admiration for university president Richard Lyman’s handling of the disruptions. He and his wife Jill developed the layout for their campus home, with a room
for Jill’s art projects and a room for his music, where eventually a custom-built pipe organ was installed. He explains that he felt driven to write a single, major piece of music for pipe organ based on the biblical book of Revelation. That piece, Fantasia Apocalyptica, premiered in Sweden on his eightieth birthday in January 2018.

Knuth discloses that writing has always been very important to him. As he worked on successive chapters of The Art of Computer Programming, the printing industry changed to the point where he says that his galley proofs “made him sick,” so he altered his life plan to work on digital typography, putting the system he developed, called TeX, into the public domain.

Knuth reveals that when he is writing he sits in the “perfect Dux chair” that he has owned since 1970, crossing out in pencil on paper, then later goes to his stand-up desk, wearing Sensi sandals, to enter text into the computer, editing as he types. He notes that he bikes to a campus pool four days a week, and as he swims laps he can often work out problems that he’s been wrestling with in his writing.

In addition to being a computer scientist, Knuth expresses the importance of the spiritual side of his life. He discusses his love of history and his exploration of original source materials in multiple languages in order to help him understand the process of scientific discovery.

Knuth also reflects on chairing the Computer Science Department’s graduate admissions and curriculum committees, the influence of the Stanford Library Associates group, the beauty of the campus and his pleasure walking or biking through it, the large expansion of the department to almost sixty regular faculty members, and the valuable synergy between Stanford and Silicon Valley.
Donald E. Knuth
Biography

Donald E. Knuth was born on January 10, 1938, in Milwaukee, Wisconsin. He studied mathematics as an undergraduate at Case Institute of Technology, where he also wrote software at the Computing Center. The Case faculty took the unprecedented step of awarding him a master’s degree together with the BS he received in 1960. After graduate studies at California Institute of Technology, he received a PhD in mathematics in 1963 and then remained on the mathematics faculty.

Throughout this period he continued to be involved with software development, serving as consultant to Burroughs Corporation from 1960-1968 and as editor of programming languages for the Association of Computing Machinery (ACM) publications from 1964-1967. He joined Stanford University as professor of computer science in 1968, and was appointed to Stanford’s first endowed chair in computer science nine years later. As a university professor he introduced a variety of new courses into the curriculum, notably Data Structures and Concrete Mathematics. In 1993 he became professor emeritus of the Art of Computer Programming. He has supervised the dissertations of twenty-eight students.

In 1962 Knuth began to prepare textbooks about programming techniques. This work evolved into a projected seven-volume series entitled *The Art of Computer Programming*. Volumes 1-3 appeared in 1968, 1969, and 1973. Volume 4A appeared in 2011, and he is now working full time on the remaining volumes. More than one million copies have already been printed, including translations into nine languages. He took ten years off from this project to work on digital typography, developing the TeX system for document preparation and the MF system for alphabet design. Noteworthy byproducts of those activities were the WEB and CWEB languages for structured documentation, and the accompanying methodology of Literate Programming. TeX is now used to produce most of the world’s scientific literature in physics and mathematics.
Professor Knuth’s research papers have been instrumental in establishing several subareas of computer science and software engineering: LR parsing, attribute grammars, the Knuth-Bendix algorithm for axiomatic reasoning, empirical studies of user programs and profiles, and analysis of algorithms. A series of nine volumes containing archival forms of these papers was completed in 2011. In general, his works have been directed towards the search for a proper balance between theory and practice.

Professor Knuth received the ACM Turing Award in 1974 and became a Fellow of the British Computer Society in 1980, as well as an Honorary Member of the Institute of Electrical and Electronics Engineers (IEEE) in 1982. He is a member of the American Academy of Arts and Sciences, the National Academy of Sciences, the National Academy of Engineering, and the American Philosophical Society, as well as a foreign associate of l’Académie des Sciences (Paris, France), Det Norske Videnskaps-Akademi (Oslo, Norway), the Bayerische Akademie der Wissenschaften (Munich, Germany), the Royal Society (London, England), and the Russian Academy of Sciences (Moscow, Russia).

He holds five patents and has published approximately 160 papers in addition to his twenty-five books. He received the Medal of Science from President Jimmy Carter in 1979, the American Mathematical Society’s Steele Prize for expository writing in 1986, the New York Academy of Sciences Award in 1987, the JD Warnier Prize for software methodology in 1989, the Adelsköld Medal from the Swedish Academy of Sciences in 1994, the Harvey Prize from the Technion in 1995, the Kyoto Prize for advanced technology in 1996, and the Frontiers of Knowledge award for communication and advanced technologies in 2010. He was a charter recipient of the IEEE Computer Pioneer Award in 1982, after having received the IEEE Computer Society’s W. Wallace McDowell Award in 1980. He received the IEEE’s John von Neumann Medal in 1995 and the Institute of Engineering and Technology’s Michael Faraday Medal in 2011.

He holds honorary doctorates from Oxford University, the University of Paris, the Royal Institute of Technology in Stockholm, the University of St. Petersburg, the University of Marne-la-Vallée, Masaryk University, St. Andrews University, Athens University of Economics and Business, the University of Macedonia in Thessaloniki, the University of
Tübingen, the University of Oslo, the University of Antwerp, the Swiss Federal Institute of Technology in Zürich, the Armenian Academy of Sciences, the University of Bordeaux, the University of Glasgow, and nineteen colleges and universities in America (including Brown, Dartmouth, Pennsylvania, and Harvard in the Ivy League). “Minor planet (21656) Knuth” was named in 2001.

Professor Knuth lives on the Stanford campus with his wife, Jill. They have two children, John and Jennifer. Music is his main avocation.
Schofield: Today is May 8, 2018. I’m Susan Schofield with the Stanford Historical Society’s Oral History Program. I’m in the home of Donald Knuth and I will be interviewing him today for our Faculty Oral History Project. Don, your CV lists numerous prior interviews that describe your prolific career as a world-renowned computer scientist. A lot of that information about you is already in the public domain and we’ve agreed that the primary focus of this interview will be your experiences specifically at Stanford--influences and observations of the university where you have spent your past fifty years. If you don’t mind, please start with just a very brief, pre-Stanford personal history to set the stage for those who might be listening to or reading this interview.

Knuth: [00:01:03] Hi. If you hear beeping in the background, that will be some construction trucks that we hope don’t have to move too often today.

I was born in Milwaukee, Wisconsin, in 1938. I have just celebrated my 80th birthday. I went to college in Cleveland--undergraduate at Case, now called Case Western. I did graduate work at Caltech [California Institute of
Technology in Pasadena, California]. At Caltech, I was a math major. Of course, there was no such thing as a computer science major in those days. Computer Science was actually pioneered largely at Stanford.

At Caltech, I was doing computer science off the record or in my spare time. I stayed on the faculty at Caltech after I graduated. I got my PhD in 1963 and I was in the Math Department. I was also working as a consultant to Burroughs Corporation, which had a big division of software writers in Pasadena. My computer science life then was mostly nonacademic, through editorial work and consulting at Burroughs, though I taught a few classes at Caltech. I visited Stanford for the first time probably in 1964. George Forsythe [George Elmer Forsythe] was inviting everybody who dealt with computers to Stanford. Computer Science was in Polya Hall, one of the Eichler buildings on campus, and it didn’t look like an office building. I thought I was in the wrong place. After half an hour, I figured out where to go.

Schofield: George Forsythe then was chairing the computer science part of Mathematics?

Knuth: [00:03:27] That’s right. The department was officially launched in 1965 as a separate department. I’m told that starting at the beginning of 1962, there was a Computer Science Division of the Math Department. That’s when Ed Feigenbaum and John McCarthy were hired--I think McCarthy was the first full professor of computer science. George was going around trying to corner the market on people because he had the vision that computer science would eventually exist, and he was giving talks all over the country explaining
why this was going to happen. It was a very radical idea at the time. I, myself, had no idea that computer science would ever be an academic discipline.

**Schofield:** How did you see it if not as a discipline?

**Knuth:** [00:04:36] I saw it as something that people did when they wanted to. That’s a good question. I always thought of it as fun.

**Schofield:** Fun. Maybe a tool, but not a discipline?

**Knuth:** [00:04:53] Well, I got paid for doing it. But I didn’t realize that it had its own vocabulary and problems that were of interest in their own right. I started to understand its importance only after having discussions with other people, which I realized we couldn’t have had unless we’d had several years of experience with these concepts. The concepts were so natural to me that I didn’t think of them as revolutionary or different or something that a student would learn. In retrospect, I probably was blind, but George saw it right from the beginning. At the time though, I think very few people had the foresight of George Forsythe.

**Schofield:** The foresight of George Forsythe. That’s good.

**Knuth:** [00:05:53] Anyway, I gave a lecture in the weekly seminar series [here] and then George tried to get me to join the faculty. He wrote me a letter--somewhere in my files, I can find the letter where I replied to him, saying: I love Stanford. I really enjoyed my visit here but I have to finish writing my book first. So give me another year.

**Schofield:** And this book was?

**Knuth:** [00:06:27] This was the book *The Art of Computer Programming*, which I’m still only half done writing. [laughter]
Schofield: At that point, you had a misguided notion that it could be done in a year?

Knuth: [00:06:36] I thought that I would have it done by the time my son was born. We were expecting a child in the summer of 1965, and so I figured okay, I'll work really hard and get the book out. [Laughter] Seriously, I have that letter and I believed it at the time. One of the recurring themes of my life is that I'm a terrible estimator of how long things are going to take. I never know how much time it's going to involve in order to get something done right. Maybe that's been a blessing. Maybe it's been a curse. But it's certainly been a factor in my life all the way through.

Schofield: It's dominated the way you've approached your writing and what have you?

Knuth: [00:07:24] Yes. If I had any idea how much was going to be discovered in computer science--by the end of 1966 I had 3,000 pages of handwritten draft for the book and I thought it was just going to be a matter of typing them up and getting them out. Anyway, my first contact with Stanford was to turn down an offer saying give me some time--and then when I'm ready to make a move, I’d like to come somewhere where I have tenure and I don’t have to think about moving more than once in my life. [laughter]

Schofield: That part worked out.

Knuth: [00:08:18] Yes. George was always on everybody's case to accept. When I did come to Stanford--

Schofield: In 1968?

Knuth: [00:08:35] My appointment went through the advisory board in February of 1968. The first volume of *The Art of Computer Programming* came out in January
of 1968. I was only thirty years old. There was a little hesitance at making a full professor of a thirty-year-old guy. I was five years out of my PhD.

Schofield: Pretty young. [laughter]

Knuth: [00:09:17] Then they saw the book, and George said everybody was all smiles. My job offers from Harvard and Berkeley had already come through some months before Stanford. I don’t know who had the higher standards [laughter] but I always joke that Stanford raised the standards after I came. Anyway, the fact is, Stanford was the one I was hoping to get, because George Forsythe was here. At Stanford, I could come to be one of the boys. I could come and do computer science. If I went to Harvard, I’d have to spend more than half my time explaining to Harvard why computer science was necessary and justifying computer science because I would have been one of only two or three people at Harvard. I would have had a huge responsibility to--

Schofield: To create the department in a way?

Knuth: [00:10:31] Right, right, to make it go. Also, I had an offer to stay at Caltech and develop computer science there.

Schofield: Did Berkeley, at that time, have a computer science department?

Knuth: [00:10:41] It had a division; Beresford Parlett was the chair. He was so kind even when I declined the offer, he said, well let’s make some agreement so you come visit us as often as you can and so on.

Schofield: Talk a little bit about the culture of computer science when you did get here. It had been already made into a small department. What’s the culture like?
My understanding is that at the beginning, it wasn’t just academic computer science but it was also running Stanford’s computer center.

**Knuth:** [00:11:35] It was--Feigenbaum was the director of the computer center and the computer that students used was in Pine Hall, which was right next to Polya Hall.

**Schofield:** I remember well. I was here in those years.

**Knuth:** [00:11:51] Yes? Well you were a student when those buildings were built I guess.

I’m getting off the track, but I remember one of my few trips to Stanford, probably in the spring of 1967, meeting Feigenbaum in his office as the director of the computer center and I was touting Niklaus Wirth’s accomplishments and trying to explain why he should get a promotion or something. When I joined the department, there were I think ten to a dozen faculty and we had several dozen grad students. When I visited in spring of 1967, I spent a lot of time with the students.

I remember Sue Graham [Susan Lois Graham] was one of the very prominent grad students here. She went on to become a distinguished professor at Berkeley. She was working with Wirth--“Veert” is the pronunciation in Switzerland and “Wurth” in America. He was a junior professor at that time. It turned out I was his replacement and he became a full professor at ETH in Zürich [Eidgenössische Technische Hochschule Zürich], the first professor of Computerwissenschaften in Europe. The senior faculty when I came were John McCarthy, Ed McCluskey [Edward J. McCluskey], Bill Miller [William F. Miller], George Forsythe, Jack Herriot
[John G. Herriot], and Gene Golub [Gene H. Golub]. Maybe Gene was still associate professor but certainly Bill Miller was full professor and McCarthy. I never kept much track of those ranks.

At Caltech, I had tenure before I knew what tenure was. Quite seriously, I often told my advisees that they shouldn’t worry that much about tenure because worrying can only hurt them. If they deserve tenure, they’ll get it and if they don’t, they shouldn’t spend time worrying about it.

**Schofield:** I wonder if that reassured them? [laughter]

**Knuth:** [00:15:11] I read in the paper while I was at Caltech that a certain person had not gotten tenure at UCLA, and I said to the man who had been my thesis advisor, and was now chair of the department—“Marshall, what does that mean that he didn’t get tenure?” The answer was, “Well, Don, you remember the last time you got your appointment papers from Caltech, and there was a line on there that said the date of termination, and that line was empty? That’s tenure.” [laughter] I didn’t pay much attention to rank. We had junior professors then—Jerry Feldman [Jerome Feldman], Klaus Wirth, who I mentioned, Joyce Friedman, and oh gosh, there must have been some others. We were split into four different places on campus. John McCarthy’s AI lab was up in the hills at the so-called D.C. Power Building, named after Donald C. Power. Feigenbaum had a group that was on Welch Road. Bill Miller’s group was up at SLAC [SLAC National Accelerator Laboratory]. Forsythe and my part of the department were in Polya Hall. He had to shoehorn the department onto existing Stanford property, and in order to finance it, he had to get lots of people supported by soft money. You only have a certain
percentage of a billet or something like that, or a joint appointment with
some other department. I don’t know all the details, but I know Joyce
Friedman worked in Linguistics.

Schofield: With a joint appointment in Linguistics and [Computer Science].

Knuth: [00:17:40] Probably. We were in the School of Humanities and Sciences,
under--

Schofield: Was Halsey Royden [Halsey L. Royden] the dean then?

Knuth: [00:18:13] No. it was--he went on to be provost.

Schofield: Oh, Al Hastorf [Albert H. Hastorf].

Knuth: [00:18:32] Hastorf, yes. He was in Psychology. He was studying the Terman
generation.

Schofield: Yes, yes.

Knuth: [00:18:39] Hastorf was our dean at that time. As he retired after being
provost, I remember he said, “Boy, if I knew when I was dean what I know
now, I would have really been a much better dean. I would have known what
I could get away with.” [laughter] Royden, yes, became our dean some time
in early 1970s [1973]. I got to know him when I was on the H&S
Appointments and Promotion Committee during the 1970s.

Schofield: How was that?

Knuth: [00:19:19] It was wonderful to meet the other professors. Also I enjoyed
being part of a university where we don’t have just computer science but we
have music and we have, of course, physics and chemistry and biology and a
medical school. I served also on the university’s Advisory Board with people
from the medical school like Bob Chase [Robert Chase] and Ken Arrow [Kenneth Joseph Arrow].

**Schofield:** Maybe we can come back to that later.

**Knuth:** [00:20:00] Yes, on the Appointments and Promotions Committee, I would enjoy going and actually looking at the papers of the candidates and checking the references carefully. I was probably overly aggressive, making department chairs work harder than they would have had to. We sent at least one set of papers back and the faculty of that department were pretty angry, but I don’t think they had done their homework.

**Schofield:** But they did ultimately do their homework and the papers came back and you were able to approve it?

**Knuth:** [00:20:40] Yes, right. I took my job seriously but I also enjoyed very much getting to know people from other departments. We would meet at the Faculty Club at the members’ table occasionally. Being part of a university has always been one of the joys of being at Stanford.

**Schofield:** I think there are only a few obvious ways in which that kind of intersection happens--as you say, on something like an Appointments and Promotions Committee, on the Faculty Senate, on the Advisory Board, where, by structure, people are being brought in from all the different divisions and schools.

**Knuth:** [00:21:28] Right. People of our department meet people from other departments mostly if they happen to be our representative to a university board like the senate or something like that. There are people who do joint research, for example with medical school people or biologists. Committee
work was much more useful for me. I kind of bemoan the way Stanford grows and the workload goes up so it becomes harder and harder to fit in being a university person as well as a department person. I went to Lyman’s [Richard W. Lyman] funeral and maybe only two or three other people of our faculty were there. It’s just become much more insular now than it was then.

Schofield: I think it has. I think you’re right. I get that sense from a few people who’ve been here the longest. It might have something to do with the strengthening of professional loyalties that are now international, drawing loyalties maybe a little bit away from the university.

Knuth: [00:22:52] From the computer science viewpoint, I would say it’s mostly due to the workload—the fact that we’re drowning in students and we want to do our best for them, and also the field is changing so fast. Other fields are changing rapidly too, computer science is really accelerating. We want to keep ahead but we have to spend an awful lot of time just treading water. The amount of time for other contacts is limited. You recall Stanford had this “submit your big ideas” exercise last year. Next month or soon they’re going to announce winning submissions. I submitted something that was a small “big idea” but it was intended to promote inter-university--

Schofield: Citizenship?

Knuth: [00:23:56] --by having something I called Stanford 101, which meant “one-on-one,” university subsidized one-on-one lunches between people at Stanford who had never met each other before. There would be an app that would schedule these things and print out a ticket for the Faculty Club--
Schofield: You are going to go have lunch with this person here.

Knuth: [00:24:24] Yes.

Schofield: I think it’s a fascinating idea.

Knuth: [00:24:26] We’ll see if anybody ever picks it up.

Schofield: If it makes the cut.

Knuth: [00:24:29] Yes. The things that make the cut are things that actually are, you know, we’re going to solve the housing crisis, or something.

Schofield: Big ideas that maybe other things could cluster under.

Knuth: [00:24:48] Anyway, I do feel strongly about trying to improve the community at Stanford. I’m a visiting professor at Oxford and I tend to go there maybe one week a year. During that week, I’ll have lunch with four people I’ve never met before who are fascinating. And we both enjoy the experience.

Schofield: You arrange those?

Knuth: [00:25:15] Well, I arranged the one with the editor of the Oxford English Dictionary. I invited him to my college for lunch. But mostly I just sit at a random table at my college and I’ll meet somebody there.

Schofield: Which Oxford College is it?

Knuth: [00:25:36] Magdalen College [pronounced “Maudlen”]. Sometimes I’m unlucky and I get a lawyer, but most of the time it’s somebody very interesting [laughter]--no, even the lawyers are okay. [laughter]

Schofield: Let’s go back to the culture and trajectory. Computer Science then moves into the 1980s and it’s getting bigger and probably has more faculty. Then a decision comes to move it out of Humanities and Sciences and into the
School of Engineering and to start an undergraduate major, which is big, obviously. Talk a little bit about that and how you saw it.

**Knuth:** [00:26:08] During the 1970s, we had entirely graduate students and that was a conscious decision. We felt that Computer Science wasn’t mature enough yet to offer enough things for an undergraduate that would give them a proper education by the time they had their degree. We could give them a bunch of courses that we thought were important but still we thought, much better to be a math sciences major or something like that; math sciences was a combination of different kinds of applied mathematics.

It is very important for student programmers to understand mathematical principles because you have to be able to understand the idea of what it means for something to be correct and provable. We felt that the courses we were teaching were good but there weren’t enough of them to really provide a decent general education for students.

**Schofield:** And the faculty, at that time, was pretty much all in agreement? Or was there any disagreement around that?

**Knuth:** [00:27:43] Oh yes, a hundred percent. We saw undergrad majors offered in other colleges that we’d visit and we weren’t impressed by what was happening. We didn’t think that was working well. Of course, ten years is a long time in computer science. We did mature. [laughter]

**Schofield:** Now you make it into the 1980s and--?

**Knuth:** [00:28:13] I guess I should actually mention this. It’s kind of an amazing thing. Stanford had one of the very first computer science departments--
1965. By 1975, every university had a computer science department. It went from zero to one hundred percent in ten years.

**Schofield:** Around the country?

**Knuth:** [00:28:49] Yes. I believe the reason was that there’s a certain kind of mental structure that people like me have. If I had to give one word for it, I would call it “a geek.” That oversimplifies it but let’s say that two percent of the world’s population is geeks, all right, and that this has been true for hundreds of years, that there’s something about the way people grew up or how the brain organizes information or whatever it is that makes them resonate with what we now call a computer. I can read things written in the nineteenth century by somebody and say, he would have been a great computer programmer.¹ Let’s suppose this as a hypothesis, that there exists a certain small percentage of the world that are geeks. Those who were in universities before 1965 would find themselves in different departments. Some of them would be mathematicians. Some of them would be physicists. Some of them would be lawyers.

**Schofield:** Statisticians maybe?

**Knuth:** [00:30:01] Right, whatever. Chemists, mostly doctors I suppose, but poets, whatever--they would still be really geeks. Anyway, computer science started to exist and the geeks finally had a home.

**Schofield:** It was like a magnet. It attracted?

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¹ Note from Don Knuth: Lord Byron’s daughter Ada Lovelace was arguably the first programmer.
Knuth: [00:30:19] They could meet other people who laughed at the same jokes that they did, understood the same analogies that they did, instantly communicate more effectively with other geeks, and they had a home.

Schofield: You’re saying it’s more intrinsic than taught?

Knuth: [00:30:45] Yes, absolutely. You don’t just say okay, now there are good jobs in computer science, so okay, I’m going to learn it. You have to be a geek. That’s my opinion. It’s borne out by every project I see that has failed; it’s because the people who were in these projects weren’t really geeks. [laughter] It’s a controversial opinion now. Some educators say no, people just aren’t motivated enough. But they’re geeks. I think they [the educators] don’t understand what it means not to be a geek. On the other side, I know aspects of other sciences that I’ve tried very hard to learn and I’ve failed. I know that I would need a different kind of a brain if I were really going to be good at quantum mechanics, for example. I’ve tried hard, but I just don’t get it.

Anyway, this accounts for why computer science departments went from zero to a hundred in ten years. It was because of this phenomenon that people came together and they knew that it was a discipline where they had their own concepts that were of importance—not as applications to physics and chemistry and other things but also as applications to computer science. People like me began to know that this kind of knowledge deserves to exist. As I said, in the early 1960s, I didn’t realize I was a geek. I didn’t realize that there was this body of knowledge. But Forsythe did, and I came here. I was probably 110 percent geek, I don’t know, but certainly it was very strong for me, and not exactly the same in any two people.
Computer science was evidently an instant success. Not, however, because of the economic importance of computer science or things like that. It was because of the skill set that people had. They realized that they could use their skills and develop the ideas further.

The next stage was that every university had computer science. But sometimes it was in the Business School, sometimes it was in the Engineering School, sometimes it was in H&S, as at Stanford. A few places like Purdue and Carnegie had started Schools of Computer Science by the 1970s.

Schofield: Does anyone have that now--Computer Science separated as an entire school?

Knuth: [00:34:12] Yes, yes. Certainly it’s thrived at Carnegie, and Purdue I think later had one. Waterloo in Canada, and others. Some of our faculty have said, why don’t we leave the Engineering School and start a School of Computer Science at Stanford; computer science is starting to become joined to all kinds of other things. I said, boy, how to win friends and influence people is by telling people that we’re really so important that we’re going to start our own school. Yet it has happened at other places.

By the 1980s, the majority of our faculty had been trained at computer science departments that were part of an engineering school. They understood what it was like to be part of an engineering school. I personally didn’t. I’d been in Mathematics and H&S at Stanford. The strongest factor was that at Stanford, Engineering had to compete with the other engineering schools of the world and so it needed to have its computer science
department too. Stanford’s School of Engineering was trying to match brownie points or something with every other engineering school. People asked, well what do you do in computers. Stanford had been hiring faculty to be in the Computer Systems Laboratory as part of the Electrical Engineering Department. Students applied to that, got admitted and so on. We had one or two joint faculty. There were a couple of cases where people didn’t get tenure because they had to be approved by both schools.

Schofield: And both departments.

Knuth: [00:36:36] Anyway, by and large, during the 1970s, we said oh, we’ve got two groups of computer scientists at Stanford; let’s use that to our advantage. If we can’t get something through one dean, we’ll get it through the other. We’ll get the job done.

However, it turned out later that we found that we’d be forever competing for resources if we had two groups at Stanford, so we had better decide which way it was going to go. It was much better to go to the Engineering School because the majority of other universities in the world, by that time, had computer science in engineering. Stanford was an oddball, still having it in the same school as mathematics and physics.

Schofield: I can see why Engineering wanted it, and felt they needed it. Was it problematic to Humanities and Sciences to give it up, or did they just sort of see that that was logical?

Knuth: [00:38:04] I wasn’t involved with that. Jim Rosse [James N. Rosse] is gone. We can’t ask him. Certainly Jim Gibbons [James F Gibbons, Dean of
Engineering] is here and Nils Nilsson [Nils John Nilsson] was hired at the
time to manage this transition.

Nils was a senior researcher at SRI [Stanford Research Institute] and
had written substantial textbooks. Actually he’s also the best email writer of
anybody I’ve ever met. This takes a special skill, and Nils was one of the
pioneers of potential Pulitzer Prize-winning email style. It’s very difficult if
you’re composing email to avoid flaming or to get your emotions across
properly. He was a master at communication. I just wanted to bring that up
now because--

**Schofield:** You might forget later?

**Knuth:** [00:39:28] Yes, and he deserves it.

I suppose, in a way, I might have been perceived as one of the main
holdouts for H&S because of all our faculty, I’m probably the least interested
in Wall Street, you know, in the economic potential of computer science. I
put my computer programs in the public domain. I’ve never had the slightest
intention of starting a company. I love the fact that people use computer
programs, but I’ve never understood why they pay for them, or why anybody
pays for anything. Really, I’m no good at financial questions of any kind.

Anyway, I was always interested in the theoretical rather than the
moneymaking aspects of computer science. Of course, on the other side,
people say that when there’s economic competition, then that makes people
think harder and you get feedback as to how good your ideas are because
people will buy it or they won’t. That’s important.
I was always trusting in people’s good intelligence to decide what’s good and bad instead of their pocketbooks. I’m not sure how many other people on the faculty were pure scientists as I was, but I was certainly one of the ones that had to be convinced if we were going to go into the School of Engineering. I definitely became convinced when I realized that the competition between the two groups was hurting Stanford and Stanford’s engineering school. And I said well gosh, that’s going to go on for years and years unless we move.

**Schofield:** Very shortly after that move, then the department makes the decision to begin an undergraduate major. That starts an onslaught of undergraduate students.

**Knuth:** [00:42:16] It began slowly. I think we had eight majors the first year and sixteen the second year and thirty the third year. I don’t think it doubled regularly. It grew slowly at the very beginning; we were feeling our way but also we were getting better at teaching it. The early students had no other peers saying this was a cool major to do. Now it’s too much the other way. The students who want to major in English are hearing other people in their dorm telling them they’re stupid for doing that. This has caused tremendous anxiety to the English professors at Stanford and I think it’s a terrible shame that peer pressure is part of the fact that we have so many majors, peer pressure and parent pressure.

**Schofield:** And parental pressure, I agree. CS is seen as a quick way to a good job.

**Knuth:** [00:43:32] If someone’s born a geek, then they definitely should major in computer science. There’s a huge need for these talents. If you’re doing it not
because you really are going for the degree, but you only say well, this is necessary in order to have the lifestyle I want or something like that, that’s not a way to choose a career in my opinion, nor a major.

**Schofield:** You are not still involved in undergraduate teaching, are you?

**Knuth:** [00:44:12] I’ve been retired--

**Schofield:** Since 1993 I think.

**Knuth:** [00:44:14] Since 1993 officially. But unofficially, I went on leave of absence in 1990. I told Nilsson in 1989 that I was going to go on leave of absence after a year because I had just gone through a whole year where I felt I had made only one day’s progress on the *Art of Computer Programming* during 365 days.

So I said, you know, this is not the way I want to live the rest of my life. I can be a good teacher and do all these other things I’m doing at Stanford, like raising money, but really I can contribute more to the world by writing these books. And I don’t need the salary, so why shouldn’t I retire?

**Schofield:** Were the books generating income that made you not really need the faculty salary?

**Knuth:** [00:45:34] Oh, it’s like an oil well. As we speak, somebody’s buying one of those books. How many, I’m not sure. The book that came out in 1968, that made the faculty all smiles, is in its fortieth printing of the third edition and it probably sells ten copies every day.

**Schofield:** Oh my goodness. And it’s been translated into multiple languages I’ve seen.

**Knuth:** [00:46:23] That’s just in English. There’ll be three thousand English copies sold a year. That’s not quite ten per day, but anyway, it gives me approximately $100,000 a year of royalty income.
Schofield: That's pretty rare for an academic book. [laughter]


Schofield: You probably didn’t expect it either did you?

Knuth: [00:46:51] That was never a motivation. I wrote it because I saw the need for it.

Schofield: Let’s wrap now on the department. You had graduate students, obviously.

You supervised some doctoral students and once there was undergraduate teaching--you did some undergraduate teaching. Did you teach the introductory course?

Knuth: [00:47:23] I taught the introductory course maybe in 1970-1971. It was a different introductory course; it was a three quarter sequence actually. I guess I taught it maybe three years altogether. We would start out with basic things and then the third quarter we would actually have a project like a term paper for students and we’d get into more advanced subjects.

I introduced another course into the curriculum called Concrete Mathematics in 1970 and I taught that, oh, ten times. We had guest professors teaching it sometimes. That course became a book as well. It was the kind of mathematics that wasn’t being taught in the Math Department. It was very useful for computer scientists to know. A lot of math majors took the class also.

Schofield: Did you enjoy teaching?

Knuth: [00:48:34] Oh absolutely. Yes. I’d love to talk to you more about teaching.

When you said we’d wrap, I was wondering if you meant R-A-P or W-R-A-P.

Schofield: W-R-A-P is what I was thinking.
Knuth: [00:48:48] You know, we can rap about it. Most of my classes after the mid-1970s were in Skilling Auditorium where we had TV cameras in the room so it could be broadcast. But also I could use this to have students do a lot of the talking. Now one of the big trends is to have what they call the inverted classroom. I was doing that all the time at Stanford. I was always assuming students could read the book outside of class but in class we’re going to talk--we’re going to work as a team solving problems. I wanted all the students to be participating as if it were a language class or something.

I had the rule that no student could talk more than three times in an hour. Instead of putting a minimum on the number of times a student spoke, I put a maximum because that would force the others to talk. The loquacious ones, if they had something really important to say, I said, tell it to your neighbor and have them say it. I wanted to get everybody involved. The point of that was to learn how to recover from making mistakes and to understand the kind of things you can’t put in a textbook. When you’re solving a problem, what skill set do you need for that and how do you recover from errors?

Schofield: When you go down a little bit of a blind alley, how do you come back?

Knuth: [00:50:47] Yes, exactly. That was the point of it, that there wasn’t enough education on that. I really enjoyed my classes because I wouldn’t know what mistakes people were going to make, or what mistakes I was going to make. Some questions came up that I couldn’t answer. Okay, then I would report back the next time.
Students didn’t have to spend all their time taking notes as they did in other classes. I had my TAs writing up notes of all the discussions that were going on and these would come out a day later, so the students would be free to participate in the discussion.\(^2\)

I really enjoyed teaching and I think I had a successful style. I never had a hundred students in the class. I would have more than fifty and, in such cases, you know, everybody couldn’t participate. But I would say, today all the people wearing yellow, or grey, or something else, will participate; or all the people in the back row will participate. [laughter] I’d choose some subgroup of the audience [to be the participants]. That was always the focus of the class, to do something that’s not in a book.

**Schofield:** When you retired early, was teaching one of the things you missed? Or did you keep teaching after retirement?

**Knuth:** [00:52:30] I didn’t keep teaching regularly, but I would do guest lectures, and still do--two weeks ago, I spoke to the theory students at lunch. Every quarter I give a lecture to all the theory students and I give occasional guest lectures in other Stanford classes.

**Schofield:** That keeps you sufficiently in touch?

**Knuth:** [00:52:59] I also have lunch with the students every Thursday.

**Schofield:** You have lunch with computer science majors every Thursday?

**Knuth:** [00:53:09] Yes.

**Schofield:** Anyone who wants to show up?

\(^2\) Note from Don Knuth: I had started to teach this way already at Caltech in the 1960s. My motivation actually came from Stanford’s famous math professor, George Polya. One of his Stanford class sessions was made into an inspirational film, entitled “Let us Teach Guessing.” That movie changed my life. I think people can still watch it.
Knuth: [00:53:11] It’s a weekly meeting. We have weekly talks at lunch. We used to call it the *Algorithms for Lunch Bunch* but it’s a tradition that goes back fifty years.

Schofield: How many kids show up?

Knuth: [00:53:28] We have free food so actually [laughter] it’s usually standing room only.

Schofield: Where there’s food, the students will find it. I’m thinking of another, Stanford-related question--you arrive in 1968 and this is the time of upheaval on college campuses, Stanford included. There are riots. There are windows being broken, et cetera. You’re pretty young yourself. You’re barely past student age. How do you see that? How do you participate or what have you?

Knuth: [00:54:16] In the first place, I really came in 1969, not 1968. I was on leave of absence the first year. This was negotiated because I wanted to do a year of national service. I was in Princeton that year working for the Institute for Defense Analyses, which is one of the main subcontractors for NSA [National Security Agency]. I was working on cryptography--breaking codes.

I was under very high security clearance and I’m still not allowed to tell my wife what I did that year.

Schofield: So you’re certainly not going to tell the microphone what you did that year.

Knuth: [00:55:00] No. It’s kind of strange that somebody changed my Wikipedia biography during the last twelve months to have a whole paragraph about my working for the NSA in 1968, as if this was a big part of my life. It wasn’t, and I’m not sure why that got magnified or why it’s important to people. Anyway, during that year, I met a lot of very smart, great people and I wasn’t ashamed of breaking codes. I think people do have a right to secrets; but I think it’s still important to do what we can in order to know if people can
break our own codes, for example. My work involved a lot of computing, at
the limit of what's possible using computers.

I knew that I was born to be an educator. I didn’t like keeping
secrets. I knew that government work would not be a career move for me.
But I wanted to do something, because I had been deferred from the draft
and I had been given the privilege of living in a country where I didn’t have
to go to war and defend my house and things like this that other people did. I
thought okay, I can give back in this way. I arranged then to do that work for
a year before coming to Stanford.

Meanwhile, I was there in Princeton. People asked where are you
from, and I said Stanford. They said, oh isn’t that where the students just
burned down such and such? I said, well, I don’t really know, I’ve never
actually been to Stanford. That year I did visit Columbia, when there were
riots going on one day and the students tried to destroy the computer.

At the place where I worked on the Princeton campus, students once
surrounded the building. The administrators took away the guns from the
security guards, very wisely. [laughter] This was before Kent State, which
happened after I got to Stanford. I came to Stanford then and the first year I
was there was 1969 and Ken Pitzer [Kenneth Sanborn Pitzer] was the
president. I never really got to know him but I saw him on commencement
day when there was smoke visible in Encina Hall behind Frost Amphitheater
where we had the commencement. He was a broken man. He had aged ten
years in one year through this; I guess he was a chemist. This was a terrible
time when all kinds of people were coming from off campus to start these
protests because Stanford was an easy target. Other places were well protected and so we had to have the sheriffs and crowds here. There was a sign where Starbuck’s is now on El Camino, “Buy your guns here.” Do you know El Camino on the other side of Stanford Avenue?

Schofield: I know exactly where you mean. That was a gun store?

Knuth: [00:59:04] Yes, it was a gun store. Later I think you could buy barbecues and stuff there, right, but it said “guns” in big letters.

When I arrived in 1969 Nixon was our president. Of course I was opposed to the Vietnam War and the way things were going. Spring quarter of my first year here was kind of a loss, because there was pretty much a boycott of classes for a long time.

Schofield: That would be spring 1970.

Knuth: [01:00:10] Spring 1970--April was the beginning of spring quarter and we actually kept our classes going but all kinds of things were happening. Teach-ins they called them, about the truth of what’s going on that we’re not being told. At the beginning of my classes in spring quarter, I would write a square root sign on the blackboard. This is a radical sign [in mathematics]; I'm saying, my sympathies are with the radicals but for the next hour, we’re going to talk computer science, okay.

The last straw came the day that Nixon invaded Cambodia. On that day I didn’t go to class. I picketed Pine Hall. Bob Floyd [Robert W Floyd], my colleague, and I were sitting there--I'm sure that somebody took our photo. We surrounded that building so that nobody would go in and do “business as usual” that day.
Schofield: Or damage the building?

Knuth: [01:01:41] Yes, well that’s another story. Somebody set fire to Polya Hall the next year and I had already taken all my files home for protection. Yes, this was not a time when an academic career seemed to be a great idea.

Schofield: “Is this what I had in mind? No.”

Knuth: [01:02:14] But I also knew that if Stanford closed, I would find some way to meet with students and we would find some place to sit and talk about computer science. We would do it without a structure. This became very clear to me, that my life’s purpose was to teach and to communicate these ideas. Whatever way it had to be done, we would do it. It got me to thinking, what are my real priorities. I certainly knew that I was born to be a teacher, but my comfort zone had changed.

Where were we? I’m coming to campus and Bob Floyd and I are picketing the Computer Center. I have to admit we were talking computer science to each other. We were doing research while we were sitting there. [laughter] But we still wanted to make a statement: No business as usual today. I guess I’d have to go look at my record book to see what was actually accomplished in classes that year. The campus was a battleground. Encina Hall was smoking during commencement. Actually I think the next year might have been even worse. I have this vague feeling that people talk about the 1960s, but everything really fell apart in the 1970s.

Schofield: The early 1970s were bad.

Knuth: [01:04:26] Right, but Lyman was able to handle it sensibly. I’d like to talk a little bit about that because before I came to Stanford, I was being recruited
and one of the things Forsythe sent me was the report of a visiting committee to the Computer Science Department; it had been invited maybe in 1966 or something like that. He brought in leading experts in computer science from around the world for two or three days to talk about exactly what was going on at Stanford. I was given transcripts of these meetings. There was somebody named Lyman who was asking the most intelligent questions in those transcripts. I asked George Forsythe, who this was.

**Schofield:** “Who is this guy?”

**Knuth:** [01:05:23] Yes, and he’s our provost, the person who’s the number one in the faculty. I got to admire the depth of intelligence behind his questions. Of course, Lyman was a historian. He had to cope with unprecedented problems, most of which were caused by other groups coming to campus rather than by Stanford people themselves.

**Schofield:** There were certainly Stanford students involved but also a lot of outside provocation.

**Knuth:** [01:06:09] Yes. Stanford students were involved but there were many, many other people. Lyman had to deal with these things, and listen to people and not just reject them, and try to talk sense. As far as I could see he did very well solving unsolvable problems as well as any human being could have done. Of course, it’s the nature of progress that it involves some conflict, and you try to avoid needless violence. I always try to avoid controversy whenever I can. I don’t enjoy arguing with people.

**Schofield:** Did you have any involvement in or opinions about the Bruce Franklin [H. Bruce Franklin] case?
Knuth: [01:07:45] I just saw that he was a charismatic speaker and he could get students or whoever fired up. The fire in our building occurred within a few days of his harangues. I thought that he went beyond the boundary--there’s free speech but there’s also destructive speech. But I wasn’t very thoroughly involved with that.

Schofield: I believe Donald Kennedy was the chair of the Advisory Board at that time. The Advisory Board split on it.

Knuth: [01:08:45] You mean on whether to--

Schofield: Whether to actually fire him or whether to otherwise discipline him but keep him on the faculty. They split but they were predominantly in favor of firing him. He’s gone on to have a perfectly respectable academic career. I think he’s at Rutgers.

Knuth: [01:09:06] Angela Davis was fired by UCLA wasn’t she? Yes. I could understand where he [Franklin] was coming from but I thought he--

Schofield: He’d taken a bit too far?

Knuth: [01:09:27] He was too charismatic, maybe, but didn’t know it.

Schofield: Maybe he didn’t know the power he had?

Knuth: [01:09:32] I’ve never involved myself much in politics. I’ve done a few things in the background. For instance, I wrote letters to people in Czechoslovakia when I heard that a Czechoslovakian computer scientist was not able to work because he had been a kind of a whistle blower. I said that his research had inspired some of my papers. I wrote that I was playing Dvorák’s [Antonín Leopold Dvorák] music today and it made me think of Czechoslovakia and how sad I was to hear that one of the scientists whose work I respected
might be in trouble. I said I didn’t know if these rumors were true or not, but if so, I wondered if there was anything that I could do to help him.

I wrote a letter in this vein and two months later, I received anonymously two books of Dvorák piano music--one of the gems of my collection--and also this man was allowed to exit and come to America. He had lost his job at the Academy of Sciences but he was given permission to leave the country. Anyway, I never wrote op ed pieces or anything. It was sort of “if Knuth speaks out on something, then it must be really bad”

[laughter]

Schofield: You were going to talk a bit about your colleague, Bob Floyd.

Knuth: [01:11:55] Right. Of all the other computer scientists in the world that I’ve ever worked closely with, certainly Bob is the one that stands out way more than any other person. I tend to work alone most of the time. I’m a bit of a hermit I suppose, but Bob and I worked it out so that we could both come to Stanford at the same time. I was at Caltech and--oh, I guess I should first say how we met. Bob was one of the first people in the world to realize the importance of proving computer programs to be correct.

Ninety-nine percent of the world or almost a hundred percent of the world thought that you write a computer program and you fiddle with it until it seems to work, and then you hope it stays working. Bob said, no--mathematicians have a better idea. They have the idea of proof, where you can actually prove conclusively that this is going to work. Almost nobody else in the world had that attitude. He became famous for the idea of verifiable computer programs. I met him at a conference in 1962. I was still a
graduate student and we hit it off. He was definitely a born geek too. He had never gotten a PhD. He was one of the students at the University of Chicago in an accelerated program for gifted young people. They got into graduate school when they were young. But then they discovered girls or something and dropped out. Bob got a job early on as a computer programmer and it turned out that he could write revolutionary, superb computer programs.

Eventually the two of us met and we realized that we were birds of a feather.

Schofield: He was a little older than you, but not much?

Knuth: [01:14:31] Yes. He lived in that house right over there. [pointing]

Schofield: Oh, out the window. We can almost see his house.

Knuth: [01:14:58] He would sit in his living room. He could see if my light was on and if I was writing my book or not.

Schofield: How did he come to Stanford?

Knuth: [01:15:08] That’s exactly the right question to ask. The two of us were writing letters back and forth, each daring the other to outdo the previous theorem and result, and challenging each other. We had an amazing technical correspondence that reminded me of the letters that I had seen by mathematicians from the seventeenth century, stirring each other on. This was very exciting for both of us. Finally he came out to meet me at Caltech and we spent a week together; we would go hiking in the desert and various things.

When I knew that I was going to want to move once in my life, I wrote to him and said, “Hey Bob, wherever I move, I’d like you to go there too.” We both had ideas about the different places to spend the rest of one’s
life. He wrote me this long letter where he summarized the way things were currently happening, at the main centers of computer science in America. He rated Stanford pretty high. He said basically that if I chose to go to Stanford, he’d like to go to Stanford too. I let George Forsythe know this and said that we would like to have a package deal [laughter] if possible. Bob had no PhD. Yet out of the top five papers in computer languages, which was one of the main fields of computer science, he had written four of them. He had a good track record as far as research was concerned but, you know, to appoint him as a full professor was a bit much.

Schofield: A bit of a stretch?

Knuth: [01:17:26] Right. They did agree to give him a job offer as an associate professor, and the two of us then decided to come to Stanford.

Schofield: An associate professor. That would be with tenure, or was it not?

Knuth: [01:17:44] That’s right. It was with tenure but not--

Schofield: Not full professor.

Knuth: [01:17:48] Right. I think it was in 1971 when he became full professor. There was an International Congress, which featured the leading computer scientists of the world, and one of the major honors would be to give one of the invited addresses at the International Congress of Information Processing. Bob was the only person in the world who had been invited to give two of them. [laughter]. This was enough for me to convince Stanford that he should be promoted to full professor in spite of not having a PhD.

Schofield: I wonder if he’s unique, or I presume one of the very few, who achieves that rank but does not have the PhD.
Knuth: [01:18:46] You would have the skill set to--

Schofield: I could maybe find out.

Knuth: [01:18:50] Okay, so he went on then to be chair of our department during a crucial time when we were working with architects to move into Margaret Jacks Hall; the Boys’ Town Center was on the first floor and we were on the second. Right in the center of campus--

Schofield: Right on the front of the main Quad.

Knuth: [01:19:11] Yes. Our department had been scattered all over. I mentioned earlier that some were at SLAC and the D. C. Power Lab and elsewhere. Our new building brought us all together in the center of campus right there on Memorial Court. Bob was the department chair at the time when we made the transition. He took his responsibility extremely seriously and worked very closely with the architects and so on.

He was not a great communicator. He was a very shy person and not a, what do you call it, a wheeler-dealer type at all. He was more like President Pitzer. He was--let me say, a consummate pure researcher. He was a successful chair but different skill sets go with different chairs. Some are good at fundraising and some are good at parties and whatever.

Anyway, Bob was extremely important to our department and he worked very hard. During that time he worked so hard as chair that he didn’t have time for research and he fell behind. He was entitled to two years of sabbatical after that, to go to MIT I think and other places and get back up to speed on research. But it wasn’t the same afterward. We had worked very intensively together during the 1960s and early 1970s. But then in the 1980s,
I think we only wrote one, maybe two, joint papers during that time. I was working in typography and he was working on other projects, even though we lived near each other. His marriage broke up and various things were happening in his life. We finally drifted apart. The tragedy was that he got--I'm not sure what it’s called--somebody’s disease. It’s a little bit like Alzheimer’s--

**Schofield:** A type of dementia?

**Knuth:** [01:22:05] Yes, but it has another name.

**Schofield:** Was it Lewy body dementia?

**Knuth:** [01:22:20] If you had it right, I would have recognized it. I wrote his obit, and it’ll probably be in the Senate resolution.

**Schofield:** Right, the memorial resolution.³

**Knuth:** [01:22:34] At the end, during his last years, he had a loving caregiver. The last scientific conversation we had was coming back one night in 1997 from Ed Feigenbaum’s house where a lot of us old-timers had gotten together to be filmed about our memories of the early days of the Computer Science department. These films are part of the Stanford archives. I think they’re somewhere on YouTube. It’s called *The Living Legends* and we were all there. Bill Miller was there of course and John McCarthy and Herriot, I think maybe Gio Wiederhold [Giovanni Corrado Melchiorre Wiederhold], and Ed and Penny Nii, Ed’s wife.⁴ They made video archives at that time of our reminiscences. Bob was there but not participating really strongly.

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³ Editor Note: Pick’s disease, a neurodegenerative illness

⁴ Note from Don Knuth: Gene Golub was also present.
We came home and we were watching a comet [the Hale-Bopp comet] that was visible in the sky that night. As we walked home, we talked a little bit about it. That was the last time Bob and I had a sensible conversation. Let me repeat that it was a package deal, that we came to Stanford together and we thrived. He received the Turing Award, which is like the Nobel Prize of computer science, during the 1970s, just as he was coming to the end of being chair I guess.

Schofield: Since you mentioned the Turing Award, you have awards and honors that would go up my arm and down the other arm. Obviously they’re all listed in your CV and I think they were all important in their own right. Are there any that are most memorable or most meaningful to you?

Knuth: [01:24:58] Bob [Floyd] had this idea that the first award is always the hardest one. Once you get one, then everybody else is willing to take a chance on you. They don’t want to be the first person to give you an award. I was lucky that I got one early on in my life and then it could be--

Schofield: Was that the Turing Award?

Knuth: [01:25:22] No, it was the Grace Hopper Award. That’s an award for the best computer scientists under the age of thirty. I had received that a year or two before I got the Turing Award. Then the floodgates opened. The Turing Award was for The Art of Computer Programming--by that time I had published three volumes. We’ll talk more about that. Anyway, partly I came along at a time when computer science was riding waves and so I could become the poster child for computer science. A university would start up a computer
science department and then the department would want to prove its worth by giving an honorary degree.

Stanford doesn’t give honorary degrees but most other universities do. In order to do that, it has to be voted by a consensus of the entire faculty. Duke University, for instance, can’t give an honorary doctorate in computer science unless the physicists, chemists, biologists sign off on it. I think I have more honorary degrees than Ronald Reagan. [laughter]

Schofield: There were a heck of a lot of them listed on your CV.

Knuth: [01:27:11] Yes, it’s more than three dozen now.

Schofield: Do you go and physically receive them?

Knuth: [01:27:19] In all except one case. In one case, I was getting radiotherapy for cancer treatment so I couldn’t attend. I thought they would defer but they awarded it in absentia. I could also write a book about commencements of the world--

Schofield: All the ones you’ve sat through.

Knuth: [01:27:45] Garrison Keillor is such a tremendous commencement speaker.

I’ve always considered the acceptance of awards that cover all the sciences to be a good use of my time, in order to increase the visibility of computer science in the world, because we are the new kids on the block. We still have to broadcast the fact that this is a body of knowledge that has its own importance. A hundred years from now people will say yes, of course, computer science is important, physics is important, chemistry is important. Historically, one of them had to be recognized first. One of them had to be recognized second. And we just happened to be recognized late in the game.
We’re all equally important, but still we had to get up to speed. I’ve looked on receiving these honorary doctorate degrees as not being for me so much personally but just that I was a natural person to represent the whole field, as exemplar of why the field is important.

Schofield: Alfred Nobel was gone by then, so he couldn’t create the Nobel in Computer Science.

Knuth: [01:29:05] It was nice that one of my honors was actually to get an honorary doctorate degree from the [University of Oslo] at the time they started the Abel Prizes, which are the mathematicians’ “Nobel Prizes.” Anyway, I consider that most of those awards were not specifically for things that I did but things that computer scientists had done and that I was a recognizable person to put in there.

Schofield: You may be understating the importance of yourself as an individual, but I get the point.

Knuth: [01:29:56] Yes, I’m trying to prove how humble I am now.

Schofield: I think you are. [laughter]

Knuth: [01:30:01] Quite seriously, somebody had to fulfill that role and it was easier for people to make a case for me because of the [laughter] books I wrote, because they were reading my books. The big awards were the ones that I suppose had the largest committee voting on them--like the Kyoto Prize, which goes through quite a large vetting process.

Schofield: That was in 1996, I think?

Knuth: [01:30:43] Yes, that was 1996, right. That’s a very important one and--
Schofield: I think I read somewhere that it has a pretty big cash prize and that you donated it to charity?

Knuth: [01:31:00] This is true. I don’t know how many million yen it was, but it came out to $400,000. Jill [Nancy Jill Carter Knuth] and I are very happy and we didn’t want that money to ruin our lives. So we wanted to figure out what to do responsibly with $400,000. It turned out it was not easy to donate--I don’t want to go into the details--anyway, in order to do it in such a way that it would be a legal charitable donation, we had to go through a special group on the peninsula that sort of acts as a “money laundering” place. They’re a recognizable charity--

Schofield: Are you talking about the Peninsula Community Foundation?


Schofield: Yes, they manage the money and then you can designate the charities through them.

Knuth: [01:32:11] Right. I designated that $100,000 should go to our church to replace its pipe organ; $100,000 should go to Stanford; $100,000 for our relatives to go to Japan.\(^5\) Anyway, we divided it up because we didn’t need it.

Schofield: You thought you had enough money?

Knuth: [01:32:42] Yes, and we aren’t that great at managing investments. We didn’t want to have to do that. We divided it four ways.

Schofield: Did you do this anonymously, or did they know that you were giving these gifts?

Knuth: [01:33:00] I don’t think we did it anonymously. Then I got an award from the BBVA Foundation in Madrid. That was, I don’t know, about ten years ago

\(^5\) Note from Don Knuth: The remaining $100,000 went to my high school, Milwaukee Lutheran High School, in Milwaukee, Wisconsin.
now. That also had quite a large vetting process so I could represent computer science in that one. Again, the money was donated. I think we donated a lot to CSLI [Center for the Study of Language and Information, at Stanford] Publications at that time.

Schofield: I notice a lot of your talks are filed or archived there in CSLI.

Knuth: [01:34:06] Yes. CSLI has published eight volumes, containing all the technical papers that I wrote.

Schofield: Why CSLI? Were you particularly connected to them?

Knuth: [01:34:24] I met Dikran [Dikran Karagueuzian] while I was working in typography and he approached me many years later to publish a book--the first one was called *Literate Programming*. That was a spin-off of my work on typography, a new way of programming that makes it possible for computer programs to be understood as literature--so you’re writing for human beings and not for computers.

Schofield: Dikran--I don’t know who that is--

Knuth: [01:35:00] Dikran Karagueuzian has been the head of CSLI Publications since the 1970s. I met him when he was designing Armenian typefaces and I was working in typography. We became friends. He’s a publisher that worked with Etch [John Etchemendy] to develop strong publications.

Schofield: Tell us about this beautiful home that we’re sitting in, which you helped to design, and your home life in general. You’ve been married to Jill for your whole married life and raised two children. Please talk a little bit about that.

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6 Editor’s Note: Frontiers of Knowledge Award, awarded by the Banco Bilbao Vizcaya Argentaria Foundation to Don Knuth in 2010.
Knuth: [01:35:55] Jill and I were married right after her graduation, which was 1961. Our son was born in 1965 and our daughter in 1966. And we designed this house. One of the great advantages of Stanford was to be able to live on campus. If I had gone to Harvard, I would have had to wait twenty years to get a house anywhere near the Harvard campus, for example, and Berkeley a similar thing. It was very appealing to know that I could spend my life without commuting. I'd be able to bike, and I still bike four days a week to the core campus.

Schofield: You were a leader before your time on that.

Knuth: [01:37:18] One of the reasons I spent my first year on leave of absence, though I was officially a Stanford professor, was that it gave me a legal right to participate in the draw for lots in the Frenchman’s Hill area where we are now. We got to choose our favorite four lots among those still available, and this is the one that was assigned to us. During our year at Princeton, we spent every Sunday night talking about our dream house. Jill and I had actually spent our first date in college talking about our dream house, but this time now we were [laughter] actually going to build one. We came out here with lots and lots of notes and we met a wonderful architect--Jim O’Neal. He was with a firm called Sabin, O’Neal, Mitchell that lasted only a few years, but they had worked on Foothill College I think. They designed three other houses in this area. Jim was a very good listener and he could look at all our plans and see which ones actually made sense.

Schofield: Were these just verbal plans?
Knuth: [01:39:00] No, we had made sketches. We had ideas like round walls and strange angles and things like this. He would know what we really had in mind. He understood how light goes through windows and, you know, we didn't have any good understanding of this. We went through twelve rounds of plans because one of the things that fascinated us was a spiral staircase. We thought we really wanted a house with a spiral staircase in the middle. But that was just wasn’t working.

The first ten plans were different versions of trying to get a spiral staircase to work. On our trips to Europe—we had enjoyed the idea that there were some rooms that were larger than normal and others that were smaller than normal, and they weren’t all the same size. We wanted a big bathroom and a big place for a dressing room. We wanted a small bedroom for intimate things—for reading; we wanted a small parlor—for talking; and things like that. These were part of our dream house. Jim was a good listener and processor. We spent our first year out here meeting the architect, talking to him, and then watching this house being built. All the houses on the street were going up at about the same time. Ours was one of the last to be built.

Schofield: And this is then 19--?

Knuth: [01:40:51] This was 1970 or 1971. By the way, the Stanford Historical Society ought to have a house tour in Frenchman's Hill some day. They always use the old part of the campus, but, you know, there are several unusual houses in this area that would be interesting to tour.

7 Note from Don Knuth: We moved into the house in September 1970.
Schofield: That’s coming up. The Historical Society made a commitment to research all the pre-1930 homes and they’ve pretty much finished. Now they’re looking to the 1950s and 1960s and 1970s houses.

Knuth: [01:41:34] Okay. For example, Herb and Eve Clark [professors of psychology and linguistics, respectively] have a house that’s on the second floor. There’s no first floor.

Schofield: And that’s on Vernier?

Knuth: [01:41:48] No, the first street after Stanford Avenue.

Schofield: Wing?


Schofield: You’re right. There are some very interesting newer houses.

Knuth: [01:42:00] Right. And around on Tolman, there’s another house by Sabin, O’Neal, Mitchell that consists of four parts that face each other, at ninety degree angles, to catch the sun at different times, and so on. There’s much to be done. [laughter]

You said you admired the cedar paneling in the house, which we love very much because of our experience in Scandinavia. We said we would really love to have a house that featured wood. We couldn’t afford the cedar paneling at first so we lived with plasterboard for the first three years until some more royalties came in from my book.

Schofield: Is this what’s called rough-sawn cedar? I think it is.

Knuth: [01:42:56] Yes.

Schofield: It’s beautiful.

Knuth: [01:43:01] We had carpenters living in the house for months putting it in.
Schofield: In front of the wallboard?

Knuth: [01:43:08] Yes. As our house was going up, people said you must be really worried about earthquakes because you’ve got so many beams and wood bracing in there. The architect may have done it so you could turn it on its side [laughter], I don’t know. Anyway, the house cost an unbelievably high price of $100,000.

Schofield: Which of course, at that time, was a lot of money.

Knuth: [01:43:51] This was considered to be a really outrageous, expensive house. Well, it's 4,000 square feet. We wanted to have one room for Jill's artwork, and one room for my music. So we set aside one room where a future pipe organ could be. We couldn’t afford that then, but the architect specified support under the floor to handle several tons of weight. We were really glad to be able to live on campus and to choose our own architect. It was an incredible deal that’s possible because of the way Stanford organized its planning.

Schofield: I think it was particularly advantageous for those of you in that era that could be the first on those lots.

Knuth: [01:44:52] Yes, right. There were lots and lots of kids playing in the streets. At Halloween, we couldn’t have enough candy in the house. There are a few kids coming back now but it’s very different. The trees were small. As the street is maturing, we’re growing with it--we used to be able to see the Bay [laughter] out the window.

Schofield: Really?
Knuth: [01:45:42] Yes, because there were no trees in the way. Not this window but the window on--

Schofield: I wouldn’t think you were high enough, but I guess you are just barely.

Knuth: [01:45:51] We are.

Schofield: As a neighborhood, has that been important in your Stanford life in any way?

Knuth: [01:46:04] We did have a lot of meetings ten years ago with respect to earthquake preparedness and we’ve had block parties and things like that. But it hasn’t been extremely important. John McCarthy lived over there [pointing] and Bob Floyd lived over there [pointing]. Bill Dally [William James Dally] lived across the street from us. We had various social connections that way. I started to make a point of reading all the books that were written by my neighbors. [laughter] I gave that up after a while because there are so many of them. A lot of people on this block have written some very appealing books.

There’s a novel by Spyros Andreopoulos--the guy who was head of the Medical School News Bureau--*Heart Beat*, I think it’s called. Our neighbors, the Cancians, had done wonderful research in Mexico that we wanted to read about.

Schofield: What’s the last name?

Knuth: [01:47:24] Cancian [Frank and Francesca Cancian]. They both were professors of anthropology. Living on this block gave me an opportunity to enjoy other parts of life than computer science.
Schofield: Yes, you were mentioning that there are a few opportunities in a university to go beyond your field. The campus neighborhood can be one—it isn’t for everyone I find—but it is for some.

Knuth: [01:48:01] Right. SCRL [Stanford Campus Residential Leaseholders] has three or four parties a year. I spend those parties learning some biology or something from the people I meet.

Schofield: If you have curiosity. You said Jill’s an artist or she needed a room for her art. Say a little bit about her life apart from yours.

Knuth: [01:48:33] She’s an artist-designer and has never really worked for salary, but does all kinds of freelance work and charity work and volunteer work. She’s trained as an artist. In Pasadena, when we lived at Caltech, we had a big kiln in our back yard to do firing of her pots. One of Jill’s teachers was one of the great Japanese-American potters, Toshiko--what was it?--Takaezu--was her name. If Miss Takaezu didn’t like your pot, it was broken right away. [laughter] Just smashed. Jill is especially skilled in design and so she’s designed lots of logos and banners.

She has a book about designs of banners. It’s called *Banners Without Words* and the idea is that you can get a spiritual message across just by the images. She combined fabric in very intriguing ways. She wrote a monthly column for *Modern Liturgy* magazine for a while and those columns were collected into a book. We used to have a collection of a hundred of her banners but now they’re at a church in Palo Alto that maintains them. She had different shows of this kind of work, often with fabric or with pottery.
The large room at her side of the house has north light so she can work there, and she has excellent projects going on all the time.

I have the music room which now has an organ and two pianos, and lots of chamber music instruments.

**Schofield:** Shall we talk about music in your life? I think it’s very important to you and you’ve done some really very interesting things with music. Let’s do that and maybe we’ll end on that theme for this session.

**Knuth:** [01:51:23] Good idea. My father was a church organist and choir director. He taught me piano when I was very young--maybe seven years old. Through high school, I was the accompanist for the chorus and I was part of the band--they didn’t have an orchestra. I was part of the marching band in high school and college.

**Schofield:** Playing what in the marching band? Not a piano. [laughter]

**Knuth:** [01:52:05] No, I played a sousaphone.

**Schofield:** A sousaphone, ah.

**Knuth:** [01:52:09] I always took the instruments that the school would pay for. We didn’t have enough money to buy instruments of my own but the sousaphones come with the band. I enjoyed playing piano at fraternity parties and things like that. Actually I could have chosen one university and majored in music, or I could have gone to Case and majored in physics. I chose the physics line but it was--

**Schofield:** You could as easily have gone either way? Well until you discovered you were a geek, then maybe you would have moved away from music?
Knuth: [01:53:07] Musicians can be geeks, you know. We actually have a Stanford professor whose name is Ge [Ge Wang] which are the first two letters of geek. [laughter]

Schofield: We do?

Knuth: [01:53:26] Yes, yes. He’s a wonderful resource. He started SLOrk, the Stanford Laptop Orchestra. Have you heard about it?

Schofield: No.

Knuth: [01:53:35] Ge Wang is one of Stanford’s great people. You’ve got to get to know him. He’s very young still. His first book is coming out later this year.

Music was a strong hobby for me all of the time. At Stanford, there’s this nice custom that the chair of a PhD [oral examination] committee comes from another department. Over the years, I don’t know, maybe half a dozen times, I served as the chair of a PhD thesis oral exam committee in the Music Department; other departments too. Music was always the most fun for me. I haven’t sat in on these for a while but that was always the rule--somebody from another department is the chair of the oral exam. It’s a three-hour obligation. You go and then you get some cookies afterwards. The student makes a presentation and then there’s a consultation among the faculty, where they try to impress each other as to how smart they are and how much they understood of what the student did. [laughter] This was a very nice part of being at the university because I could also get to know my faculty colleagues that way--Al Cohen [Albert Cohen] and John Chowning and Leland Smith. Chowning and Smith were involved with computers.
Schofield: CCRMA [Center for Computer Research in Music and Acoustics], and they end up founding it I think.

Knuth: [01:56:04] Yes, right. In fact, CCRMA was going to [move to Margaret Jacks Hall with us] and a space was soundproofed especially for music, but it turned out that Computer Science had grown so much that they put computers in that room instead. We were intended to be closer to the musicians, during the 1970s when the building was designed.

In the back of my mind, I thought, some day I would like to learn enough about music that I could compose a significant piece that would make a certain number of people happy to hear. Originally I thought well, I’ll do it with computers. I’ll learn enough about music that I can teach a computer how to write music.

A lot of people have actually been pursuing that. I’ve always felt that the best way to learn something is to try to explain it to a computer. You don’t realize how little you know until you try to teach it to somebody who doesn’t know it and especially to teach it to a computer. Computers don’t just nod their head and say they get it. The computer has to understand--

Schofield: Every building block has to be there.

Knuth: [01:57:55] Yes, the computer is the ultimate test of whether you understand something--if you can explain it to a computer. I had that in my mind.

So I learned a few things--like in this book [pointing out a book on his bookshelf, Selected Papers on Fun and Games], I have a little essay about some tricks that I learned during my year at Princeton about algorithms that harmonize music, finding a good chord pattern. I knew a little bit about these
things. Over the years, I read lots of books about music theory and so on. I had the book knowledge but I didn't ever put it into a machine myself.

I did decide finally that if I'm going to write music, I probably ought to limit myself to one piece, because really what I do best is write books about computer programming and I shouldn't take too much time away from that. If I have any good music in me, I would like to write one piece but this would be the only one. And when I finally got around to writing it, I threw in everything including the kitchen sink. [laughter]

I'd had in the back of my mind since the 1960s that somebody ought to take the biblical book of *Revelation* and all of the symbolic motifs that recur--I've got to backtrack a little bit. People since the fourth century have noticed that the book of *Revelation* is written a little bit like a piece of music, that it doesn't follow in straight lines but it has lots of different symbolisms that are woven together.

Schofield: And that recur?

Knuth: [02:00:29] Yes, right. At first I noticed the numbers because there are a lot of numerical symbols that appear--the numbers three and four and seven and twelve. Then I also saw that many other symbols go in there. There are angels and blood and gold and candles and demons and trumpets. A lot of it specifically reminds me of music and there's this musical nature. I said, somebody ought to write a piece of music that has motifs that are woven together the same way the author of the book of *Revelation* wove motifs.

Here's something that has been inspiring people, for two thousand years, to produce many great pieces of music and many great pieces of art.
Wouldn’t it be nice to have kind of a literal translation, where I would actually not just adapt it but I would rather closely follow the original text of *Revelation* as to what musical motifs are present?

This was a question: Would it work at all or was it a crazy idea? When you have something that hasn’t been done before, there are two main hypotheses. One is that it really needs to be done, and the other is that it’s a stupid idea. [laughter] You never know which of those two it is. Something had been bugging me to do this since the 1960s.

**Schofield:** What did Jill think? Did she think you ought to do it?

**Knuth:** [02:02:42] I don’t even know if I asked her. That’s a good point though. [laughter] But I have to tell you that while I was actually doing the composition, it was very hard on Jill. Because what I’m doing is, I’m sitting there at the organ or at the piano and playing, trying things out. If they don’t work, then I play them again but a little differently, you know. I keep going at it until it sounds good. Then I go to the next step and again it doesn’t sound good. She’s in the other room trying to do artwork and she’s hearing this screeching and all my errors in there. I don’t know how composers’ wives handled this in the past. I would plan to do most of the work when she was out shopping or visiting her sister or something.

**Schofield:** To somehow relieve her from the cacophony of it?

**Knuth:** [02:03:49] Right. Anyway, she knew that I had this drive to do it. The drive was so strong—if say three years ago, somebody had told me that I had only six months to live, and how would I spend those six months, the answer is
that I would have put all my energy into finishing this piece, because I felt so strongly that my life was incomplete without having it done.

Schofield: You were meant to do it somehow.

Knuth: [02:04:34] Yes, it was as if I was being driven by a muse behind my shoulder, as if I was channeling--the music was there and I just had to listen for it until I heard it and then I could write it down.

Schofield: Did it feel like a religious muse, a religious motivation?

Knuth: [02:04:58] It’s hard to describe spiritual feeling but it’s definitely--it was a combination of unconscious and conscious, somehow. I have no way to really explain it rationally but I know that it’s a very emotional experience of some kind. Whether Benzedrine or something would have made the music better, [laughter] I have no idea. But I do have this feeling that somehow some force wanted--

Schofield: Wanted you to do it.

Knuth: [02:05:43] --was driving me to write it.

Schofield: Over what years did you work on this?

Knuth: [02:05:47] I started keeping a notebook on Thanksgiving Day, 2012, I think. I got out this book [showing it]. My grandson had made some drawings and then my daughter packaged it into a book that was a blank book. There it is. 23rd November--no, 2011. “In this book I plan to jot down thoughts for a project that may be crazy but a muse has been encouraging me to embark upon it for more than forty years. I hope to be able to write a piece of organ music based on the text of the apocalypse, the mystical book of Revelation, using the basic philosophy of Oulipo, namely that constraints help to create
great art. The constraints are following the motifs of this book.” I kept
working on this for five years and--

**Schofield:** And?

**Knuth:** [02:06:59] I got to the end and I introduced it to an organist--a distinguished
Canadian organist who I had met when I got my doctor’s degree at Waterloo.
We actually played a joint organ concert while I was in Canada. I told him I’d
tried to make a fairly literal translation of the book of *Revelation*. He
immediately understood what I meant and he started sending me every day a
recording of parts of--

**Schofield:** Things that he imagined would go with it?

**Knuth:** [02:07:47] No, no. I mean, I put all the music on the internet and he
downloaded it and played it on several organs. He would take his Blackberry
and record himself playing the organ and he immediately liked the music,
which, of course, was very encouraging for me because it was a different kind
of a sound.

**Schofield:** It is all composed for organ?

**Knuth:** [02:08:22] It’s composed for pipe organ and--you see, the book of *Revelation*
covers so many different emotions and themes that it was natural for me to
throw in the kitchen sink because there are many different moods that you
want to convey in this one piece. So I need the organ with its great variety of
tones and also I need to combine a great variety of styles. My piece has rap
music, for example--

**Schofield:** Rap music played on an organ?
Knuth: [02:09:01] Rap music. And it has calypso and it has a lot of classical themes, references to Broadway shows, and great chorale music.

Schofield: Was all of this music that you were familiar with and enjoyed yourself, or you looked for it specifically to represent a motif?

Knuth: [02:09:26] I can show you a hundred pieces that I collected. I went and tried to find every piece of music that had been written based on the book of Revelation. I have them sitting in the next room there. I played through each piece to see if there were parts of it that would be worth paying some homage to. I found that there was one part of Revelation that had been set to music by four different composers in four different centuries, and that their works blended together. I heard Brahms’s Requiem and I realized that Brahms had also used that same text, so I added another theme to include Brahms with those other four. I pay homage to other pieces of music as well and I have different styles to convey the different moods.

There’s this menacing beast. For the beast I used music that was inspired by the music for Double Indemnity, the movie. Miklós Rózsa wrote some captivating music for that. I had written much of The Art of Computer Programming, Volume 1 to the accompaniment of Double Indemnity on late night TV. It was showing about twice every night and advertising used car dealerships and so on. While the kids were asleep, I could work on my book and or type my book with Double Indemnity playing on TV, and I heard this music in the background.

Anyway, various things in my life got into the piece. Like when I turn on my washing machine, it plays a little jingle—“power on.” There’s a part of
Revelation that talks about power coming on. [laughter] The entrance to heaven is my wife’s ringtone. I’m taking a twenty-first century view of it--but doing it seriously. I don’t believe that you have to make a distinction between having fun and being serious.

Schofield: So it’s done. It’s complete and it had its world premiere at your special eightieth birthday celebration?

Knuth: [02:12:20] Right. This was incredible, how it seemed that something outside of me was making sure that it worked because it got finished--

Schofield: It would be done in time.

Knuth: [02:12:35] It was done in time and things fell in place so that we could have more than 150 people in northern Sweden at the beginning of January [2018]--so the performance was on exactly my eightieth birthday--January 10th of this year. Everybody got there without mishap and all the buses worked and all the hotels--all the other things that could have gone wrong went well.

Schofield: Why the choice of that location?

Knuth: [02:13:09] That happens to be the place that has the best possible pipe organ suited for my piece. Northern Sweden has a great tradition of pipe organ music going hundreds of years back. The music school in this small town had the foresight to commission one of Europe’s finest organs, designed to be the organ of the future. It was planned to be a combination of the best German organs plus the best French organs, plus avant-garde things, all in one instrument. There’s no other organ that I know of that could handle all of the different tonal experiences that go into my piece.
Schofield: Even though you had to design it and hear it on your own organ, which has some variation, but it didn’t have what that [Swedish organ] would allow?

Knuth: [02:14:15] Right. It will sound fine on the small organ in our church in Palo Alto; but for the premiere, I’d read about this organ in Sweden, which was dedicated in 2012. A month after the dedication, I saw a report about it. One of the main people involved in that dedication, by the way, was Stanford’s former organist--she’s in Arizona now, what’s her name?

Schofield: I’m thinking of Morgan [Robert Huw Morgan], but that’s a different organist.

Knuth: [02:14:58] Right. No, it’s before then. She was going to start ORCAS, the Organ Research Center at Stanford--Kimberly [Dr. Kimberly Marshall]--yes, she was organist at Mem Chu [Memorial Church] for several years. She was one of the main people at the dedication of this organ in Sweden in 2012. Immediately I said wow, that sounds like it’s actually good for the piece that I wrote because one of the other things that they had in the organ was the provision to display videos at the same time. There are screens at both sides of the organ so that for the audience, it’s not just organ playing but also video showing. That’s part of my piece too. I have three video tracks that go with it.

Schofield: And it’s called Fantasia Apocalyptica?

Knuth: [02:16:06] Yes, Fantasia Apocalyptica. It’s a fantasy musically.

Schofield: How did you feel about it when it premiered and when you finally heard it there?

Knuth: [02:16:18] It was just an incredible high. It was working. I got to the point where I didn’t have to be sensitive about it, and it now feels to me like it’s
part of the existing musical culture of the world. And I just happened to be lucky enough to be able to write it down.

Schofield: You channeled it.

Knuth: [02:16:43] Yes, but it’s not that I’m questioning anymore, should I have changed it. I’m very happy that it came out the way it did. I’m sure that a great musician could have done better with the same project in mind of translating Revelation, but I think I did okay. There are parts of it where I do feel proud that those particular ideas came to me on those days.

Schofield: That’s great. Has it received reaction that you’re aware of?

Knuth: [02:17:25] Yes, but how do I know what people say behind my back? But it’s definitely getting a lot of--certainly everybody at that concert was happy with it. I know from the comments they made that they also understood the videos and the things that I was trying to convey.

Schofield: How long does it run?

Knuth: [02:17:50] It takes an hour and a half. [laughter] It’s torture if you don’t like it, but they liked it.

It’s sad that the organist who performed it had a heart attack two months later. He is now making an amazing recovery. I’m in touch with him and he still hopes to be able to play the Canadian premiere because he’s gradually getting back his--

Schofield: Motor skills?

Knuth: [02:18:23] His left hand and left foot. We were hoping that he would perform.

Schofield: His name is Jan Overduin?
Knuth: [02:18:38] Overduin, yes.

Schofield: How did you pick him?

Knuth: [02:18:41] As I said, we met in Waterloo. We had been in correspondence before that about organ music since I have an organ in my home. I wanted to have as much music as I could that was written for two people to play together. He had written some articles about it and we got in correspondence.

Schofield: That organ can be played by two people at the same time?

Knuth: [02:19:11] Right. The concert that we gave in Canada was a dozen pieces for eight hands and eight feet—no. Four hands and four feet, I’m sorry.

Schofield: Eight would be too many.

Knuth: [02:19:25] Yes. [laughter] I added feet plus hands, getting eight.

Schofield: Why don’t we call that a good ending to this session?

[End of Part 1 of 2, Interview with Donald Knuth - May 8, 2018]
Schofield: Today is May 11, 2018. This is a second session in an interview between Susan Schofield of the Stanford Historical Society and Donald Knuth, professor of Computer Science. When we ended last time, we had been talking about music, and I thought we would move on, if that’s okay with you, to talking about your writing. You’re a prolific writer. On your CV, I think there are over thirty pages of publications.

Knuth: [00:00:37] Those include the translations.

Schofield: Oh, those do include the translations, you’re right.

Knuth: [00:00:43] Anyway, there are about thirty-three books in print at the moment.

Schofield: I see. I call that prolific. [laughter] I’m interested in your process of writing--your interest in writing--just however you want to tackle the topic.

Knuth: [00:01:01] With emphasis on Stanford, I guess. On my tax return, I describe myself as a writer. They ask what’s your occupation. That’s what my income represents basically, since I’ve been retired now for twenty-five years.

Schofield: Did you used to say computer scientist?

Knuth: [00:01:40] Professor.
I’ve liked writing ever since I was young. My teachers were not very good at science, but they were very good at English. We learned details of English grammar in seventh grade. When I got to high school, the high school classes were mediocre by comparison to what I’d had in what we called elementary school in those days. Still, the teachers were strong and gave us opportunities so I had a chance to work on the school paper and the school yearbook. My friends and I wrote plays. I enjoyed the idea of communication. That was always a part of my life.

I wanted my students at Stanford to also have that experience. At one point, I was editing a dozen journals in computer science and I would get papers submitted from all over the world. If I got a paper from England, it was almost always well written. But I’d get a paper from [the United States], and it was almost always rather awkward and would need editing. I figured this is nurture, not nature. Americans don’t have different genes from the English. They have a different educational system. In Britain, they have this tutorial system where students do a lot of writing for their teachers.

Therefore, in some of my Stanford classes, I decided to take a week off, and I would teach writing instead of computer science. In many of my classes, there would be a term paper requirement, especially the two-quarter sequence classes, and in the last quarter each student would be expected to write an original term paper.

By the way, I used to advertise this on campus. I put up a sign in all the departments around campus saying, “Free computer expertise. If you want a student to help you on your research by writing a little computer
program, let me know and advertise it to my classes and one of my students might take it up as their term paper.” I was doing that in the 1970s and I got to meet a lot of other professors that way. I remember Amos Tversky [Amos Nathan Tversky] particularly. We had a couple of times where students in my course were writing term papers for me based on his projects. Also people in the German Department, Music Department, and so on.

Schofield: But these papers had nothing to do with computer science? Or they helped in the other discipline?

Knuth: [00:05:19] They helped faculty in their own research. Tversky, for example, would analyze questionnaires that he’d been [administering], so the student could do that. And they were interesting problems. Hardly anybody had computer skills in the 1970s, so the professors had a little appetite for that--those who heard about it--computers were pretty new.

Schofield: Clarify for me. So the students would write the computer programs that would help, let’s say, Amos Tversky, but then for you, they’d have to write an English paper about what they’d done.

Knuth: [00:06:04] Yes, thirty pages or something. I graded their term papers as an English professor. I marked them for commas and semicolons and i-t-‘s versus i-t-s. I actually would take time off from teaching science. I figured this was important for their education. Later I taught an entire one-quarter class called Mathematical Writing. It was about how to write when your paper has technical content, especially mathematical content. I had great guest lecturers come in for this course. It was videotaped, so people still use
the tapes. Stanford has writing counselors, in the Engineering School, and H&S--

[00:07:28] The people who work with students on writing often recommend these videotapes of the class I gave. My two teaching assistants wrote up each session and this became one of my thirty-three books in print. It’s called Mathematical Writing and it has the verbatim transcripts of what went on in our class. It’s been used as a text at various universities too. Many people have told me they learned writing from this.

It’s not only something that I like to do myself, but I also spend a lot of time as editor and helper of other people to develop their writing. There are cases where I wrote to someone--for example a major professor at Cornell--and I said, “The research in this paper is really good, but I think you ought to take seriously the fact that you haven’t practiced writing enough.” I gave him a twelve-page rewrite of his paper. He thanked me so much. He said this improved his career. That’s a story that, of course, nobody is going to know except him and me, unless somebody goes through my collected correspondence sometime and finds this letter.

Schofield: And figures out who he is.

Knuth: [00:09:16] I’ve found that half of my--let’s say my life has been the combination of writing and X, where X was computer science or mathematics. Well, I wrote essays on non-technical things once or twice. Anyway, writing was always really important in my life and I ascribe it mostly to the experience I had when I was young, getting started and practicing.
Schofield: Was it more satisfying to you to actually teach the writing or to teach the computer programming?

Knuth: [00:10:10] I can see the programming as something I know I’m uniquely able to do. Other people could teach writing but they didn’t take time for it. As a result, the students just were never challenged and they didn’t have the practice. With the practice, they learned.

Schofield: They might have resisted a bit, “Wait a minute; I thought I was just going to learn programming. What’s he doing to me?”

Knuth: [00:10:38] Yes, I know. My son and daughter, I wanted them to practice writing--I still have their essays in my file cabinet--how old were they? I don’t know, second grade, third grade. For several years, if they didn’t write [a weekly] essay, they couldn’t watch TV that week.

My son developed a formula for how to write a one-page essay. He would say: In the first inning, the Giants scored one run; in the second inning--you know, he went on and just filled the page. So I had to change the rules, no writing about a sports game. [laughter]

That experience helped my kids too, of course. The British tutorial system where students are expected to write more than a page for their tutors weekly was really a game-changer for them. Stanford in England has the tutorial system--kids go there and that’s good.

Now about my own books. I was approached when I was a second year graduate student--it was January of 1962--so I was what, 24 years old. A publisher took me out to lunch and said, “Don, how would you like to write a textbook about how to write compilers?”
A compiler is a very important kind of computer software. I had
gotten a little bit of notoriety because I was one of the few people in the
country who had written good compilers at the time. For example, that same
year a company said, “Why don’t you leave graduate school and write
compilers? How much would it be worth to you?” [laughter] I said, jokingly,
“Okay, well, give me $100,000 and a full-time assistant.” Without blinking an
eye they said okay. But I was just joking.

Schofield: That was a lot of money back then.

Knuth: [00:13:54] Yes, in 1962, that was.8

Schofield: Off the charts. They shouldn’t have said yes.

Knuth: [00:14:07] My current joke is, if Bill Gates wants me to work as a consultant,
my fee is ten million dollars a day, payable to Stanford. If a lawyer wants me,
it’s twenty million. [laughter]

It was clear that I didn’t want to base my career on maximizing the
amount of money I could make. But I had written compilers, and that was
considered a bit unusual but still potentially important. The publisher was
Addison-Wesley, who had been publishing my favorite textbooks--my
calculus book, my physics book, and several others.

My textbooks in college were published by Addison-Wesley--I
enjoyed reading those books and they also were well printed. They looked
nice. I was sort of drooling saying wow, I would really love to write a book
that looked like the books that were my textbooks.

8 Editor’s Note: Over $800,000 in 2018 dollars.
That afternoon I came home and somewhere I still have the piece of yellow paper on which I jotted down my ideas for twelve chapters that I thought ought to be in this book. Chapter twelve was actually compilers. Chapters one to eleven were preparation for writing compilers. I sent a preliminary outline, telling the editor that we might as well cover a lot of other basic techniques, so that the people who read the book can do more than just write compilers. I had found that the literature at that time was sadly lacking and most of the techniques nobody had ever described before. The editor loved the idea and said, “Okay, let’s call it The Art of Computer Programming.”

Those twelve chapters are still--I told you the other day that George Forsythe had asked me to come to Stanford and I’d said, “First I have to finish a book”. That’s the book that we were talking about.

Schofield: That’s the book, yes. Thinking you could do it in a year.

Knuth: [00:17:01] Right, before my son was born. That’s the book that I’m still writing--I’m in the midst of chapter seven now.

Schofield: Are you still keeping the same structure, your notion of what those twelve chapters should be?

Knuth: [00:17:20] Almost exactly. Some of the chapters--the order got changed.

Schofield: But you haven’t gotten to compilers yet?

Knuth: [00:17:28] Compilers is chapter twelve, and “volume seven.” Other people have written very good books about compilers now so that’s not--

Schofield: That will not be as important?
Knuth: [00:17:40] Yes. There are lots of areas where I do feel that my personal take is better than anybody else’s that I know. Those are the things I’m especially interested in developing. Of course, a lot more things are known now than were known in 1962. Computer science keeps growing, daily, and it exploded during the 1970s. For example, consider chapter seven, the part of my project that I’m doing now. I sort of threw that chapter in only as a whim in 1962, because it was something that was quite undeveloped but was the kind of thing I enjoyed the most. I threw it in because I liked it, not because there was much known about it. During the 1970s, it exploded and more than half of all the articles in all the computer science journals were dealing with topics that belonged in chapter seven.

Schofield: What’s the rubric for chapter seven?

Knuth: [00:19:02] It’s called combinatorial algorithms. This is where you have methods that are dealing with zillions of possibilities. As computers got faster and bigger, people could think more about this and get better ideas. This was an area where one good idea could make something go a million times faster.

Schofield: Not exaggerating? Really a million?

Knuth: [00:19:38] I’m not exaggerating--in fact there are cases where it’s a billion times faster, just because you do something in a different way. All the way through, even in the 1960s, I knew that there were things where once you had the right idea, you could do something ten times faster than the obvious way. With combinatorial algorithms, you can go way, way faster. Even if you don’t make the computer go faster, your program goes much faster on the same computer.
More and more people were getting these kinds of ideas, especially in the 1970s, which was the heyday when things were going so fast. At that point, I had already published chapters one to six but I was trying to keep up with chapter seven. I finally was ready with the first hundred pages of chapter seven in 1978 when I realized that I should work on typography, which is another part of my life.

**Schofield:** I want you to talk about that.

**Knuth:** [00:20:58] It was time to put out a second edition of volume 2, which was chapters three and four. It was time to come up with the second edition of volume 2 because of many new things that had been discovered. Meanwhile, the printing industry had completely changed, going from hot metal type to optical film, and photographing things. In the process, they lost the ability to typeset mathematics correctly. The galley proofs that I got for the second edition made me sick. I didn’t want to ever write a book that was going to look like that.

**Schofield:** From an aesthetic point of view?

**Knuth:** [00:22:07] Right. The letters were blotchy and they didn’t match each other. The mathematics, the spacing of all the things in the mathematical formulas, was bad. When they changed technology, they made the new technology work well for magazines and newspapers and ordinary literature. But mathematics printers--they used to call it “penalty copy”--if you want to typeset a formula, you have to pay extra. The printers didn’t have the skill to do mathematics correctly. The professional mathematics journals began to

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9 Note from Don Knuth: There were two chapters in each volume. Volume 1 is chapters one and two. Volume 2 is chapters three and four.
look atrocious. Almost nobody remembered how to do mathematics. There were some places like India and Hungary where they still used metal type and still had old people who did it well, but they were dying out. I was really feeling bad about it. In the Stanford archives, you can see the copies of these galley proofs that I got and you can see how bad they are. I think this was exhibited at the library a couple years ago because Becky Fischbach [Elizabeth Fischbach] has the collection.

In the spring of 1978, I was finishing the first hundred typewritten pages for chapter seven. As part of my duties that year I was chairing what we call our Comprehensive Exam Committee.

Schofield: This is in the Computer Science Department?

Knuth: [00:24:25] In Computer Science. Graduate students had to pass one comprehensive exam, which covered all of computer science; they had to also pass one specialized exam in their particular specialty within computer science, like artificial intelligence or compilers, or whatever their specialty was. I was chair of the committee and one of our duties was to put out a reading list for students to prepare for the comprehensive exam. A new book had just come out that had been typeset by a brand new method that used digital type instead of optical type.

All books nowadays are done digitally, but in 1977 it was unheard of. Digitally means that you divide the page up into little pixels and each pixel either has no ink or has ink. For the first time in my life I saw a well-printed book that was made with pixels. At Stanford, we had experimented with pixels, but they were very low resolution. You had only two hundred dots per
inch. It looked a little bit like a book but it really gave you a headache if you read it for too long. It looked a little more like the real thing because the letters didn’t look just like a typewriter. It was like changing from butter to margarine. It wasn’t the real thing but--

**Schofield:** It was better than its predecessor?

**Knuth:** [00:26:49] It was useful, yes. People were getting interested in this--the idea of being able to do something digital, but the quality was still awful. At that time, you wouldn’t think of actually doing a professional book that way. It didn’t look anywhere near as good even as those bad galley proofs. However, this new book that I saw, as I was building the new reading list, was done on a brand new machine in Los Angeles. It had been invented by a brilliant computer scientist. It was doing five thousand dots per inch, because they had developed it not only to make ordinary pages, but also to make microfilm. They would make film that was really tiny but still readable if you magnified it. Then they took that technology and adapted it to printing. I guess the *Los Angeles Times* was involved with this somewhat. I saw a galley proof done with that.

Now here’s the point: Having the whole thing digital means that you’re dealing with pixels, you’re working in computer science territory--zeroes and ones, off and on. I’m supposed to be the best person in the world for getting zeroes and ones to do the right thing. I know nothing about metallurgy. I know nothing about optics and film. Zeroes and ones, that’s me.

**Schofield:** That’s your wheelhouse.
Knuth: [00:28:49] Within a week, I flew down to Los Angeles to look at this machine, and decided to change my whole plan for what I was going to do. Our family was going to spend the next year--it was my sabbatical year--we were going to go to Santiago, Chile, where I could continue working on chapter seven. I'd thought it would be a nice opportunity to learn Spanish; I'd go south. But we cancelled those plans. We decided to spend my sabbatical year at Stanford where I'd be able to make fonts and do the digital work. Again, my estimate was that in one year I could write all the computer programs I would need in order to typeset my books digitally.

My writing had sort of forced me into doing something about printing. Again, Stanford came into it strongly. In the spring of 1977, the Stanford Library Associates -- oh gosh, what’s the name, starts with a “B” -- her husband had rare books--Byra Wreden was very active in Stanford Library Associates and organizing events around fine printing. Stanford has this really wonderful collection in the rare book room called the Gunst Collection. I had tremendous resources to read about what I wanted to do digitally, by learning what had been done with the previous technology.

The library associates organized a tour out to the gold country. We visited people who lived in the woods with their own hand presses. It was my entry into this world of fine printing, and led to making friends in San Francisco who were involved with the state of the art.

My idea then went from getting a book that looked nice, to using computers to get a book that looks as good as has ever been made--to maximize what we could do digitally. I changed my whole life plan at that
point. I put everything else on hold for what I thought was one year, in order to work on typography.

It’s a long story, which is told in my book, *Digital Typography*. But the other relevant Stanford aspect was that I decided early on that I didn’t want it to be proprietary. I wanted to put all of this work in the public domain, so I didn’t even ask Stanford if I had permission to do this. I just did it. As a result, it became one of the very first examples of what people now call open source software or free software. It’s not free in every sense of free, but it meant that I suddenly had thousands of volunteers all over the world wanting to pitch in and help make it good.

The alternative was to do as everybody else did and say okay, well you can use this great system if you pay me for it. Then Stanford, of course, would have gotten a lot of royalties. People were charging a lot of money for other computer-based systems for printing--like the system, called Page Three, that had been used for the book I’d seen in Los Angeles.

Each manufacturer of a new kind of digital printing had their own system, and they weren’t interchangeable with each other. Each person who developed such a thing thought that he was going to get everybody in the world paying him for it. That didn’t sit well with me, because I felt this was something that really belonged to everybody--the ability to have beautiful books. I put all of my computer programs in the public domain and I had thousands of volunteers and it took off at a very nice--

*Schofield:* This is the system called TeX?
Knuth: [00:34:58] TeX, yes. It’s not an X though. It’s a chi. Because the Greek word for art is Techne [τέχνη]. Technology comes from the same root as the word for art. Did you know--techne?

Schofield: No. And your one year became what?

Knuth: [00:35:27] Ten. [laughter] We finished the project. Then I had my sabbatical--1985, I think, we finished the main phase. You can see several books over here [pointing to bookshelf]. There are five volumes where the covers are in different shades of grey. The last one is light grey. Those are five books that summarize the work I did on typography--Volumes A, B, C, D, and E. Those books sort of describe themselves because--well I’ve got to show you. I’ve got the tenth printing of this, which is Volume E. It shows how all the letters are actually designed by computer. You can take the letter “R”--

Schofield: This program here produces this letter?

Knuth: [00:36:41] Right, and it also produces these variations if you say you want it in a different style. We are looking at the letter “R” here, but the book describes how the book itself was made because, you know, there’s a letter “R” on that page. That “R” was actually generated by the program. These five books came out in 1986, when I was on sabbatical in Boston.

Schofield: Do people still use this system? Does everyone use this system?

Knuth: [00:37:21] Physicists and mathematicians--more than 95 percent use it. Biologists are 20 percent. Chemists, maybe 5 percent. There are many encyclopedias that have been written using it. Since it’s open [source], nobody is promoting it. There are other people promoting their own thing. Yes, it has certainly cornered the market of technical writing. A good
example--let’s look at a journal, taken at random from the bookshelf. This one comes from 2006 but anyway, all of this is done with that same letter “R.” [laughter]

**Schofield:** I can see how it would be a typesetting challenge to create formulas that are spaced correctly and read correctly.

**Knuth:** [00:38:42] Yes. This is what there was a need for and what had been forgotten when printing technology went digital.

**Schofield:** You mentioned that you didn’t ask Stanford, you just put it in the public domain. Did Stanford in any way push back on you?

**Knuth:** [00:39:05] I talked to Niels [Niels J. Reimers] a little bit but he always smiled. I don’t know what he was saying behind my back. [laughter] At that time, Stanford was doing very well with its biology patents, for example, and I think also Marty Hellman [Martin Edward Hellman] had some patents about cryptography that were done with Niels. Anyway, I considered that I wanted this not for myself but for the world. I didn’t see why I should try to--if I had been in a situation where I wasn’t already doing well with the books that I had written, that would probably have been a different story--I don’t begrudge other people not putting their work into the public domain. But, in this case, it seemed to me advantageous. And it was borne out because of all the help that I got. The whole system got much better because of all the ideas that were flowing in from users.

That’s why it took me so long to finish. As more people used it, they would say, “Oh yes, you know, you ought to change this.” And that would give me new ideas. Again, it affected Stanford because we had a major
workshop here in 1982, I guess it was, bringing the leading font designers and stone cutters and people who were working in fine printing around the world, for two weeks in the summertime. It was kind of funny because everybody was staying at one of the dorms; as they went to the building where we were meeting, they passed the cheerleaders who were here for summer camp. The cheerleaders were chanting, “Give me an A, give me a B.” We went to our sessions and were talking about As and Bs.

Schofield: As and Bs. I love it. Stanford during summer camp season is a wild and crazy place. The diversity of folks that are here for different things is really pretty wonderful.

Knuth: [00:42:07] Right.

I’d originally been funded by the National Science Foundation (NSF), for research on algorithms. I was still working on algorithms, but my algorithms all of a sudden were about typography, and I was still publishing papers about algorithms of other kinds. That money--a lot of it--went to pay for the students who were helping me with the software and getting things going. That was another reason I wanted to put this in the public domain, because it was supported by government funds. I didn’t think I was putting anybody out of business because none of the printers really liked to do mathematics. I was doing something that they didn’t want to do.

However, there was one man whose career actually was to make printing systems for mathematics and to sell them to publishers. He wrote a letter to, I don’t know, maybe his congressman or someone asking why his tax money was being used to put him out of business. That made me
unhappy because I didn’t think I was hurting anybody by my work. However, I showed that letter to the people at NSF. They said he didn’t have any case. It’s one example, but there was nothing I could do to improve the quality of things and not hurt somebody I guess.

Schofield: Yes, but that is one of the goals of federal funding, that results should make their way into the public domain.

Knuth: [00:44:33] Yes, right. A lot of people will say that of all the things I ever looked at, this was the most important because it has affected so many people. Of course, by now lots of people also have a career providing services based around TeX. Without this, they wouldn’t have their job, because of the services that they build on top of it. It’s amazing. Jill and I visited Prague in the early 1990s and were waiting for a tram. We noticed that the posted tram schedule was done with TeX--of course in Czech.

Schofield: You could recognize it?

Knuth: [00:45:46] The letter forms are distinctive. But it also made me feel bad, because I remember they had a special Saturday schedule which was bold, or somehow different. The letter “S” didn’t look right to me. I said, “Oh no, I shouldn’t have made that central stroke so heavy.” [laughter] I was so embarrassed that my mistake was there on every street in Prague.

Schofield: You didn’t come back and change it did you?

Knuth: [00:46:25] I did. [laughter] Of course. It doesn’t look so bad any more.

Schofield: Oh my goodness. I love it.

Knuth: [00:46:31] Also on buses in Prague, we saw advertisements that had been done with a typeface called Lithos, which was the brain child of Carol
Twombly, one of our students at Stanford. With Chuck Bigelow [Charles A. Bigelow], we had a joint program between the Art Department and the Computer Science Department in digital typography. Carol was one of the most outstanding--well certainly the most outstanding font designer. She’s done many lovely things and her work was there, it has spread around the world. Everybody loves that typeface--Lithos--and others of hers. I got to sign her diploma because it was a joint program between Art and Computer Science.

**Schofield:** Does that program still exist?

**Knuth:** [00:47:42] No, we didn’t have enough funding to get a permanent [faculty] billet. Chuck was supported by soft money. In order to make it permanent, it would have taken more than one billet, so it was too much. The program thrived for, I don’t know, five, six years. As a result, many of the leaders in Silicon Valley who created Adobe and so on, who are responsible for digital graphics, are products of that program. That came out of writing you see.

[laughter]

**Schofield:** It came out of writing. When you go to write the next chapter or the next ten pages or whatever--in terms of habit or physical process, what do you do?

**Knuth:** [00:48:47] I write with pencil on paper and I have--is it in here? I usually keep my manuscript in here--but I’ll show you, because I’m in the process of writing something. Here it says March 8th. I’m in the middle of this paragraph right now. I scribble and I cross out, and I do it this way because I’m too good a typist. I type faster than I think.

**Schofield:** Oh, fascinating.
Knuth: [00:49:36] That causes synchronization problems. But I think at the same speed as I write in pencil.

Schofield: As you can print, yes.

Knuth: [00:49:47] I learned this about myself when I was in college actually. I was writing letters home and it would take me longer to type them than to write them because of synchronization. I would sort of lose my train of thought.

Schofield: Fascinating.

Knuth: [00:50:06] So I’ve got this handwritten document, but it’s raw copy. Then I type it and I edit it as I go. I can edit at typing speed. My second draft goes in [the computer]. When I’m writing the first draft, I’m sitting in this chair.

Schofield: This very chair.

Knuth: [00:50:39] This chair--it’s called Dux. It’s a Swedish chair that we discovered when we were living in Scandinavia, and we found out later that the man who designed it actually came to [the United States] and lived on the peninsula years ago. I think he might have even gone to the church that we go to now. I’ve never seen a chair that was anywhere near as comfortable for sitting and writing for hours at a time. It’s low. It has a particular shape. I don’t know but--

Schofield: It suits your own body.

Knuth: [00:51:28] It’s just perfect. Right. I’ve had it refinished now. This leather is about the fourth version. Originally, it was some fabric.

Schofield: You originally bought it when?


Schofield: It does have that sort of 1970s Scandinavian design look.
Knuth: [00:51:46] Absolutely. The way they shaped the wood and bent it and things like that.

Schofield: It’s beautiful.

Knuth: [00:51:54] Even if it had been made of something else, the way it sits low and reclines is just absolutely right for me. I sit in the chair and write.

Schofield: With a pencil.

Knuth: [00:52:09] With a pencil. Then I do my editing, I stand up and I go to my stand-up desk. I didn’t have a stand-up desk until the 1990s, but I learned about that from Martin Gardner who’s one of the most prolific writers ever. He must have a hundred books. He’s the hero of many people because he wrote monthly for *Scientific American* for thirty years. Everybody read and learned about mathematics from his columns. It was recreational mathematics, mathematics that people have fun with. He wrote many other books too about philosophy, and novels, and so on. I got to be friends with him. He had his typewriter up on a pedestal and he did all his typing standing up. That’s good for my health—for my back.

At the end of the 1980s, I was having some back problems. I learned at that time why people used to say physical education was important for everybody, because I had never done much exercise. Then I started going to the pool four times a week at Stanford, at the end of the 1980s. That improved my back.

Before that, I was thinking, how am I going to have a comfortable chair to sit at when I’m using the computer? A Stanford engineering professor--Bob Eustis--had designed a new kind of chair with special joinery
and everything. He loved to make these chairs and I talked to him about having a custom-designed chair for me to sit at when I was using my computer. He was one of the major [mechanical] engineering professors. I also talked to somebody named Sam Maloof who was a great furniture designer and craftsman. We worked on the design of a custom desk just for the best way to sit. I sometimes wanted to have my feet up in some way for questions of posture and all. The stand-up desk was the real solution though, so we never got these other things made.

Schofield: Once you tried that, it worked. You probably wouldn’t want to stand up for three hours straight, would you?

Knuth: [00:55:49] Actually I found out that I can stand up for three hours if I’m wearing these sandals [pointing to his shoes]. They’re made for people to go to the beach and they have little bubbles in them. The same company makes the sandals in exactly the same shape without the bubbles, and my feet get tired after ten minutes. With the bubbles, they do something, they give some signal to my nerves that keep them happy.

Schofield: What’s the company?

Knuth: [00:56:23] It’s Sensi. It’s Italian--made in Italy.

Schofield: So now you make sure you have at least a couple pairs of those?

Knuth: [00:56:33] Yes. They wear out after a while and I have one backup for next time. Yes, standing up wouldn’t work if I didn’t have these.

Schofield: I haven’t heard about that particular shoe but I have heard people talk about--

Knuth: [00:57:04] Some kind of stimulation for the feet. It’s pretty magical all right.
I learned something else with the Stanford Library Associates when we went to visit Jack London’s Wolf House. They used to have really nice tours where we would take a couple of days, stay overnight somewhere, and see something connected to books. For example we visited Steinbeck [John Ernst Steinbeck, Jr.] country. The Jack London trip was to a state monument up north--which county is it in--Napa? [Ed: Sonoma County] He was building this incredible house that burnt down within a year after it was made [in 1913].

Anyway, he lived a very boisterous life. He came from a poor family in Oakland and once he was making money on his books, his relatives all came to get as much as they could. He had this rule that he would write a thousand words every day before he talked to anybody--a thousand words of new copy. The rest of the day he could edit galley proofs and correct things, but he had to have one thousand brand new words before anybody was allowed to--

**Schofield:** To even speak to him?

**Knuth:** [00:58:55] This was a rigid rule. That’s why I brought him up because, well, okay, I’m not that disciplined. But I do try to organize my time so that the times when I’m most creative are when I’m able to write, and the times when I’m more tired are when I do other chores that are important but don’t require special creativity.

**Schofield:** Do you feel most creative in the morning?
Knuth: [00:59:34] I used to feel most creative in the evening, but I'm getting older now and it happens, like this morning, I woke up with a really good idea at 6:00 am.

Schofield: All right! Did you get it written down?

Knuth: [00:59:46] No. [laughter] No, but I remember it well enough that I’m pretty sure I’ll--

Schofield: I really hate it when I wake up in the morning and I have had some kind of “brainstorm” or I thought it was, but I can’t retrieve it for the life of me. I should have a little pad right next to my bed.

Knuth: [01:00:03] Yes, a lot of times it dissolves completely. Last night is a little bit unusual because I had stayed up till 1:00 am. I was thinking about something but my mind must have been somehow processing that because the concepts that I was fighting with at 1:00, I finally saw, “Oh, this makes a beautiful pattern.” So I got a new page for chapter seven out of this [laughter] which, let’s face it, it’s brilliant.

Schofield: And it’s fun. How great is that?

Knuth: [01:00:49] [laughter] Yesterday, after coming from this party in Berkeley, in the back of my mind I said, “Yes, but what about this problem.” I didn’t understand the structure of it. It dawned on me what the real answer was this morning. So this happened.

With the music, there are a couple cases too. The first three bars of chapter twenty-one of Fantasia Apocalyptica came to me when I woke up on a plane as we were flying into Prague one day. I call it my Prague theme. That I wrote down.
Schofield: You had been asleep on the plane?

Knuth: [01:01:53] I had been asleep on the plane. I woke up and this melody was in my head. I had a piece of paper with me and I wrote it down. When I came home I put it in this notebook and eventually I used it. As I said to you the other day, it was dictated somehow.

Schofield: Yes, you were called to do it. I was thinking after we talked the other day about your notion of being born geek and also your fascination with music. It made me think of Gödel, Escher, Bach, Hofstadter’s [Douglas Hofstadter] book, which connects mathematics to music to art. What do you think of that theory?

Knuth: [01:02:46] I actually met Doug again this year in January in Uppsala. He’s working on some interesting things now still. I definitely see this connection. Not everybody in the world is affected, but a detail-oriented person like me sees these kinds of patterns and grooves. Although I never was a huge fan of that particular book, Doug has written other things about translating that I loved.

Schofield: *Le Ton Beau de Marot,* yes. I thought that was a fascinating book. I actually happened to know Doug when I was much younger and we were in school in Geneva.

Knuth: [01:03:51] Yes, he’s a great friend. Actually Martin Gardner, who had a column in *Scientific American,* retired and asked me if I would be interested in taking over the column. This was a huge responsibility--and I couldn’t believe that he would ask me this--and so I declined. Doug Hofstadter took it over for five years or something like that.
Doug and I also intersected in my typography project, because I wrote an article for typographers about the concept of a metafont. Remember when I showed you the letter “R” a minute ago? There were three Rs on that page but they were all drawn by the same computer program. Doug had this idea that you could call them knobs, which you get to turn. I had this program and you can turn a knob saying how bold do you want it to be? How narrow do you want it to be?

There are some sixty different knobs that you can turn affecting the shape of the letters. I called this a metafont because it incorporates many fonts at once. It’s not just one design. Computer scientists are used to the idea that you can make a meta description of something that goes beyond a single description. It varies as parameters vary.10 We’re used to writing a program that will produce different effects if we change the settings of the parameters.

But this was a brand new concept to font designers. They would treat each font as a new challenge. If one week they were asked to do it an ordinary way and then the next week their boss said, “Now do a bold weight for us,” they would start all over again.

With the computer I can say well, try to imagine what would it be if it was half bold, what would it be if it was something else—you know, try to solve many problems at once instead of each one, one at a time. I wrote an article for typographers called *The Concept of a Metafont*. This article was actually fun to write because in the middle of its sentences, I could distort the

10 Note from Don Knuth: Parameters or “knobs.”
letters in different ways. I started the article with a font that’s in a very old sixteenth century style of type, and I ended it with a hyper-modern style, where the x-height is large and there are no serifs. In the middle, there’s a section that takes the 23rd Psalm and the first letter of the 23rd Psalm is in this old sixteenth century style--there are six hundred and some letters in it--and the last letter is in the hyper-modern style. Each letter gets a little bit closer to the final one.

[01:08:05] Doug loved this. He put this in his *Scientific American* article. It went into the Russian translation so we had the 23rd Psalm in Communist Russia [laughter] as an example. Then he wrote an essay about letterforms because he was inspired too. He wrote an article that shows, I don’t know, fifty different versions of the letter “A” and asks what does this tell us about human psychology and things like that. He made a statement in his article saying the most important question of artificial intelligence is what is the letter “A”? Let’s paraphrase his statement and say the most important question of AI is what is the letter “A”? I replied, “And the second most important question of AI is what is the letter ‘I?’” [laughter]

Those are my Doug Hofstadter stories. Of course, I visited his house on the Stanford Historic Houses Tour.

**Schofield:** Where he grew up?

**Knuth:** [01:09:40] Yes. It’s in San Juan Hill.

**Schofield:** Let’s move on to some other topics. You’ve mentioned that you go swimming, that you started that as a form of exercise and you still do that every single day--no four times a week.
Knuth: [01:10:02] Monday, Tuesday, Thursday, Friday. On Wednesdays, I stay home.

Schofield: You go to one of the Stanford pools?

Knuth: [01:10:08] Right now I go to the new one, which is-

Schofield: By the Roble Gym?

Knuth: [01:10:21] Right. It’s a brand new pool. They had a small pool there before and we would go there sometimes in the summer. Now this new Arrillaga Outdoor Recreation Center has a nice pool.

Schofield: You swim laps?

Knuth: [01:10:43] Yes, right. My main worry about swimming is that I might get too good at it and then I’d take it seriously.

Schofield: You don’t want to become a master swimmer?

Knuth: [01:10:54] That’s right. I just want to enjoy it.

Schofield: Just get the exercise.

Knuth: [01:10:58] It’s very good for my heart and it’s very good for my muscles, lungs and so on. I have to admit that Stanford has some lovely students who are very graceful as they’re swimming, and so I enjoy that aspect of our pools. I’m not a competitive swimmer, but I do enjoy seeing other people enjoying the water too.

Schofield: When you see someone who’s really a beautiful swimmer, where the strokes are even and lovely, it is very graceful.

Knuth: [01:11:49] It’s like a poem, yes. Sometimes I’m thinking about my book as I’m swimming. If I’m working on a hard problem, at the beginning I need pencil and paper and I have to scribble and cross out things. When I’m nearly ready to solve the problem, I can do it in my head while I’m
swimming. I know how well I'm doing on something by to how much I can do while I'm--

**Schofield:** While you're swimming. Interesting.

**Knuth:** [01:12:37] Yes, and, of course, I meet other people from other parts of the campus also at the pool. That’s another time when I get out of my immediate department circle.

**Schofield:** And you bicycle also, right?

**Knuth:** [01:12:54] I bike to the pool, and that’s part of keeping my back in shape.

**Schofield:** Whenever you go anywhere on campus, you ride your bike and suitably put on your helmet, to protect your noggin?

**Knuth:** [01:13:07] There are some people who’ve never seen me without my helmet.

[laughter] At the library especially. I don’t know if they would recognize me otherwise.

**Schofield:** The only thing about bike riding is you do have to watch out for all these other crazies around you.

**Knuth:** [01:13:27] Oh it’s true. I had some close calls at different times, yes.

**Schofield:** But you’ve never had a serious bike accident?


**Schofield:** But you don’t go out on major roads?

**Knuth:** [01:13:50] I don’t go very often. No. I started that at the same time of pretty much the end of the--well, I was biking all the way through.

**Schofield:** It’s nice. You live on campus and you’re close to the places you need to get to.

**Knuth:** [01:14:11] That’s exactly why I came to Stanford, because I could live within a couple miles of my house and my office for the rest of my life.
Schofield: I’ve noted things that I think you’ve described, or I would describe, as personal values, for example the value of rigor and elegance. I wondered if you wanted to talk about either those, or other personal values. Also I think you have quite a strong history of connection to your church, your Lutheran faith.

Knuth: [01:14:52] Certainly I grew up in a very loving community that set the tone. My parents were both very much oriented towards service to others rather than what they could get out of life for themselves. My father’s name was Ervin, or Erv for short. He started a company that operated out of his house, to do projects for his friends. He called it Erv’s Service and the logo was “sErVice,” with erv in large letters. Service was sort of the story of his life, to see what he could do that other people would appreciate.

He operated in a local environment. In other words, hardly anybody outside of Milwaukee would ever know of anything that he did. But where he was, he was always pitching in and helping people with things.

My mother was also the same way. She was a member of many volunteer organizations, and she was a little bit more visible than my dad because she sort of ran several of the skyscrapers in downtown Milwaukee; she was manager of the buildings.

Schofield: Property manager.

Knuth: [01:16:43] She had to work with the cleaning crew if there were floods, but she’d also design space for new tenants, all the doctors and bankers and so on. She was doing a lot of things in the downtown area and she was a member of the Building Owners and Managers Association and one of the first women officers of that nationwide organization. She did this full-time--
but it didn’t detract from any of the volunteer work that she was doing part-time. So I grew up with the idea that this is the way to live.

Special among the values was the idea to help each other with whatever skills we happen to have. Now that we have a president whose ideals sort of contradict all of mine, it’s much easier for me to understand what my own ideals are.

**Schofield:** I hear you.

**Knuth:** [01:18:29] I’m glad to see that I’m not the only one that has them here. But I’m amazed at how many people—I used to think there were more good souls around.

**Schofield:** It’s hard to imagine quite how we’ve come to this place, quite how so many people were able to believe that he should be the president of our country.

**Knuth:** [01:19:01] Yes. It’s not the policies. It’s just integrity, the whole notion of character. Jill and I went to a Stanford Continuing Education event a few months ago where Herant Katchadourian led a study of the seven deadly sins.

**Schofield:** I think I read about that.

**Knuth:** [01:19:35] We spent all of Saturday at these sessions, and he’s absolutely a brilliant lecturer. All the way through I’m thinking, okay, what would Trump have to say about each of these seven deadly sins. Is there any one that—okay, so we’ve got greed, sloth, lasciviousness [or lust], gluttony, wrath, envy, and pride—maybe not sloth so much. Give him a pass on that one. For moral values certainly come out of what I think is actually common to all of the major religions of the world. And Trump stands in contradiction to most of those principles.
Now there’ve always been people who had those faults but they weren’t so blatant and they weren’t in positions where they’ve sort of represented me. I just hate the fact that more people hate me now than before, but I didn’t change. [laughter] What I mean is that people have so much more reason now to think that I’m a bad person than they would have had before, because they might identify [the United States] with the values that Trump exhibits. They’ll sort of think, “Oh, he’s American, he must be like that.” Maybe not, but I find myself thinking that about some places. I sort of characterize people unfairly but--

Schofield: I know. I think we all have tendencies to. But remember there was an era when we were called ugly Americans? The tourists who went to Europe somehow exhibited horrible, bad behavior.

Knuth: [01:22:25] I have met them [laughter], yes--

Schofield: Let’s just believe that this too will pass. We have to do what we can do to--

Knuth: [01:22:43] Sure. But it brings it into sharper focus. As a computer scientist and a lapsed mathematician, there’s part of my life where I’m able to find the absolute truth about something. With mathematics and computer science, we can prove that something is correct without a doubt. It’s airtight. Physicists don’t even have this ability. They never know whether they’ve captured the laws of nature. They can only measure to a certain extent. Mathematicians can measure all the way to the end and know that they have exactly the answer and two plus two is never going to be anything but four. That gives me some satisfaction that I can surround something and understand it completely.
On the other hand, I also celebrate that there are mysteries that I
never will understand, that there are things that are beyond me. There’s no
reason for me to be hubristic and think that I can conquer any problem. I’m
only a human being and have human limitations and so there are mysteries--
and I’m very comfortable with that aspect too, that there are questions I’ll
never know the answer to but I can still keep searching and keep
approaching a little closer to the answer. That’s the way I view the spiritual
side of my life, the religious side of my life. I do believe that God wants me
to continue this quest, of learning more about what God wants me to do.

I don’t consider that God is a convenience or something like that. I
think of God as a presence that’s there and, thank goodness, can never be
proved or disproved, but remains a mystery. And it gives me some confidence
that there’s some sense and order and everything isn’t just random.

**Schofield:** This is God in a sense that transcends an individual religion?

**Knuth:** [01:25:53] That’s right. I’m not saying that any tenets of any particular
religion will ever be provable. A lot of the great philosophers thought that
but I think they were wrong. I think if it were provable, everybody would run
through the proof and memorize it and forget about it the next week. That’s
why I thank God that it’s a mystery. I spend a lot of time pursuing all the
clues that I can get about what God might want me to do. For example, I
sort of have the feeling that God, he or she, wants me to prove the theorem I
proved this morning. [laughter] And write music. That drives me.

Also I have a different feeling about privacy. I never felt that I had
secrets from God, so I’m not very good at working on parts of computer
science that would protect privacy. I certainly don’t want crooks to know all about me and to exploit that. But I still am not uncomfortable with the idea that my worst characteristics might be known to some. I just feel that part of life is not being totally private.

That is the short answer as to how I interact with spirituality. I became a little bit of a poster child for it because I was asked to speak about it a few times in my life. I think what I do well is computer science, but computer science isn’t everything.

When I was asked to come to MIT for a quarter and to give public lectures about the interaction between faith and science, well, I was honored that they would think of me. And I also said okay, maybe that’s something I ought to do once in my life. I didn’t want to make a career of doing something that I wasn’t that good at, but I thought the interaction between faith and science was something worth addressing. I spent three months and really enjoyed preparing those six 1-½ hour lectures, about forty minutes from notes and then the other fifty minutes was improvised like this [interview], question and answer. These were actually videotaped and on Dr. Dobbs’ video channel for another ten years afterwards, and supposedly were getting the most hits of all the things on that channel for a long time. It showed that other people also found a need to contemplate different parts of their life.

Schofield: And to see that science was not antithetical to religion.

Knuth: [01:30:17] Antithetical, right. I didn't provide answers or say that I believe this and I’m smart so you’d better believe it too. I was saying, here are things
that I think are interesting. Don’t you think they’re interesting too? What do you think about these controversial questions?

I think this personal idea of realizing that we don’t have all the answers is worth taking time to explore. What better place could there be to do it than in Boston, where there was so much going on theologically, as well as at MIT where there was so much going on with science?

Schofield: What year was this?

Knuth: [01:31:09] This was 1999. I had previously lived in Boston, during a sabbatical year in 1986 after the TeX project was done. That was my wife’s sabbatical year. It was our 25th wedding anniversary and the kids were out of college and out of the house--I could do all the cooking and shopping and Jill could work on her books that year.

Schofield: That was your sabbatical?

Knuth: [01:31:38] One year out of 25, I gave to Jill as her sabbatical. I was the househusband and I--

Schofield: And you followed that faithfully for the year?

Knuth: [01:31:49] Yes. During spare moments I went to Boston Public Library to research my book on 3:16, where I had this crazy idea that I would study chapter 3, verse 16 of every book of the Bible and see what had been written about it over the years. In my spare time that year--we were living in downtown Boston, downtown Cambridge, no Boston Back Bay, so six blocks to Boston Public Library.

Schofield: After one year of being a househusband, you decided that’s enough?
Knuth: [01:32:30] Oh, I got to appreciate what it involves. One of the major events was that my son John was directing Stanford’s Fleet Street Singers that year and they came on tour and they all slept in our apartment one night.

Schofield: Did both your kids go to Stanford?

Knuth: [01:32:54] No, no. Jenny knew she didn’t want to go to Stanford, but still she wanted to see if she could get admitted, and she did.

Schofield: She got admitted and then went to--?

Knuth: [01:33:11] To Brown. She wanted to roll her own major. John didn’t want to venture very far so he applied as far east as College of the Pacific in Stockton. [laughter]

Schofield: Let’s see. Let me ask you about--I have a couple things here but I was thinking we might move to your interest in history.

Knuth: [01:33:53] In history, yes, because I found as I’m writing *The Art of Computer Programming*, one of the most important things is not only to realize that there were geeks who lived in other centuries, but also to put the human aspect of the story in it. I say okay, we’ve got these wonderful results; but somebody first thought of them. And if you understand how people thought of great ideas, then you’re more likely to be able to think of new, great ideas yourself. I’ve tried to show the way ideas are born and refined and how this enters into the human experience.

It’s really wonderful that cultures from all over the world have contributed to computer science, and for so many years. I often find myself working with other friends and scholars to study Sanskrit documents, and French and Russian and German and Spanish and Japanese and so on,
Schofield: All of which you can read? Or you read in translation?

Knuth: [01:35:30] Oh, I’ve only learned how to “pattern match,” and how to use a dictionary—I’ve got dictionaries sitting here, Dutch or whatever. I’m not a great linguist but usually I can recognize the combinatorial patterns that the person who’s writing has used—then I have a small number of pages that I can show to some other Stanford professor. For example, if I had a question on Latin, I would talk to Michael Wigodsky. I would use Stanford resources for all of these things. George Brown [George Hardin Brown] has also helped me with medieval Latin.

I realized early on that reading source materials by people as they’re discovering things is very important for me in understanding the process of discovery. I try to reflect this in my writing. But it really was also the worst failure in my career, as none of my students—well with one exception now—have picked up this love of history that I have. I wasn’t able to convey that to them when I was their advisor. But Lyle Ramshaw [Lyle Harold Ramshaw] wrote a paper a couple of years ago where he did some great historical research going back into eighteenth century Sweden. He has caught the bug a little bit.

Schofield: You did try to convey it in your classes?

Knuth: [01:37:41] In my personal advising more than anything else. In my classes, I tell the history and I give public lectures. For example, I focused on Arabic and Sanskrit in the lecture I gave at Christmas I guess a couple years ago. These are fascinating stories to see how people were ahead of their time. I guess I should also mention the Hebrew writings in the Kabala that
anticipated ideas in computer science. This is more than a hobby for me. I think it’s important.

Right now, we have the situation that universities in America are not supporting history of science the way they do in Europe. There are only two or three places in the United States where they have a good professor of the history of mathematics—Princeton, Yale, and the other one is West Virginia or something like that. But the main historians of mathematics are in England and Germany and France.

**Schofield:** I think Stanford had a small history of science program, but I don’t know if it still does.

**Knuth:** [01:39:53] History of science went through a sea change. Fifty years ago, history of science was talking about how scientific ideas were discovered. Now they’re writing about how the scientists got funding, they’re not getting into hard science hardly at all. It’s gone from internal history to external history. Look for instance at the main journal of history of science; it’s called *Isis*, of all things. That’s the Egyptian goddess of wisdom [or fertility] or something. I went and read through *Isis* from fifty years ago and then I read the current issues. I rated them as to how much science they got into versus how much--what do you call it--context, living in the world, how did scientists pay for their education, who criticized them.

**Schofield:** More sociological?

**Knuth:** [01:41:26] Part of the reason is that science is getting harder. [laughter] So if the people who are going to promote you are going to understand your papers, you’d better not write anything about a specialty that’s going to make
those people uncomfortable. That will subtly make them feel that they aren’t
deserving of their own professorships and so they aren’t going to support you.

Anyway, for some reason, this sea change has occurred. I got upset
about it, but I also realized part of the problem is that not a single U.S.
university computer science department supports a historian of computer
science.

There are people who belong to some history of science program but
they aren’t allowed to write about computer science itself because their
colleagues aren’t going to understand what they say if they really talk that
much about technicalities. They write about interesting things like, this is the
first woman who did this. They stick to more cultural things and, of course,
these are important issues but it’s taken over one hundred percent. I vented
about this at the talk that I gave in the Kailath lecture of 2014. I’ve been
trying to work out a plan where Stanford would employ a full-time historian
of computer science, to lead the next generation of historians. However, I
don’t have enough personal time to fight this battle. I’m retired and I know
that I do better at writing my books than fighting battles. I’m hoping that
somebody else will carry the torch. Anyway, while we’re talking oral history, I
wanted to mention history.

Schofield: Good for you, a plug for history. I know you’re a fan of many of the things
that the Stanford Historical Society is doing. I see you popping up in all sorts
of places where interesting talks are happening.

Schofield: What are you working on now? You’re continuing with *The Art of Computer Programming* and hoping--

Knuth: [01:44:01] Chapter seven, section 7.2.2.1. I’m hoping that by October I’ll have three hundred pages ready to publish.

Schofield: You’re publishing it in pieces?

Knuth: [01:44:19] Yes. This paperback on the desk is number six. Number five is what I’m working on now, which comes before six and then when I have five, six, and seven, I’ll make it a new hardcover volume.

Schofield: I get it. All right. That’s one way to feel like you have accomplished stages of it, as opposed to feeling like the whole thing has to come together.

Knuth: [01:44:58] The subject has grown so much that I can’t be on top of everything. By putting it out this way, I get people all over the world critiquing it and helping me fill it in, to get the story right.

Schofield: If it’s published in this way--soft cover and then you get feedback on it, do you then update it before it becomes hardcover?

Knuth: [01:45:25] Oh yes, absolutely. Right. Here’s the hardcover of volume 4A. That’s the beginning of chapter seven but it only gets to nine hundred pages.

Schofield: This is volume 4?

Knuth: [01:45:44] 4A.

Schofield: Part 1?

Knuth: [01:45:48] That’s right. [laughter] I’m sorry, volume 4A, right, is Combinatorial Algorithms, Part 1. Volume 4B will be Combinatorial Algorithms, Part 2. They contain parts of Chapter 7, which is the chapter that, as I said, exploded during the 1970s. I still keep calling it Chapter 7, but, you know, that’s why I
have 7.2.2.1 as part of chapter seven. This volume originally came out as fascicles number 0, 1, 2, 3, 4 in paperback. Before the paperbacks came out, it was on the internet in pre-fascicle form. Right now, every three weeks or so, I update the current version of what I’m working on.

**Schofield:** I’m seeing at the back “Answers to exercises.” So it is a textbook? A book where you pose problems and you have the answers?

**Knuth:** [01:47:04] It’s for self-study. This was one of the most effective ways to compress a lot of information into one book. I can get a lot of important detail in the exercises and the answers. I can compress a ten-page paper into a five-line exercise followed by ten lines of answers. If somebody is motivated to work on the exercise, then the answers are enough to give them all the key ideas that were in that paper. If I had to write everything out and introduce all the thought process and everything, then it would take a lot longer.

**Schofield:** I just happened to find a page here where you have penciled notations at the top. Is that something you’re hoping to change?

**Knuth:** [01:48:00] This is my master copy. This particular volume is now in its eleventh printing and in each printing maybe sixty pages have been updated.

**Schofield:** I see. You write something down that you want to update.


**Schofield:** What a process and it’s never ending!

**Knuth:** [01:48:25] If it’s in blue in that master copy, I corrected an error. If it’s in orange, it’s a minor improvement. If it’s in yellow, it’s an amendment or extension.
Schofield: And if it’s just in pencil?

Knuth: [01:48:41] That’s a mistake. I should have color-coded it. Where is the new answer? I should have made that in yellow. [laughter]


Knuth: [01:49:08] You mentioned one of my values was rigor and elegance--I try to find the most elegant way to present these answers. I’m surprised there isn’t more blue coming out at us. This was a mistake.

Schofield: I have read, and you’ve talked about this, that you encourage anybody who finds mistakes to let you know. And if you agree it’s a mistake, then you pay them?

Knuth: Two dollars and fifty-six cents.

Schofield: Two dollars and fifty-six cents, which hasn’t changed?

Knuth: [01:49:46] Right. This pile over here has letters [I’ve received]--like here’s a misspelling in Russian names; here’s somebody who says look at page 862. Yes, these are letters I haven’t answered yet. Every four weeks or so, I go through this pile.

Schofield: And does your assistant go through all the email that you don’t receive directly and choose the things that she--I believe it’s a she--thinks you need to see?

Knuth: [01:50:28] That is the way it worked until she retired fifteen years ago.

Schofield: Uh-oh. Now how is it working?

Knuth: [01:50:33] People aren’t supposed to know this, but the mail goes to Maggie McLaughlin [Margaret McLaughlin] who worked at Stanford for many years. I use her email account.

Schofield: Oh, so it’s really you?
Knuth: [01:50:48] It’s really me.

Schofield: Fascinating. Do you want us to take that back out of this oral history so people don’t learn that?

Knuth: [01:51:00] It’s all right. Here are cases where I’ve already made the correction. I do have a secretary now who comes in one afternoon a week and mails out the checks.

Schofield: Mails out the two dollar and fifty-six cent checks? I love it.

Knuth: [01:51:21] The checks are designed by my wife, from my own bank. It’s a fictitious bank, the Bank of San Serriffe. Jill designed this check.

Schofield: But they will work?

Knuth: [01:51:42] No, no, it just says “deposit to the account of” and then it goes on the internet and everybody gets brownie points for having their names there. If they want to convert their balance to real cash, then they can tell me that they want it, and I can send them stamps or something.

Schofield: Yes, but they probably would much prefer to have this unique check.

Knuth: [01:52:09] That’s why we tried to make it a nice-looking check.

Schofield: Yes, it is nice-looking. We’re closing in on the time that you and I probably have available to give to this. Let’s end with talking about the Stanford environment, maybe memorable Stanford moments or people who have visited. I noticed that you were on the guest list when Queen Elizabeth [Queen of the United Kingdom] visited. I don’t know if you actually attended that luncheon but--

Knuth: [01:52:41] Yes, we went to the president’s home at Hoover House. I remember that she was very short. They had a wonderful schedule for her
and every few minutes, she would retire. I remember Prince Philip [Prince Philip, Duke of Edinburgh] was very tall and that he had hair growing out of the middle of his nose. [laughter] It was very prominent so he must have taken pride in it.

Schofield: That's rather unusual. It's the kind of thing one would normally get rid of, don't you think? This was in 1983 I believe?

Knuth: [01:53:32] Right. That's what? Thirty-five years ago, but I still remember the hair growing out of his nose. I don't know what it looks like now. That was Don Kennedy's house at that time, right?

Schofield: Yes, the Hoover House is the president's residence.

Knuth: [01:54:01] Occasionally I met a few US senators and so on. Once I met Nicolae Ceaușescu when I went to Romania.

Schofield: What was he like?

Knuth: [01:54:41] He was a busy man who, at that time, was surrounded by television cameras. He just mumbled a few words. Much more important, I got to meet the King of Sweden. Ah yes. Jill and I had dinner with him and for half an hour we could just talk.

Schofield: When was this?

Knuth: [01:55:11] I got a medal from the Swedish Academy, an Adelsköld Medal. I should be able to figure out what year that was. Yes, 1994.

Schofield: So you went to Sweden to receive the medal?

Knuth: [01:55:47] Right. It doesn't have money associated with it like the Nobel Prize does. It's a nice-looking medal. It is issued by the same academy that
approves the Nobel Prizes. It’s given every, I don’t know, ten years or something like that. People like Thomas Edison have received it in the past.

Schofield: That’s an honor, to be in such company, lovely.

Knuth: [01:56:27] We were there and the king came to the ceremony. The United States had a new ambassador of Sweden who had been appointed by Bill Clinton; he had just presented his credentials or something like that, and turned the king over to us. I talked to him. He was asking about what they called the information highway at that time. The internet was just beginning and he was saying how his teenage daughter was interested in computers and so on. He was a very pleasant man. He was very shy and actually he spoke English well. He’s dyslexic so people may think that he isn’t as smart as he really is.

Schofield: What about Gorbachev [Mikhail Gorbachev], who visited campus twice? Did you ever intersect with him?

Knuth: [01:57:51] I admire him a lot. While he was here, I saw somebody who saw him. There were so many crowds. But I could look at a person and I could see that that person was actually seeing Gorbachev.

Schofield: By association.

Knuth: [01:58:10] Yes.

Schofield: What about any other, I don’t know, famous or interesting people to you--computer scientists, probably you’ve met them all--musicians maybe?

Knuth: [01:58:21] Of course, Stanford being I think always number one in computer science, everybody comes through here. Stanford was so strong in the early days--we don’t have a corner on the market now. I’m glad that there are many places in the world where--
Schofield: Where they are doing this kind of good work?

Knuth: [01:58:58] Good places, yes. At that time, we would admit twenty students to graduate school and eighteen of them would accept. Five of them would have been awarded National Science Fellowships. They would all come to Stanford. Every good place had admitted these people and had to cross them off of the top of their list. We had a ninety percent acceptance rate. Now we’re getting fifty percent.

Schofield: For the twenty that were being accepted, how many were applying?


Schofield: You worked on graduate admissions somewhat, didn’t you?

Knuth: [01:59:48] I was chair of that committee in my turn.

Schofield: But you were never chair of the department?

Knuth: [01:59:54] No, no, no. I told Stanford that the only reason I would ever think of leaving was if I was asked to chair the department. [laughter]

Schofield: You knew where your talents, interests, and commitments were?

Knuth: [02:00:10] I also knew where my failures were.

Okay, in the Admissions Committee, I invented a fairly interesting procedure for reading the applications, kind of a design so that every applicant would be treated fairly but it wouldn’t take so much time on the committee. They still use that--I made up a new kind of combinatorial design for this purpose.

I once was chair of the Curriculum Committee and they were trying to decide policies for the courses we were teaching our undergraduates. I thought, okay, I have a good idea how to handle the contentious issues. I will
charter the second floor of a Chinese restaurant, then we will all go there and
have our meeting and we’ll have our meal and handle all the business and
we’ll solve all the problems.

Schofield: We’ll just hash it out?

Knuth: [02:01:27] Yes. Worked out beautifully. All the problems were solved and we
went home. But I forgot to tell anybody what the solution was. [laughter] It
was off my mind. Yes, I know I blew it. In other words, as a potential
administrator, I’m a very bad communicator.

Schofield: Hopefully somebody filled the gap--“I think this is what we decided, right?”

Knuth: [02:01:52] I finally remembered what it was.

Schofield: As you look at the campus--

Knuth: [02:02:01] It’s beautiful.

Schofield: --or its culture, both things, over fifty years, what strikes you? The changes here?

Knuth: [02:02:13] In the first place, it strikes me that I’d much rather walk through
the campus to another building to talk to somebody--because it’s just such a
pleasant campus--than to pick up the phone and call them.

It has changed, though. If I do pick up the phone now, I almost
never get anything but voicemail. Hardly anybody answers his or her phone,
including in the rare book area in the library. People found that they have
this machine now that takes the message and so they turn off that part of
their life a lot more than they did fifty years ago. But still I don’t have to do
that very often because I just love to go through the gardens and see the
buildings that I pass.
For example, I use the library website very heavily and I often find problems with it. There’s a guy named James Harris who would answer my letters when I saw something about the website that could be improved. I always wondered who he was. I found out oh, he’s in this office, not in the library but over in the old business school. The fourth floor’s been remodeled and you can’t go up there unless you have a key or something. But I found my way to his office--talked people into letting me in to meet him in person. That’s the way I like to work at Stanford--to see people. I enjoy that. I’ve always liked that aspect.

**Schofield:** It’s becoming more difficult. I think you’re right.

**Knuth:** Yes. The other thing is that there’s construction going on on campus. I used to say, oh how nice it’s going to be when the construction is over. [laughter]. Now I realize it’s never going to be done. I’ll have to change my bike route every few months for always.

**Schofield:** Change is good? I agree with you. In one of my previous incarnations, I had responsibilities for campus facilities and I thought okay, we can project maybe five or six really important buildings and then we’ll be done. Never. Never, never, never. In the early 1970s, I remember big plywood construction fences, and someone had painted, “Stanford has an edifice complex.” [laughter] I do believe we do.

**Knuth:** Yes. It’s necessary to keep reinventing yourself. That’s the nature of a university.

**Schofield:** I guess. But I think good ideas can be born in old buildings.
Knuth: [02:05:44] That’s true. Every time you put up a new building, you have to maintain it forever.

Schofield: Then you have to fill it with extra people and--

Knuth: [02:05:52] I understand. They’re going to take down the biology building, Herrin Lab, and build a new computer science building for us next year.

Schofield: Is that right?

Knuth: [02:06:02] Yes.

Schofield: Where’s Computer Science now?

Knuth: [02:06:15] It’s in Gates Hall.

Schofield: But it needs another building?

Knuth: [02:06:19] Yes, so we’ll have two buildings.

Schofield: Is that because Computer Science is growing--the department?

Knuth: [02:06:33] Are you kidding me?

Schofield: I know the field is growing, but is your department growing?

Knuth: [02:06:37] Oh absolutely, yes. We also have so many positions we can’t fill because there aren’t that many qualified people to hire.

Schofield: This is on the faculty side?

Knuth: [02:06:51] Yes.

Schofield: Faculty billets. Not just more post-docs or more grad students?

Knuth: [02:06:54] That’s right. The field is growing extremely rapidly. We also have a lot of our faculty in the--what do you call it--Bio-X. We’re much too big to have a party for the whole department now.

Schofield: Interesting. How many faculty?
Knuth: [02:07:27] I don’t know. It’s about sixty.  

Schofield: Oh my goodness. Bigger than some small schools. Maybe your idea that it should become the School of Computer Science was right.

Knuth: [02:07:45] I was at Berkeley yesterday and I found out that they’ve just started a new School of Data Science. Their dean is probably going to ask the School of Computer Science to leave Engineering and move--I don’t know.

Schofield: A new School of Data Science. I’ll be damned.

Knuth: [02:08:03] I don’t know. I have no idea. It’s all very contentious. I talked to the guy--it’s brand new and they really have no curriculum. Their classes are very popular but they kind of change weekly. The way students study data science now is: this week we’re going to look at the data from, say, astronomy and next week we’re going to get data from somewhere else. Each student Googles everything they can about it and works on it, and studies it, and then they go on to something else.

Schofield: Speaking of Google, were they your students?

Knuth: [02:08:55] I was retired but we worked together actually. I was always talking especially to Sergey [Sergey Mikhaylovich Brin]--not so much Larry [Lawrence Edward Page], but I knew Sergey pretty well. Sergey and I have a bet as to whether he’s going to finish his PhD first or I’m going to finish The Art of Computer Programming first. [laughter]

Schofield: They spun off to create one heck of a company. A final question, maybe this is a good segue. What are your opinions or observations about the relationships between Stanford and Silicon Valley?

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11 Editor’s Note: As of 2018, Stanford’s Computer Science Department has 58 faculty members, as well as lecturers, adjunct faculty, and emeriti.
Knuth: [02:09:40] It’s a wonderful resource and generator of new ideas that’s keeping us fresh. We can have state-of-the-art projects for our students and we have guest professors all the time who are giving absolutely first-rate courses. It’s disappointing when we lose our great faculty to their start-ups. A lot of early retirements have come from people who realized that probably their greatest skill was changing the world rather than changing a hundred students. We still see them frequently and certainly the fact that Terman developed expertise in electronics that led to Silicon Valley was beneficial for the world and for Stanford. It was the reason that Stanford could move on and keep reinventing itself.

Schofield: I think some people worry that maybe the connections are too deep, that the crisscrossing back and forth between various Stanford departments and industry is not healthy. But I certainly have no knowledge.

Knuth: [02:11:53] I don’t know. I think I told you that the thing I understand least in the world is finance and economics. As I said, in the early 1970s, I knew that if the university would somehow have closed, I would still teach—I’d find a way to teach. That’s what drives me. But then I did my typography work. I didn’t have any stake in the finances of that. But I’m not sure that my attitude is the correct one in general.

Schofield: It is the attitude you have.

Knuth: [02:12:47] Yes.

Schofield: It’s your approach. Let’s end.

Knuth: [02:12:54] Okay, thank you Susan.
Schofield: Are there any questions you wish I'd asked, or any concluding comments you want to make about you and Stanford over fifty years?

Knuth: [02:13:06] Just that I'm overwhelmed at how wonderful an interviewer you are.

Schofield: That's kind of you, but it's probably not true.

Knuth: [02:13:17] It's absolutely true. I couldn't imagine how it could have been done better in any way. I'm sure you have many other skills, but this is one of your callings for sure.

Schofield: Thank you. It is kind of a passion. I have enjoyed being involved with this program and helping it to grow, the Oral History Program. Thank you so much for giving us some of your time, even after numerous, numerous, numerous interviews in other places. These reflections on Stanford, in particular, I think will be very valuable.

Knuth: [02:14:00] Yes, you were able to set the context so that I could say all kinds of things that I was really happy to get on the record, that I don't think were on the record before.

Schofield: Well good. Thank you very much.

[End of Part 2 of 2, Interview with Donald Knuth - May 11, 2018]
Donald E. Knuth
Curriculum Vitae

Academic History
Case Institute of Technology, September 1956-June 1960; BS, summa cum laude, June, 1960; MS (by special vote of the faculty), June 1960.

Employment Record
Assistant Professor of Mathematics, California Institute of Technology, 1963-1966.
Associate Professor of Mathematics, California Institute of Technology, 1966-1968.
Professor of Computer science, Stanford University, 1968-.
Professor of Electrical Engineering (by courtesy), Stanford University, 1977-.
Fletcher Jones Professor of Computer science, Stanford University, 1977-1989.
Professor of the Art of Computer Programming, Emeritus, Stanford University, 1993-.
Honorary Distinguished Professor, Cardiff School of Computer Science and Informatics, 2011-2016.
 Theta Chi Hall of Honor, 2016-.

Professional Societies
American Guild of Organists, 1965-.
American Mathematical Society, 1961-.
Association for Computing Machinery, 1959-.
    Chairman, subcommittee on ALGOL, 1963-1964.
Mathematical Association of America, 1959-.
Society for Industrial and Applied Mathematics, 1965-.
Patents


Principal Invited Lectures Given

ACM National Convention, Syracuse, 1962.
NATO summer school, Denmark, 1967.
Britannica Scholar, Chicago, 1968.
IFIP Congress, Ljubljana, 1971.
Mathematical Association of America, San Francisco, 1974.
Symposium on Computational Systems, Monterrey, Mexico, 1975.
Chaire Aisenstadt, Montréal, 1975.
American Association for the Advancement of Science, Boston, 1976; see paper P82 below.
Gibbs Lecture (American Mathematical Society), Atlanta, 1978; see paper P91 below.
Hitchcock Professor, University of California, 1979.
Ritt Lecturer, Columbia University, 1980.
International Colloquium on Automata, Languages, and Programming, Epidaurus, Greece, 1985; see paper Q82 below.
IFIP Congress, San Francisco, 1989 (keynote address); see paper P138 below.
Organick Memorial Lectures, University of Utah, 1990.
Donegall Lecturer in Mathematics, Trinity College, Dublin, 1992.
Commemorative lecture for Fiftieth Anniversary of Mathematisch Centrum, Amsterdam, 1996.
Commemorative lecture for Kyoto Prize, Kyoto, 1996.
Pascal Lectures, University of Waterloo, 2000.
Strachey Lecture, Oxford University, 2001.
BCS/IET Turing Lectures, 2011.
Dan E. Christie Lectures, Bowdoin College, 2011.
Vienna Distinguished Gödel Lecture, Vienna University of Technology, 2013.

**Editorial Boards**

ACM Transactions on Algorithms, 2004-.
Acta Informatica, 1970-.
Japan Journal of Industrial and Applied Mathematics, 1997-.
Journal of Computer and System Sciences, 1969-.
Journal of Computer Science and Technology, 1989-.
Journal of Experimental Algorithmics, 1996-.
Journal of Graph Algorithms and Applications, 1996-.
Mathematica Journal, 1990-.
Theory of Computing, 2004-.

Honors and Awards
Member, Pi Delta Epsilon, 1958-.
Member, Tau Beta Pi, 1958-.
Member, Blue Key, 1959-.
Case Honor Key, 1959.
Member, Sigma Xi, 1960-.
National Science Foundation Fellow, 1960.
Grace Murray Hopper Award (first recipient), Association for Computing Machinery, 1971.
Fellow, American Academy of Arts and Sciences (Class I, Section 5), 1973-.
Alan M. Turing Award, Association for Computing Machinery, 1974.
Member, National Academy of Sciences (Class III, Section 33), 1975-.
Lester R. Ford Award, Mathematical Association of America, 1975.
California Institute of Technology Distinguished Alumni Award, 1978.
Doctor of Science, honoris causa, Case Western Reserve University, 1980.
Priestley Award, Dickinson College, 1981.
Member, National Academy of Engineering, 1981-.
Honorary member, IEEE, 1982-.
IEEE Computer Pioneer Award (charter recipient), 1982.
Doctor of Science, honoris causa, Luther College, 1985.
Doctor of Science, honoris causa, Lawrence University, 1985.
Golden Plate Award, American Academy of Achievement, 1985.
ACM SIGCSE Award, 1986.
Doctor of Science, honoris causa, Muhlenberg College, 1986.
Docteur honoris causa, University of Paris-Sud (Orsay), 1986.
ACM Software Systems Award, 1986.
Doctor of Science, honoris causa, University of Rochester, 1986.
Steele Prize for Expository Writing, American Mathematical Society, 1986.
Doctor of Science, honoris causa, State University of New York at Stony Brook, 1987.
Doctor of Science, honoris causa, Valparaiso University, 1988.
J. D. Warnier Prize, 1989.
Gold Medal Award, Case Alumni Association, 1990.
Doctor of Science, honoris causa, Concordia University, Montréal, 1991.
Assocïé Étranger, l’Académie des sciences, Paris, 1992-.
Pochënyi Doktor, Saint Petersburg University, 1992.
*Computer Language* productivity award, 1992. (for literate programming)
Doctor of Science, honoris causa, Adelphi University, 1993.
Utenlandsk medlem, Det Norske Videnskaps-Akademi, 1993-.
Lester R. Ford Award, Mathematical Association of America, 1993.
Docteur honoris causa, University of Marne-la-Vallée, 1993.
ACM Fellow (charter recipient), 1994.
Harvey Prize, Technion, 1995.
Doctor Scientiae Mathematicae, honoris causa, Masaryk University, Brno, 1996.
Memorial Medal, Mathematics and Physics Faculty, Charles University, Prague, 1996.
Cum Deo Award (charter recipient), Milwaukee Lutheran High school, 1996.
Kyoto Prize for Advanced Technology, Inamori Foundation, 1996.
Doctor of Science, honoris causa, St. Andrews University, Scotland, 1998.
Korrespondierendes Mitglied der Mathematisch-naturwissenschaftlichen Klasse, Bayerische Akademie der Wissenschaften, 1998-.
Fellow of the Computer History Museum, 1998-.
Doctor Philosophie honoris causa, Universitetet i Oslo, 2002.
Foreign member, Royal society of London for Improving Natural Knowledge, 2003-.
Doctor of Science, honoris causa, Université de Montréal, 2004.
Honorary Fellow, Magdalen College, Oxford University, 2005-.
Doktor der Wissenschaften, honoris causa, Eidgenössische Technische Hochschule Zürich, 2005.
Gold Commemorable Medal, State Engineering University of Armenia, 2006.
Gold medal from Yerevan State University, 2006.
Member, Pi Mu Epsilon, 2007-.
Docteur honoris causa, University of Bordeaux, 2007.
Foreign member, Russian Academy of Sciences, 2008-.
SIAM Fellow (charter recipient), 2009.
Doctor of Science, honoris causa, University of Glasgow, 2011.
ABACUS Award, Upsilon Pi Epsilon, 2011.
2010 Frontiers of Knowledge Award in Information and Communication Technologies, BBVA Foundation, 2011.
IET Faraday Medal, 2011.
Member, American Philosophical Society (Class 1), 2012-.
American Mathematical Society Fellow (charter recipient), 2013.
Dr. Peter Karow Award for Font Technology and Digital Typography, 2013.
Doctor of Science, honoris causa, National University of Ireland, 2015.
Honorary Member, London Mathematical Society, 2015-.

PhD Students: thesis titles and year of graduation

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Japanese translation, in preparation (Kindai Kagaku Sha).


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*MMIXware* (Heidelberg: Springer-Verlag, 1999), vii+550 pp. (Lecture Notes in Computer Science, no. 1750.)


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*Selected Papers on Computer Languages* (Stanford, California: Center for the Study of Language and Information, 2003), xvi + 594 pp. (CSLI Lecture Notes, no. 139.)

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Stanford University--Computer Center
Stanford University--Computer Science Department
Stanford University--D. C. Power Building
Stanford University--Encina Hall
Stanford University--Faculty Club
Stanford University--Gates Computer Science Building
Stanford University--Hoover House
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Susan W. Schofield

Susan Ward Schofield is a third-generation Stanford graduate. She earned a B.A. in French in 1966 and was a Fulbright Scholar to France in 1968-69, studying at the Université de Nice. She spent almost her entire career in academic administration at Stanford, from 1966 to 1968 and 1972 to 2002, for a total of thirty-two years.

Schofield served in many different offices and roles at Stanford: in Research Administration, in Facilities & Properties, as the Assistant Provost for Capital Planning, as the Associate Dean for Planning & Management in the School of Humanities & Sciences, in the Office of the Vice President for Planning and Management, and lastly from 1996 to 2002 as the Academic Secretary to the University, now Emerita. As Academic Secretary she supported institutional faculty governance including the Faculty Senate and its Steering Committee and Committee on Committees.

Schofield was a freshman/sophomore academic advisor for twenty years, co-founded the Amy J. Blue Award to recognize exceptional university staff, and served on or chaired numerous university committees. In retirement she has continued her active engagement with the university as a member of the Emeriti Council and a Stanford Historical Society board member, including two years as SHS President and three as Vice President; she chaired or co-chaired the Society’s Oral History Committee from 2006 to 2018.