Things a Computer Scientist Rarely Talks About

Donald E. Knuth

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LECTURE 1: INTRODUCTION (6 OCTOBER 1999)

It's certainly overwhelming for me to see so many people here. Why did you come to this talk, when you could have gone over to hear Jesse Ventura instead? The lectures that I'll be giving during the next few weeks are entitled "Things a Computer Scientist Rarely Talks About," and the subtitle is "Interactions Between Faith and Computer Science." I'm here because computer science is wonderful, but it isn't everything. So today I want to go beyond technical stuff to consider other things that I value.

In this series I'm going to be giving six talks that are more or less independent of each other. Anne Foerst asked me to deliver between five and ten lectures, and I settled on six because I could only think of six jokes. (And that was the first.) I have to tell jokes once in awhile to see if you can really hear me.

The first reaction that I had when I was invited to give these lectures was to say, "No way, this is impossible. The whole subject of faith and science is much too deep for me." I've given lots of talks at universities during the past 40 years, but they were always to present solutions to problems, to prove some math theorems, to make precise analyses of computational tasks, to propose general theories, or to organize bodies of knowledge — things like that. Things that I suppose I'm reasonably good at. But surely I can't come before you today and pretend to be an expert on faith or God, much less to claim that I have any solutions to problems that have challenged and baffled the best human minds for thousands of years.

So it is especially terrifying for me to see so many of you here; I hate to disappoint you. I have a Ph.D., which makes me a Doctor of Philosophy, but it doesn't make me a philosopher — the Ph.D. was in math. I can do math and computer science okay, but my formal training in religious studies is basically nil since high

school. I've done a lot of reading in my spare time, but why should I expect you to listen to me talk about one of my hobbies?

When I read what other people have written about matters of faith, it's quite clear to me that my own ideas don't measure up to those of world-class philosophers and theologians. I'm not too bad at reacting to other people's notions of religion, but I'm not too good at introducing anything that is fundamentally new or important in this area.

In other words, as far as theology goes, I'm a user, not a developer.

A week and a half ago, I went to Memorial Chapel at Harvard and was in the audience when Billy Graham came. I'm happy to say that he not only had a standing-room-only crowd, as we have here today, but people filled the aisles and the doorways. He certainly deserves it.

Turning things around, however, what if an eminent theologian were to give a series of lectures about computer programming? Would I go out of my way to go to hear them? Would I find them of value afterwards? I'm not sure.

On the other hand, all computer people present here today know that discussions of computer science are not totally different from discussions of religion, especially when we consider languages for computer programming. In the 60s, people would often talk about "Algol-theologians"; these were people who were skilled in the exegesis of obscure texts passed down by international committees. Programmers could use all the analogies of religious studies when we were discussing computer languages. Over the years numerous high priests of programming have expounded one language or one methodology over another with religious zeal, and they've often had very fanatical disciples. Thus everyone knows that the world of computer science is full of cults. In this sense religion and computer science are not completely separate; they share a fair amount of common ground.

We are all familiar with C. P. Snow's famous metaphor of the two cultures that divide educated people into two camps, humanists and scientists. Last month I was in England and I visited the new British Library in London, a magnificent building that has been built to last at least 200 years. And I learned that it actually enshrines the notion of two cultures permanently in stone. The new British Library has two separate sections with two separate reading rooms,

one for the humanities and one for the sciences. It turns out that there are good reasons for this from the librarians' standpoint: The humanists tend to work with a small number of books from the historic collections, while the scientists tend to work with lots of books from current periodicals. So the architect gave the humanists a big room with lots of desks in the middle, surrounded by reference works on the four walls; the scientists got a room with lots of journals in the middle, surrounded by desks on four sides. You see, he gave the one-dimensional thing to the desks for the scientists and the two-dimensional thing to their journals, but he switched the dimensions for the humanists.

Actually this week Stanford is dedicating its own new library. Henceforth in Stanford's University Library we're going to have not two cultures but three: humanities, sciences, and social sciences. And everybody knows that engineering is yet another culture.

The truth in fact is that C. P. Snow got it wrong by at least an order of magnitude — there are many more than two cultures. I think a lot of you know the Apple Macintosh ads telling us to "think different," but people already do. From my own corner of the academic world, I know for example that physicists think different from mathematicians; mathematicians who do algebra think different from mathematicians who do geometry; both kinds of mathematicians think different from computer scientists who work on algorithms; and so on and so forth. People often decry this lack of unity in the knowledge of the world, but let's face it: People *are* different. *Vive la différence.*

Even if people did think alike — and they don't — we in universities would have to cope with a vast growth of knowledge. In my own field, for example, it once was possible for a grad student to learn just about everything there was to know about computer science. But those days disappeared about 30 years ago. Nowadays the subject is so enormous, nobody can hope to cover more than a tiny portion of it. I receive on the average at least one copy of a journal every day; the actual total is more like eight or nine per week. These are just the ones I subscribe to, not the ones that I find in the library. They're filled with good stuff, yet they represent only a fraction of my own small part of the field. Growth is relentless. So a constant trend towards more and more specialization is inevitable. Scientists have to concentrate on a small part of the world's knowledge if they want to have any hope of continuing to advance it.

There might be some light on the horizon, however. I predict that in the not too distant future, people in academic life are going to define themselves not by one specialty area, but by two sub-specialties that belong to two rather different main specialties. This means that we'll have a web of interests, in which each person will serve as a bridge between different parts of the overall structure. You can see that this is much better than having a tree hierarchy that branches out further and further, with nobody able to talk to the people on other sub-branches. We'll have people that each belong to two areas, in two different parts of the overall structure. Then we'll be able to have some hope of coping with new knowledge as it comes along. Maybe after 50 more years go by, people will carry this process further and have three sub-sub-sub-specialties; I don't know.

But in any case, besides the specialties and sub-specialties that people will have in such a future scenario, we'll also want to know something about other people's main areas of interest, just as we do today. And in future years, just as today, we'll want to know about our own place in the universe and about our relationship to God, even if we aren't specialists in cosmology or theology.

From this perspective it is surely not forbidden for people like me to grapple with questions of religion, nor for theologians to grapple with questions of computation. And people who are like me can better understand my own explanations of such grapplings than they can understand the explanations of a person who has a different mode of thinking. For similar reasons I am clearly not the best person to explain computer programming to my mother, nor even to teach her how to use Lotus 1-2-3. She needs someone who thinks like she does, in order to explain the ideas of that software, even though I'm supposed to know more about computers. Conversely, my thoughts about religion might be useful to computer scientists.

Thus I'm here now to discuss "Things a Computer Scientist Rarely Talks About." In my Stanford classes, of course, I have never spoken about any of the topics that I plan to discuss in these lectures. At Stanford I did have a tradition of setting aside the last day of every course for a special Q&A session, at which I promised to

answer any question that the students had on any subject — *except* questions about religion or politics. Religion is taboo in Stanford classes outside of the department of Religious Studies, although other kinds of knowledge are not, and I guess that makes sense.

On the other hand, I remember reading a letter to the editor of the Caltech alumni magazine many years ago. The writer said that during the first ten years after he graduated, he wished he'd had more training in his major field. Then during the next ten years, he wished he'd had more training in management. During the next ten he wished he had more training in business planning. Then for another ten, he wished he'd learned more about medicine and health. During the next ten he wished he'd learned more about theology.

I've been concerned for a long time, in fact, about the lack of material about theology that is written for people like me. There are plenty of books for other kinds of people, it seems, but not very much for a computer scientist. I can remember once going into a large so-called Christian book store and realizing that almost all of my professional colleagues would find it extremely oppressive just to be in that room. I'm disturbed by the notions of religion that many of my academic friends have; but I understand that their notions have been formed quite naturally, in reaction to the things that they see in the media, aimed at different subcultures. From my point of view, the way they perceive religion is strange and totally distorted from the kind of religion that I grew up with. Therefore when I was asked to give a series of lectures in the God and Computers program at MIT, my first reaction — "No way can I contribute anything of quality" — was tempered by second thoughts that maybe I could say a few things that might be helpful to some of the people in this audience because such things are so rarely discussed.

Naturally I never agree to give a talk unless I think I have something to say. In this case I realized that there is one important message that I can bring to you that no theologian could ever do, precisely because of my amateur status. Namely, I can give testimonials that theologians have basically done a good job. After looking at hundreds of their books, I can report, as an essentially disinterested observer, that a lot of their work has been both interesting and valuable to me as I continue to seek to know more about God. Therefore I can explain, to other people who share my own peculiar way of thinking, what I've learned by reading works outside my own field of expertise.

Please realize that these lectures don't represent a career change for me! This is a once-in-a-lifetime excursion, after which I'm going to go back home and continue working on the stuff I do best. I want to use this opportunity to say things about which I feel deeply, even though other people could say them better, partly in a effort to inspire those other people to come forward and advance the discussion. And given that I'm glad to attempt this, just once, what place to do it could possibly be better than here at MIT?

Of course it's impossible to talk about religious issues without any bias, so I have to explain to you where I'm coming from. I was born in Milwaukee, Wisconsin. I grew up as a member of the Lutheran Church, and I went to kindergarten through 12th grade in Lutheran schools. My father devoted his lifetime to Christian education in the Lutheran school system. I attended church regularly, but Sunday morning was a separate compartment of my life. I had a kind of cozy relationship with the church; I didn't feel a need to explore any alternatives. I had several excellent pastors, but I didn't know much or think much about other people's faith. I was plenty busy with computer science and mathematics, more than six days per week.

An important change for me began in the fall of 1978, when I decided it would be interesting to learn more about the Bible by applying some of the techniques that I'd been using to understand large computer programs, techniques that had also helped me learn about other complicated subjects. In that year, for reasons I'm going to explain to you next week, I decided to amuse myself by going to the library and finding out as much as I could about several dozen verses of the Bible. This became what I called the "3:16 project," because I decided to focus on the sixteenth verse of the third chapter of each Biblical book. (That was perhaps a strange thing to do, but next week in my second lecture I'm going to explain why it makes perfect sense; meanwhile please trust me.) The main point was that in this way I could read what people of all different religious persuasions and people from many different periods of history had written about those verses.

To my surprise I learned so much from this exercise that I began to think I really ought to share the experience with other people. Eventually it became clear to me that I should look at the history of those verses even more closely, and that I should try to write a book about them. Perhaps, I thought, such a book would appeal to

a few of my colleagues, who are by nature turned off by almost all the other books that deal with religion. The title of the book that I should write was also clear: It had to be called *3:16*.

I began to write *3:16* during the 1985–86 academic year, when I happened to be living in Boston. In fact the Boston connection is another big reason why I've succumbed to the temptation to come here again and give these lectures. It seems that this is the part of the world where I've had the best opportunity to study religious issues. That period in 85–86 was a very special time in my life: It was the 25th year of my marriage to Jill, and I had promised her that she could at last have a sabbatical year. I promised to do all the shopping and cooking and cleaning, so that she could have a chance to write books of her own.

Well, on some days after finishing the household chores, I did have a few extra hours to kill, so I went to the Bible Museum to copy down the 3:16 verses in dozens of different translations; I also spent many, many days at the Boston Public Library looking at hundreds of Bible commentaries. I came over several times on the Red Line to the Andover–Harvard Library for books that weren't at Boston Public. Eventually when it was time to return to California I had drafted about twenty chapters of the proposed book; it turned out that I wrote the chapters about Ecclesiastes and the Song of Solomon while I was staying a few days in Cambridge, at the home of my publishing partner Peter Gordon, who lives a few blocks from Harvard Square. (That was one week before Harvard's 350th anniversary, when Harvard gave an honorary doctorate to Ronald Reagan — some of you might remember that occasion. Ah, 1986.)

I like a phrase that I learned from Joseph Sittler, who was a guru for many Lutheran pastors in the Midwest a generation or so ago. Sittler said he was especially pleased to have been raised in the Lutheran tradition because it taught him that he didn't need a "cerebral bypass operation" in order to approach God. Martin Luther was a great scholar — a man who used his head and his heart simultaneously. The 3:16 project was a turning point in my life because it opened my eyes to what other scholars have written. I learned to appreciate the way God is present in the lives of people from many different cultures. I learned that there were deep

connections between Christianity and other world religions. I no longer lived Sunday mornings in a different world from the world that I occupied during the rest of the week.

During that year in Boston I attended an ACM conference on computer science education. Well . . . , I didn't actually go to the conference; I went only to the reception. But anyway, when people at the reception asked me, "What have you been doing lately, Don?" I had to say sheepishly, "I've been writing a book about the Bible." Wow, what a conversation stopper! At least you would think so. I distinctly remember feeling that I was somehow coming out of the closet, and that everybody would think I'd really lost it. (In those days it was okay to be religious if you were Jewish, but not if you were Christian.) To my surprise, however, several people gave me lots of encouragement, and they expressed an interest in reading drafts of the book before publication.

In summary, to make a long story not too long, I finished writing *3:16* during weekends after returning to Stanford, and it was published in 1990. I'm not here today to sell copies of that book; a good book is going to find its audience without any hype, and a mediocre book is going to die a quiet death even if it has wonderful advertising. But I have to tell you something about the *3:16* book, because the experiences I had when writing it are what informed much of what I'm going to be talking about in the next lectures; that's when I had the most time to think about religious issues. Basically that book discusses what great theologians of many different persuasions and different ages have said about chapter 3 verse 16 of Genesis, and about Exodus 3:16 and Leviticus 3:16, and so on through Revelation 3:16.

My conservative friends think the book is too liberal. My liberal friends think it's too conservative. Everybody agrees, however, that the artwork in the book is spectacular. I commissioned different artists to create special calligraphy for each of the 3:16 verses, and I'm going to be talking about that in the fourth lecture of this series. The book . . . ; how can I summarize it? It's not a preachy book where I say, "Here's what I believe and I'm real smart so you better believe it too." Rather, it's a book where I say, "Here are some important issues and some different perspectives. What do you think about them?"

I've thought of a few dozen things to say in the remaining lectures of the series that might not be entirely trivial. Lately I've gotten

a sense that people are developing a craving for better understanding of the relations between scientific work and faith. Contributions of physicists, biologists, cosmologists, and theologians that I've read with respect to this topic have been extremely valuable, but I do feel that a computer science perspective can add several things that have been missing so far from these important discussions. A lot of computer scientists have no doubt come up with similar or better ideas than the ones I'm going to be discussing in the next few weeks, and other people will no doubt be able to explain the ideas better than I can. Still, now that I have this once-in-a-lifetime opportunity, I want to put the ideas on the table and give them my best shot. I certainly hope that these lectures are going to prove to be helpful to you as you continue to ponder the mysteries of life.

You might have noticed that I have been reading from notes while speaking today. That brings up an interesting fact about C. P. Snow's two cultures: Have any of you ever been to a convention of English professors? Do you know that they actually *read* their papers to each other, word for word, relishing each and every literary nuance? It blew my mind when I first learned that — because of course computer scientists do the opposite, we always just stand up and talk. But I know that my pastor always reads his sermons, and so here today I didn't know whether I should read or just talk. I thought I'd better play it safe and try to read, since my subject has a little bit to do with faith.

On the other hand, I'm actually only half prepared today. I mean, my plan for these lectures is that they should be about 50 percent planned in advance and about 50 percent improvised. Thus these lectures are not only about interaction between faith and science, but also interaction between you and me.

So starting at this point, or whenever I happen to get to it in the other lectures, I'd like to open everything up for discussion. My only preparation for the second half of each lecture will have been to live 60 years in order to get here and meet you. I hope many of you have questions, because that way I can focus on what you really want to hear. Who wants to speak first?

Q: The Bible has so many verses. Why did you choose to study chapter 3, verse 16, and what significance could that have?

A: I guess you're wondering if I chose 3:16 because the square root of 10 is 3.16, or something like that. The answer is, "Come next week."

Q: What Bible did you use?

A: As I said, I went to the Bible Museum to look at every Bible I could get my hands on. In the Boston Public Library I found many Bibles that I hadn't seen anywhere else; the Bible Museum also has a room full of Bibles and I found a wide variety there. New Bible translations were also coming out during the time I was doing this project. I studied the Bishops' Bible of 1568, which was the chief English translation before the famous King James Version of 1611, and I also went back to Tyndale's original translation of 1525. Altogether I had about 25 different versions. It took much longer than I'd expected to write everything out in longhand, but I carefully copied 25 translations of each 3:16 verse and I got writer's cramp in the process. The third lecture in this series is going to be about translating the Bible; I finally decided to make my own translations, and I'm going to explain in the third lecture why that turned out to be one of the best decisions I ever made.

Q: I wonder about your colleagues, who you had related to only from the point of view of scientific culture in earlier years, the people who knew you only as a computer scientist. How do they relate to you now that you've published this book in which you discuss your faith and your religious feelings?

A: Let me try to explain that in a couple of different ways. First of all, my colleagues seem to approve. (To my face, at least; I don't know what they're saying to each other behind my back and in emails.) After publishing the book, I expected negative reactions, but what happened was exactly the opposite; I've gotten amazingly positive mail and a lot of positive feedback.

I don't particularly flaunt my faith; I generally wait for people to ask me about it, if they're interested in such things. For example, let me tell you a little story. I don't like to wear suits, but every once in awhile I like to wear something that's a little bit dressed up. (I have a special shirt on today. Did any of you notice?) About twenty years ago my wife presented me with a wonderful Christmas present, a

beautiful shirt based on an old Egyptian pattern called a "galabiyah," and embroidered by a Laotian refugee named Maria Keovilay who had been sponsored by our church. This woman had been the best embroiderer in her village, and she made an absolutely gorgeous decoration on top of the plain black base. I wore this shirt once to Brown University when they dedicated their new computer science building, and my wife was sitting in the audience. She heard people saying, "Oh, here comes the high priest of computer programming."

The main reason I mention this story is that my fancy galabiyah looked much more like a high priest's robe when I first received it than it did when I wore it at Brown, because Maria had embroidered a great big cross on the back. She undoubtedly thought this was the ideal way to express friendship, because she knew me only as a member of our church. But I couldn't feel right wearing that cross, because it was too much of an in-your-face thing. I'm certainly not ashamed of the cross as a symbol, yet I'm not the kind of person who explicitly emphasizes my Christianity and implicitly asserts that the people I meet had better believe in God the same way I do. So I decided that the cross should be de-embroidered from the shirt.

In general, the reaction to my having published the 3:16 book has been warm as far as I know, and in fact much warmer than I would ever have predicted.

Q: Are there any ways in which your study of theology has informed your work with computer science?

A: As far as I know the effects have only been indirect. The theological studies have given me more of a sense of history, helping me better understand the development of ideas in science, because science and religion have not always been so separate as they are now. For example, it turns out that Isaac Newton once wrote a 20-page essay about 1 Timothy 3:16, and I would have never looked at that before. This gave me a little bit more feeling for Newton's personality, but it's a historical connection. As a scientist, I'm quite interested in how ideas get started in the first place, so the more source materials I read, the better. Theological study has helped in that way. But otherwise such studies have been relevant mostly to the other aspects of my life, to the parts of me that want to understand something about my own place in an ongoing system.

Q: You've referred several times to a computer scientist's perspective. How do you distinguish that from other points of view?

A: I have kind of a radical idea about this, but I've had it for 30 years now and still haven't found anything wrong with it. Namely, suppose someone asks, "Why did computer science jell so fast during the 60s, all of a sudden becoming a department at almost every university in the world?" I answer that the reason is not to be found in the fact that computers are so valuable as tools. There's not a department of Electron Microscope Science at every university, although electron microscopes are great and powerful tools.

I'm convinced that computer science grew so fast and is so vital today because there are people all over the world who have a peculiar way of thinking, a certain way of structuring knowledge in their heads, a mentality that we now associate with a discipline of its own. This mentality isn't sharply focused, in the space of all possible ways of thinking; but it's different enough from other ways — from the mentalities of physicists and mathematicians that I spoke of earlier — that the people who had it in the old days were scattered among many different departments, more or less orphans in their universities. Then suddenly, when it turned out that their way of thinking correlated well with being able to make a computer do tricks, these people found each other.

I believe it was this way of thinking that brought computer scientists together into a single department, where they met other people who understood the same analogies, people who structured knowledge roughly the same way in their heads, people with whom they could have high-bandwidth communications. That's what I meant when I referred to a "computer science perspective."

I didn't choose to be a computer scientist because my main mission in life was to advance computation. I chose computer science simply because I was good at it. For some reason, my peculiar way of thinking correlated well with computers. Moreover, I'm sure that people had this way of thinking hundreds of years ago; when I read old publications I think I can recognize the authors who would have been computer scientists if they had lived in the time of computer science departments. There was a time when physicists were called natural philosophers, and there was a time before chemists belonged to departments of chemistry. From considerations like this I believe that computer science will eventually take its place on essentially the same level as every other field of study, say 100 years from now; the fact that this mode of thinking never had a name until quite recently is just a historical accident.

One of the main characteristics of a computer science mentality is the ability to jump very quickly between levels of abstraction, between a low level and a high level, almost unconsciously. Another characteristic is that a computer scientist tends to be able to deal with nonuniform structures — case 1, case 2, case 3 — while a mathematician will tend to want one unifying axiom that governs an entire system. This second aspect is sometimes a weakness of computer science: When we encounter a situation that can be explained by one axiom, we might still give it five, because five different rules are no sweat for us. But we're at our best in circumstances when no single principle suffices; then we can handle the discrepancies between different cases very nicely.

One of the first people to receive a Ph.D. in computer science was Renato Iturriaga de la Fuente, who graduated from Carnegie Institute of Technology in 1967. When I met him in Mexico City in 1976, he was head of the Mexican equivalent of our National Science Foundation. He told me then about his conviction that an ability to shift seamlessly between levels of abstraction and to deal fluently with nonuniform models helped him greatly to deal with scientists of many different backgrounds. In his job, he said, a computer scientist's way of thinking tended to be more effective than that of other scientists, even though he wasn't doing any computer programming or computer science research himself at the moment.

So that's what I think tends to be different about computer scientists. Experience shows that about one person in 50 has a computer scientist's way of looking at things.

Q: Do you have any comments on other religions?

A: When I said briefly that I find deep connections between Christianity and other world religions, I didn't mean to imply agreement in terms of specific doctrines but rather in terms of attitudes. I see aspects of Buddhism, Taoism, Zen, Islam, and other faiths that appear essentially Christian to me; conversely, I encounter other things that so-called Christian preachers say on the radio that I don't think are Christian at all. Of course I'm just one person, and other people are entitled to their own opinions.

In the later lectures I'm going to try to get a little further into questions like this. Ask yourself what you would do if you were God and you wanted to deal with people on the earth; how would you present yourself?

Q: Earlier you said you thought that your colleagues would be put off when walking through a Christian reading room in a book store. What was it about such an environment — the book titles, or whatever it was — that you think would put them off? Does your book *3:16* address this in any way?

A: I can't explain it; I just felt like the ceiling was about four feet lower, I don't know why. There was a certain heavy atmosphere, an overpowering aura that was very much attuned to people who already consider themselves enlightened.

But that's a cop-out; I'll try to explain. There is a certain kind of art that looks kitschy, but it can be very meaningful to people who traditionally associate it with worship. To other people it looks like the kind of art that — well, the kind of art that "those people" like.

It seemed to me that book after book in the store was saying, "Close your mind." But as I said before, the tradition that I grew up in encouraged me to look at religion with an open mind, as Luther did. Although I didn't have much motivation to check out the works of writers from other traditions until I wrote the 3:16 book, in fact I was never told that it was dangerous to read other stuff. The vast majority of the books in this store seemed to be of a much more prescriptive and restrictive kind, saying "Here's the orthodoxy. Learn rules 1, 2, 3, . . . , 10."

I guess that's the best way I can express my feelings now. My own book doesn't address the problem especially well, since its full title *3:16 Bible Texts Illuminated* implies that it "illuminates" the Bible. Still, it might be appealing to my colleagues if they look for it on the Web instead of in a bookshop.

Q: Is it possible to somehow quantify how the process of writing your book affected your faith in the Lutheran tradition specifically? Did it perhaps bring about a stronger faith, or did it possibly weaken your faith with respect to the traditions in which you had been brought up?

A: In general, I think my faith was greatly shored up by the 3:16 project, because it survived the attacks of so many writers who hold

diametrically opposite views. On the other hand the experience did weaken my faith in certain specific things, such as some of the stories about miracles that I was brought up with. At present I don't think those stories are necessarily true, although I still believe they could have happened. My current attitude is that many specific details in the Bible might not be historical, because I know now about what can happen to manuscripts over long periods of time, and because I often find significant discrepancies in newspaper accounts of events that I have witnessed in person.

I can't quantify the change in my thinking to the extent of putting a number on it. I can say that I was extremely happy two months ago when the Lutheran Church voted to have full communion with the Episcopal Church. Our national convention needed a two-thirds majority to pass that motion, and it passed; that was very good news for me. I've become much more ecumenical in my approach and not specifically Lutheran. I'm also glad that the Lutherans and Catholics will be signing a so-called Concordat later this month in Augsburg, Germany, resolving the major differences that split the church in the sixteenth century.

Q: You spoke of a free-for-all day at the end of the courses that you teach. Why did you exclude religion, and do you still exclude religion? Furthermore if you do, why do you still?

A: I see, you've given me a metaquestion there. Actually I'm retired now, so that was one scenario you didn't consider. And the truth is, I excluded from consideration not only religion and politics but also the final exam.

But when I was teaching and actually running such sessions, I felt that religion was different and special, an intensely personal thing, where scientific method and normal standards of proof don't apply. I wouldn't avoid talking about chemistry, for example, because chemistry is something that people are sort of paying tuition for to learn about. But the students weren't paying tuition for some professor to tell them what he thought their religion should be, or even what he thought his own religion was. I could naturally talk to interested students about anything outside of class, but class time seemed to be in a different category.

Maybe now there's a different attitude, at least at some universities. And probably if I had been at another place, like say Luther College, I would have had a different policy. I guess I was primarily

influenced by local tradition; Stanford has its traditions. One of the traditions at Stanford is that you don't use Stanford budget money for research — only for teaching. I never understood why Stanford itself shouldn't be interested in expanding the world's knowledge; but I went along with Stanford's tradition, according to which all support for research comes strictly from government grants, never from the endowment. The Stanford endowment goes for teaching. My thoughts about bringing up religion during class hours were similar in spirit; somehow religion seemed to be off the chart.

Q: What do you think about the rate of the growth of computer science? And what expectations do you have for the future?

A: Ah, if only the growth in computer science would slow down so that I could finally finish my books! I sort of keep hoping that red herrings will steadily come along, to keep people busy; I get secret satisfaction when bad ideas take hold and suck a lot of people in . . . like Java. (Just teasing.) But computer science keeps getting bigger and broader and deeper.

I can't predict that it's going to continue expanding at this rate. Moore's Law certainly can't go on indefinitely. But will computer science still be growing 50 years from now? It's hard for me to say that with confidence.

On the other hand I can say quite confidently that biology will still be growing 200 years from now. Biology is a much deeper subject than computer science; just by its nature, biology has much more to deal with. Nobody needs a crystal ball to predict an enormous future growth of biology. Yet even in the considerably more limited field of computer science we still have no indication of any slowdown whatsoever.

Q: Can you mention some of the theologians you've read that you find compatible with your own culture?

A: Well, I tend to be a detail-oriented person, as you can guess, and so are a lot of theologians. So I have often felt an instinctive kinship when picking up a new commentary. In fact, my experiences as I was writing the 3:16 book weren't that different from writing computer books, although I wasn't using integral signs as much. The processes of abstraction and generalization and interpreting texts were much the same. Really I would say there wasn't that much difference in mentality between the detail-oriented theologians and

myself, except for their substantial expertise in languages; languages have lots of nuances that I don't understand. With respect to linguistic matters I can only believe what I read.

My fifth lecture will be about what I learned about God during this project, and what I learned at the same time about theologians; I prefer to discuss such ideas in detail at that time.

Q: Can you say something about your thoughts on the value of prayer?

A: Prayer . . . I should probably be praying now that somebody will ask me an easier question! I believe there's great value to prayer, but I don't know why.

One of the things I want to do before this series of lectures is over is put up on the Web a wonderful parable that helps explain my feelings, although the parable itself — called "Planet Without Laughter" — has nothing to do with prayer per se. It's a little short story by Raymond Smullyan, which appeared in a book that's now out of print. When you see that short story, I think you'll get an idea about how I might "know" sometimes that prayer is important without understanding why. Some things are beyond rationality and proof, and I don't think God wants them to be analyzable or provable.

Q: What sorts of analysis that you run across in computer science proved to be most useful in doing this research?

A: Obviously there wasn't much quantitative stuff in the religious texts for me to analyze as a mathematician. But it turned out that Numbers 3:16 (of all things) was about numbers, so there was some interesting mathematics in there. The most quantitative aspect of this work was the study of randomness, and so next week in Lecture 2 I will talk about that at length.

There also are qualitative things that are implicitly informed by analysis. So, for example, the knowledge that I could in principle prove a program correct helps me to write a program, even though I'm not actually going to prove the program correct. I don't have the time to go and check that the program for TEX is actually 100% correct. Furthermore, I don't even know how to formulate the concept that a METAFONT program draws a beautiful letter A, so I couldn't possibly prove the correctness of such a program. But still,

somehow, the theory that I've learned while doing computer science gives me more confidence in the programs that I have written.

Working on the 3:16 project was kind of similar: Although I didn't have a direct connection between numbers and the study of Bible verses, the methodology that I had gradually developed by working with numbers turned out to be useful when I worked with less quantitative material.

Q: Do you have any comments or conclusions regarding the existence or the nature of evil?

A: The question is, for example, why are people killed in wars? I'll be getting to this topic later on, but I don't have any new insights that I haven't picked up from other people.

The Book of Job discusses this problem at length and tries to come to a conclusion. And if you look at ten different commentaries on the Book of Job, each one says that the conclusion was different. This proves, I think, that it's really a tough problem.

But still there must be something there, and we ought to ponder it. What would the world be like if there was no evil? I will be trying to get into this question more deeply in the fifth and sixth lectures.

Q: What do you think of the hypothesis that the human brain is a giant computer program?

A: Such a hypothesis will obviously be very hard to confirm or deny. I tend to believe that recently proposed models of the brain, which are based on the idea of continuous dynamic evolution of symbolic signals instead of on processes that resemble today's computing machines, have good prospects for helping to explain the mysteries of consciousness. If so, a lot of randomness must be involved in that, and I'll be talking a little bit more about such things also in the lectures to come.

(I guess I'm using the future lectures too often as an excuse for dodging your questions. I'm glad you're interested in all of these topics, but I don't want to get ahead of my story or I'll have nothing left to say. Please bear with me.)

Maybe the brain uses random elements; maybe the universe does too. Maybe all these things are controlled somehow by prayer or whatever; who knows? We might only be perceiving three dimensions of some higher-dimensional reality. I'm going to try to

explore these questions from my limited viewpoint later on, but of course I don't have any definitive answers.

Q: You were asked earlier about how the quantitative, analytic aspects of computer science might relate to theological studies. But a large part of your own work on such things as literate programming deals with things that are *very* hard to quantify, like maintainability of programs and ease of use. I'm wondering if you found parallels between that work and the work that you've done reading the theologians.

A: Yes, thank you for the reminder that quantitative considerations are only one aspect of computer science. You're saying that much of my work is not about theorem proving and so on but more about methodology, where I write a computer program and I feel happy about it — not because I've proved that it was correct but because I enjoy its elegance or something like that. There's a strong aspect of aesthetics, which I'll be discussing in my fourth lecture. (Again, I don't want to steal any thunder away from that lecture by dwelling on such topics today.) I believe that all the non-quantitative things probably carry over almost completely from one culture to the other.

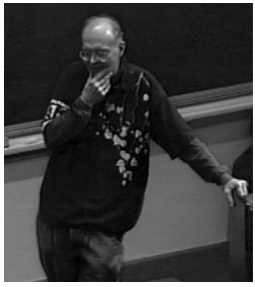
Q: What influence might computers have on future developments in theology?

A: The simple answer is that Web-based resources have recently appeared that make it much easier now to approach the vast theological literature. You can click on a word and find out what the original Greek was; you can find out where the same Greek word was used elsewhere; and so on. Many aids to self-exploration will surely continue to appear because of technology. Already there are home pages for the Gospel of Mark and other books. Soon this will extend to every part of the Bible and to the canonical texts of other religions. There will be surveys that people can refine and make much more accessible than ever before, for people who want to explore their own chosen topics in their own way.

Could advances in computer technology actually influence the manner of divine revelation? That is a really interesting question, but I haven't thought about it much. There's a general notion of so-called process theology, which says that over the centuries God has been revealing Himself/Herself in different ways. When I first heard about process theology, it sounded to me like nonsense because

I had always been taught that God was the same yesterday, today, and forever. But then the more I thought about it, the more I realized that God would best be able to communicate sensibly by sending messages that were appropriate for the current time.

For example, we know now that proteins are molecules made up of atoms; but 2000 years ago, people didn't know what molecules were, so Jesus didn't talk about them. Thus it only makes sense that different kinds of revelation are appropriate as the people in the world change. It's a very good question, whether the rapid developments we are experiencing will lead to valid and trustworthy new insights about God.



I'm worried that somebody will start a new religion based on fractals. What I mean is, religion has a certain power that charlatans can take advantage of. So if you come up with something that makes a little bit of sense and has a little bit of mystery to it, you can fool a lot of people. I also have that in mind as a possible danger.

Q: If you were asked to give a lecture for an audience of theologians on the subject of computer science, what would you talk about?

A: A lecture for an audience of theologians? Let me tell you that the amount of terror that lives in a speaker's stomach when giving a lecture is proportional to the square of the amount he doesn't know about his audience. Once I gave a series of lectures to biologists at Caltech about computer science, and that was one of the hardest tasks I ever had to face.

I guess, however, that I could explain something to the people whose writings I've read. I could explain to them some interesting ideas about infinity that they might be able to explore better than I. In fact I hope to go into some of that in Lecture 6.

Q: You've talked about a computer science perspective. Do you see any danger in that perspective, considering that computer scientists like to abstract things and say "Okay, I've got a handle on this." With religious matters such an approach may not be possible. You can't think of prayer as a black box, where you put something in and get something else out. So I wonder if you see danger ahead, when people think they've got a handle on stuff that they really don't.

A: Absolutely. That's a significant point. For example, I mentioned an essay that Newton wrote about 1 Timothy 3:16; I admire it a lot. He studied quite a few manuscripts of Greek papyri in order to analyze where a deliberate change had been made by someone copying this passage and trying to "improve" it; he nailed the manuscript where the change was introduced, and this was a original contribution made by Isaac Newton to theology.

But Newton also wrote other essays about religion, where he considered the Book of Daniel and the Book of Revelation. He took these very mystical, symbolic books and treated them as if they were mathematical formulas and axioms; he tried to say, "Assuming X, then Y must be true," and so on. I felt *so* sorry for him!

Similarly I'm sure that I also tend to make mistakes like that. Even so, I have a right to my mistakes.

Q: In your announcement of today's lecture you describe writing *3:16* as a turning point in your life, as if some part of you that was going in one direction is now going in another. Can you say more about that? What's the change?

A: Well, my work on the 3:16 verses didn't lead to a 180-degree turn, but it certainly opened my eyes to many things that I hadn't had a motivation to look at before: the way other people practice their religion, the history of different strains of Christianity, the intellectual challenge of Biblical criticism, the lack of simple answers.

Perhaps it was, in fact, too much of a turning point, in the sense that I became over-confident. Before embarking on the project, I hadn't read much, so I could only feel that maybe I was missing something. Afterwards I had read enough that I tended to feel that I knew everything, which of course I didn't. The reading gave me substantially more confidence, and maybe that was a better or worse thing.

When I pursued the project there were no holds barred on what I was going to look at. I wanted to explore whatever had been said by everybody, letting them shoot their ammunition whichever way it would go. After I had done that and still come through with what I felt was a strong enough faith to get through the rest of my life, this gave me a confidence that I couldn't have had before I did the experiment.

Thank you all very much for asking such excellent questions, and for laughing at the right times.

Notes on Lecture 1

Page 2, Snow's famous metaphor: C. P. Snow, *The Two Cultures and the Scientific Revolution* (London: Cambridge University Press, 1959); *The Two Cultures: And a Second Look* (London: Cambridge University Press, 1964).

Page 2, new British Library: See Colin St. John Wilson, *The Design and Construction of the British Library* (London: The British Library, 1998).

Page 3, Stanford's University Library: See the article by James Robinson, "Phoenix Rising: Restored Bing Wing respects past, present, future," in *Stanford [online] Report* (6 October 1999), `www.stanford.edu/dept/news/report/news/october6/libbingwing-106.html`. Also Michael A. Keller et al., "Reconstructing the heart of the university," *Imprint* **18**, 2 (Stanford, California: The Associates of the Stanford University Libraries, Fall 1999).

Page 7, title of the book: Donald E. Knuth, *3:16 Bible Texts Illuminated* (Madison, Wisconsin: A–R Editions, 1991).

Page 7, Joseph Sittler: I heard his comment on a videotaped interview by Robert M. Herhold, *Theological Reflections: Spirituality Explored* (Minneapolis, Minnesota: Video Publishing, 1981), 28 minutes. Copies of this video are currently available from Seraphim Communications, `www.seracomm.com`. (The comment occurs about 20:40 minutes into the tape.) Herhold had previously assembled a number of Sittler's memorable remarks in the book *Grace Notes and Other Fragments* (Philadelphia: Fortress Press, 1981). Sittler's implicit reference to an essentially *complete* cerebral bypass should of course be distinguished from the cerebral *arterial* bypass operation that was once believed to help prevent strokes. To me it means, "Respect the limitations of your brain, but don't abandon logic altogether."

Of course Lutherans do not have a monopoly on the idea that one's mind need not be switched off when approaching God. For example, the former pastor at Harvard, George Buttrick, once put it this way: "The church has sometimes forgotten one word in the Great Commandment: 'Thou shalt love the Lord thy God with all thy ... *mind*.' [Deuteronomy 6:5, Luke 10:27] ... The rigor of logical positivism, though it is all too small to cover man's pilgrimage, lays on every man the requirement of stringent honesty. It is a great gift that higher education should keep saying: 'Face the facts. Be honest. Do not beg the question. And make the doors of a church high enough so that a worshiper need not leave his head on the sidewalk.' " [*Biblical Thought and the Secular University* (Baton, Rouge: Louisiana University Press, 1960), 54–55.] I thank Peter Gomes for bringing this quote to my attention.

Page 8, ACM: The Association for Computing Machinery has been the leading professional organization for computer specialists in America since 1947.

Page 11, Isaac Newton: See *Isaaci Newtoni Opera Quæ Exstant Omnia*, edited by Samuel Horsley (London: J. Nichols, 1779–1785), volume 5, pages 531–550.

Page 13, one person in 50: See Donald E. Knuth, *Selected Papers on Computer Science* (Stanford, California: Center for the Study of Language and Information, 1996), Chapter 4, especially page 94.

Page 16, Moore's Law: In 1965, Gordon E. Moore gave a talk in which he observed that chip capacity was doubling every year; this remarkable trend continued until the late 1970s, after which doubling has continued to occur every 18 months or so.

Page 17, Raymond Smullyan: See the end of Lecture 4.

Page 17, TEX and METAFONT: See my book *Digital Typography*, cited in the notes to Lecture 4.

Page 19, home pages for the Gospel: Michael Spencer's *Gospel of Mark Homepage*, currently `www.geocities.com/~eutychus`, was established in 1997 and has links to many other sites. The central reference for the Gospel of Mark is now, I think, *Kata Markon*, `metalab.unc.edu/GMark`.

Page 21, Newton also wrote: Isaac Newton, *Observations Upon the Prophesies of Daniel, and the Apocalypse of St. John* (London: Darby and Browne, 1733); critical edition edited by S. J. Barnett, with notes by Mary E. Mills (Lampeter, Wales: Edwin Mellen Press, 1999).