From "Farm Boy" to Director of the Laboratory of Computer Science

2004 Interview of Octo Barnett

Interviewers:

Joan S. Ash & Dean F. Sittig

Editors:

Rebecca M. Goodwin, Joan S. Ash & Dean F. Sittig

NIH U.S. National Library of Medicine

From "Farm Boy" to Director of the Laboratory of Computer Science

2004 Interview of Octo Barnett

Conversations with Medical Informatics Pioneers:

An Oral History Collection

Interviewers:

Joan S. Ash & Dean F. Sittig

Editors:

Rebecca M. Goodwin, Joan S. Ash & Dean F. Sittig

Published by the U.S. National Library of Medicine, April 17, 2015; updated September 4, 2015.

Oral History Interview with Homer Warner, Sr.

Editors: Rebecca M. Goodwin, Joan S. Ash, and Dean F. Sittig

Interviewers: Joan S. Ash and Dean F. Sittig

Managing Editor: Rebecca M. Goodwin

Copy Editing: Cindy Allen and Marie Gallagher

Design & Layout: Troy HIll, Bona Kim, John Harrington and Anne Altemus

Photo Editing: Troy Hill and Sandy Triolo

Photo & Captions: John Barnett, Kathy A. McDermott, Ed Hammond, Nina Matheson, Don E. Detmer, Betsy Humphreys, Dean Sittig, Patti Brennan.

Deeds of Gift: Rebecca Warlow, John Rees and Jeff Reznick

Contact: wwwnlm@nlm.nih.gov
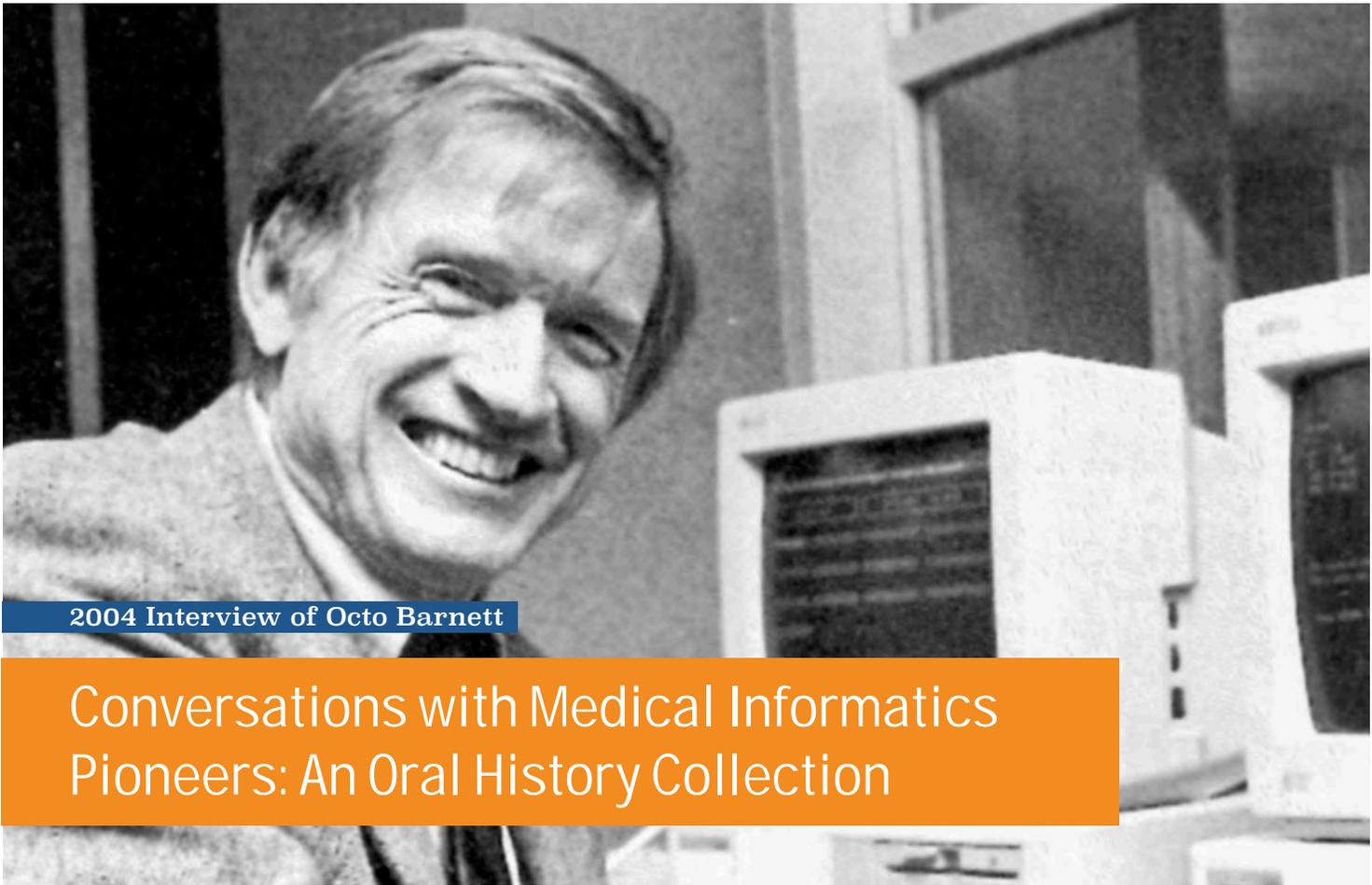
2004 Interview of Octo Barnett

Conversations with Medical Informatics Pioneers: An Oral History Collection

Dr. Octo Barnett, 1987, photographed for Harvard Medical School's New Pathway program for MDs.

From "farm boy" to director of the laboratory of computer science

Although he described himself humbly as "just a country doctor," Dr. G. Octo Barnett altered the course of the practice of medicine when he suggested, in the 1950s, "We ought to try using time-sharing computer systems to improve medical care."

**INTERVIEWED BY
JOAN ASH AND DEAN SITTIG**
OCTOBER 29, 2004
BOSTON, MA

Octo Barnett, MD served as the Senior Scientific Director of the Laboratory of Computer Science (LCS) —a medical and bioinformatics research and development group at the Massachusetts General Hospital (MGH) —and a Professor of Medicine at Harvard Medical School. Dr. Barnett pioneered the use of computers in patient care.[1–9] His work with computers in medicine fostered innovative projects including DXplain®,[10–16] Primary Care Office Insite (PCOI),[17,18] Pulmonary Artery Catheter Waveform Interpretation Tool (PACath),[19] COSTAR[5,6,20,21] (a comprehensive and widely used ambulatory medical record system), MUMPS[22] (Massachusetts General Hospital Utility Multi-Programming System, now known as Multi-User Multi-Programming System), and computer-aided graduate nursing and medical education systems.[23–26]

In 1996, he was the third recipient of the Morris F. Collen Award of Excellence.[27,28] Dr. Barnett studied mathematics, computer science, and chemistry at Vanderbilt University. He earned his MD from

Harvard Medical School and completed his residency at Peter Bent Brigham Hospital in Boston. Dr. Barnett and his wife, Sarah, also raised three sons: John, Andrew, and Robert

OB I sent you the paper I wrote about my reminiscences.

JA *That was a wonderful paper, I really enjoyed reading that.*

JA *We want to hear today what your stories are all about.*

JA *So the tape is rolling. I'd like to ask you about where you were born and raised, and what got you to the point where you were rooming with those students at MIT.*

OB How many hours do you want to spend on that one? [laughs] Well I was born in San Diego, California. My father was in the regular Navy. I was a Navy brat. He retired then in '36, always wanted to go back and go into farming. He was a farm boy from Alabama from way back, so we moved back to Alabama to a small farm in the backcountry. Miserable soil, very hard to make a living. Raised cotton and peanuts. And then he was called back in the Navy in '40 and died in the Second World War.

> I never decided that I wanted to be a doctor. It was just what a lot of people that I admired and liked in college were doing, and so it seemed like, "Well, I'll try."

I ran the farm then for six years while I was in high school. We had no money, and I had no idea about going to college. I was in a barber shop one time and heard somebody talking about scholarships, and I wanted to know what a scholarship was. We had no [college preparation in our] country high school. We had no counselor whatsoever. And it turns out there was a scholarship program for Southern boys. I applied for it, and I was very fortunate: I got a scholarship to Vanderbilt.

JA *You must have done well in high school.*

OB Well it depends what aspect of high school. For boys, the high school was very much geared toward how good an athlete you were. And to say the least, that wasn't my strong suit.

DS *You were on a tennis team, I'm sure.*

OB Well, they didn't have one. They basically had one tennis court in town, and it wasn't kept up at all. It was asphalt and had huge cracks in it. And so I swear I developed my net game because you couldn't afford to let the ball bounce. [laughter] You had to get to the net as soon as possible. But I was a 130-pounds-soaking wet linebacker and I was mauled. I decided football was not for me. High school was not a pleasant experience. I was very good

Octo Barnett with his father at home in Greenville, AL, circa 1930s

Octo Barnett, at home in Greenville, AL, circa 1930s.

at books and no good at athletics, and that's exactly the opposite of what brings popularity in high school.

JA *But you got a scholarship.*

OB Yeah. Well, I've always been good in books—that's fair enough—and tests. And so I went to Vanderbilt, and I then applied to the University of Alabama Medical School, because if you were going to be a country doctor, you got tuition free there. So I went to Alabama.

JA *At what point did you decide you wanted to be a doctor?*

OB I never decided that I wanted to be a doctor. It was just what a lot of people that I admired and liked in college were doing, and so it seemed like, "Well, I'll try." My life has not been one of carefully-thought-out decisions. I usually find out I've made a decision after I think back on it. So as a career counselor, I'm a total failure—to myself and everybody else. I went to Alabama and I was working, washing dishes in the pharmacology lab, and the head of the lab was a very nice, wonderful individual, and he let me start doing research projects. I actually started publishing papers back as a med student.[29] He said, "Well, you know, if you really like that, you shouldn't be here at Alabama. We're not the type of school for you. You ought to apply to one of the schools up north." I said, "Well, what are some of those schools?" He said, "Well, you could try Harvard or Yale, Columbia, Chicago." And so I sent off applications, and Harvard offered me the best scholarship. So I came up here for my last two years.

I was always interested in math.

JA *You changed medical schools?*

OB I changed med schools, yeah, and came up to Harvard.

JA *That's not easy to do.*

OB Oh, well, I was a token Southerner. [laughter] They needed at least one in the class I think. And then I worked quite a bit in med school for George Solomon, who was the Head of Medicine at the Brigham [and Women's Hospital], and a wonderful guy. He was very, very kind to me. Then I got a residency at the Brigham in Internal Medicine. I was always interested in math; I took quite a bit of math in college. During my residency, I took courses over at Harvard in math. And before my second year of residency I thought, "Gee, I really am not that keen on doing that second-year residency." I'd been accepted to go down to the National Institutes of Health, to be a clinical associate in the cardiac department there, but I needed to have another year of residency. So he said, "Okay, if you want to, you can go with the physiology lab and work with a guy named Cliff Barger," who was a great physiologist. So I did that.

In med school and during my internship, I had gotten to know a bunch of people who skied. When I came up here, I didn't know how to ski at all, but I was determined that these Yankees were not going to outdo me. So I went out and started going on ski trips. I'm a disaster as a skier. The only thing I ever learned was how to go downhill. I never learned how

Octo Barnett on horseback in Greenville, AL, circa 1930s.
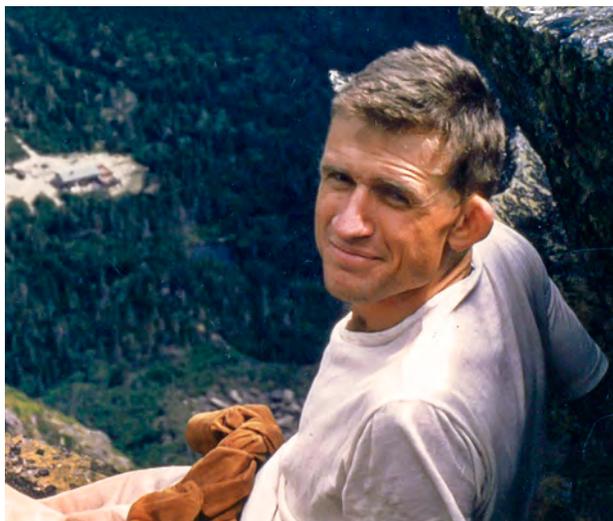
Octo Barnett, White Mountains, NH, circa 1970s.

to turn. And to say the least, that's not great skiing. But I got to know, sort of indirectly, a couple of the guys who were in their final years of graduate school at MIT, or had just graduated, and we used to go on ski trips together. And then during that period of time, they basically rented a house—actually [it] was a house owned by Claude Shannon, who was a great, great master of anything in informatics in the early days. We lived together. There were four of them— all very bright, very good skiers—and it was a wild time, to say the least. You can imagine what five bachelors, living in a house on a lake in Winchester was like. There were as many girls there, at any one time, as there were males—sometimes more.

DS *Wow.*

In my physiology work, I was trying to do systems analysis of basically hypertension and what was the relationship of the kidney to it.

OB In my physiology work, I was trying to do systems analysis of hypertension and what was the relationship of the kidney to it.[30] We talked a lot about the classic engineering idea at that time, that the system was like an electrical circuit. In other words, there must be a bunch of capacitors and resistors laid out together. So I had to figure out how that circuit breaks. [I was] totally naïve, totally. Didn't even have the slightest idea of how complex that whole system was. We still don't know how complex it is.

We used to have a lot of fun talking about how you do mathematical modeling and what was the role of computers. And then I would go over to MIT. MIT had built sort of the first computer; they used to play "Space Wars" on it. The computer hackers at that time—there were no courses—they were basically the underground railroad. They were people who were sort of the railroad enthusiasts who built model trains who got into computers. So I got to learning more about computers.

The computer hackers at that time—there were no courses—they were basically the underground railroad.

DS *This was the late '50s?*

OB Oh yeah, '57, '58 something like that. Then I went down to NIH and I got involved trying to measure blood flow in the aorta by differential pressure.[31–33] While I was at NIH, I went to the medical school at George Washington and learned a bit about four-strand analysis, etc. I used to do the modeling then on an analog computer, an old CDC, early analog computer. Over the next three or four years, it was a combination of cardiac fellowship and going back to graduate school. I went to a year at University of Washington and worked in the physiologist Bob Rushmer's lab. I came back and finished my residency at the Brigham and started the labs there—must be about '60—and was using a computer. They had an old 16-10 IBM, I believe—or maybe 16-20—that they used for some purposes, but I could use it at night. And so, during the training program over at MIT in bioengineering—I was on the faculty over there at the time as well—we used it to do our modeling between 10 p.m. and 5 a.m.

JA *Can I have you back up? You've covered a lot of territory in a very short time here. What was happening in your personal life at the time?*

OB Oh! Well, basically, a friend who was in one of the courses that I was taking at Harvard said that she had a roommate who liked to go skiing, and could she go on one of our ski trips? I said, "Sure." You know, I figured we had so many girls, we'd never even notice one more, but I did notice her and wound up thinking, "Hey this is a wonderful young lady!" And so we started dating, and got married. Our courtship probably lasted three or four months—[sarcastic tone] it was very long. I was going down to Washington for two years, and I never believed that I could maintain a long-distance Relationship. So we got married just before I went. That was a good period.

After about two years of research, I'd finally gotten that hypertension is clearly a baroreceptor problem. That is, there's a resetting of a baroreceptor somewhere in the body, because all the reflexes remained the same, they're just set at different levels. So somewhere there must be something that looks like a thermostat, and some sort of control mechanism somewhere that gets reset, and if I could just find it, maybe we could figure out how to treat it [when it gets damaged]. Again, taking a system that's got 27 different pathways, and God knows how much— But I got, finally, the signal neurofiber recording. I was trying to find out from the cortical sinus nerve, whether it was the place where it changed the different type of signal. And I was doing a lot of signal nerve fiber recording. That's a hard life, trying to dissect out the signal nerves. I mean, [you] get interference. I didn't have good enough technology to do it with, but I learned a lot more about computers in the processing of those things. I had graduate students from MIT working with me who were very good in terms of teaching me more about it.

JA *Why did you make the various moves that you did?*

OB [laughs] Again, you're assuming that I did these with [a] thought-out plan. Basically, at that time, my lab was over at the Brigham and MGH—I mean, we could go on with stories all day. [Robert Bradford] Bob Newman was a wonderful early pioneer of all sorts of computer technology over at Cambridge. They were way ahead of their time, many years. They were the ones that helped developed the Internet and the nodes for that. And they had an absolutely fantastic engineer named Jordan [J.] Baruch.

Octo Barnett, circza 1960s.

Source: From the personal collection of John Barnett.

I went down to NIH and said, "We ought to try using time-sharing computer systems to improve medical care."[34] And he wanted to do it in the administrative area, in the financial area, which is by far the most logical place to do it. And they said, "No, you can't do it [in those areas], it's got to be in clinical care." There was one other problem: they still hadn't developed time-sharing yet, either. They had an idea of how to do it, but they hadn't already gotten around to it. And so NIH gave a whole batch of money as a contract. They said, "You have to have a hospital, you can't just do it at Cambridge." And so we said, "Well, what are some [hospitals]?" They said, "Well, MGH is a fine hospital. Go up and talk to them." And so I came up and talked to the director of MGH, who didn't understand at all what was going on but wrote a wonderful letter saying, "We'll be glad to cooperate with you, as long as it doesn't cost us anything." And you can imagine the difference of what that's been over the years! Talk about a bad guess [because it wound up being expensive]! And so they worked on this for about a year and were getting nowhere, partly because they still were working mostly on developing time-sharing, but nothing was happening in the hospital. The first day the new director of the MGH came here—a guy named John Knowles, who was an unbelievably imaginative individual—there was a site visit from NIH. They just gave MGH a very hard time, saying, "You're not doing your part at all," which [John] didn't like at all, [because he was a] very proud person. So he said, "What should I do?" [They said,] "Well, you ought to get somebody who knows something about medicine and computers down here to run the project."[35]

JA *Was Homer Warner* on that site visit?*

All the code had to be written, basically, in assembly language.

OB Homer Warner was on the site visit. So [MGH] asked Homer, "Where can we find somebody like that?" I'd been talking to Homer. Homer, in fact, was one of the ones who encouraged me to get in the field of cardiology, way back yonder, when we were both sort of physiologists.

DS *Where did you meet him?*

OB Oh, he was at one physiology meeting in Atlantic City. I'd gone up to him and said, "Hey, can I talk to you? I want to know, is there a field here that I could go [into]?" He was just beginning then. He was very excited. And he was a very good guy. [Homer] told [MGH], "You ought to talk to this guy named Barnett over at the Brigham." And so here I was in a little closet office over there, when the MGH director and the chairman of the Department of Medicine came over to me in my little office and said, "Would you like to come down and run this project?" I had no idea what was going on. They didn't either. We [realized that we] were going to have to talk to this engineer [Jordan Baruch] who could have sold refrigerators to Eskimos without even going there. He gave me the most glorious vision of what it's all about.

JA *Was this Baruch?*

OB Jordan Baruch, yeah. He was a pathological liar, but undoubtedly also a guy who had a vision and a brilliance and ability to verbalize it in a way that I've never met since. He talked to me and said, "It'd be a great opportunity." Well, I came down [to MGH]. The first two years were absolute disaster. We were doing [the work] on Model 33 teletypes, 10 characters per second. We first put a couple of teletypes out in the care unit and started doing lab test reporting and medication ordering. All the code had to be written, basically, in assembly language. There were no such things as programmers then. They would hire people—basically, I think the idea of how to recruit programmers was to find out if they could play the flute. That seemed to be the qualifying—they couldn't find any other desirable qualifications they shared. The system was erratic; it would go up and

> # The hospital does not tolerate things that are just there for research.

> # They built, actually, the first time-sharing system ever made.

down. I remember one time they had a program, we tried it, it crashed. I started the program, it crashed. I called up the programmer. He said, "Well, try it again; maybe it'll work this time." I told him, "That's not how we do things at Massachusetts General Hospital."

You know, there's all sorts of stories. We couldn't use telephone lines, because at that time it was all plugin, operator-type stuff. And so we had to get a solid copper wire connection.

DS *Between Cambridge and—?*

OB Between Cambridge and here [MGH in Boston]. Well, the telephone company didn't have any of those. They didn't have a thing called a tariff. They had no way to sell it. And this engineer [Jordan] found out, basically, that there was a tariff for lines that were laid along a railroad track, using the telegraph wires, because for the telegraph wires, you had to have a continuous connection. [Jordan] said, "Why don't you pretend you're going to lay up railroad track between Cambridge and MGH?"

DS *Good idea.*

OB So they put a copper wire underneath the Charles, and got over here, and we got four copper wires connected over there.

DS *Just for you?*

OB Just for us, yes.

JA *Who paid for that?*

OB I don't know.

JA *He just got it done?*

OB With Jordan, we would never know what he paid for what. To say the least, there was enough going on that we could do that was very provocative. The hospital does not tolerate things that are just there for research, though. People have work to do. Anyway, to say the least, [what we were doing with computers] was novel. Several classes formed to teach what computers were. You know, have them hold up their hands to say what "one, zero" was, and so on.

The teletypes were noisy. They had to build a black box to put them in. A nurse called up one time and said she couldn't figure out where to pour the blood into this thing that did lab test reporting.

DS *Oh, my goodness!*

OB We were well back in the beginning time, to say the least. It was very frustrating, because we weren't making much progress in terms of the technology. And that's fair enough. They built, actually, the first timesharing system ever made. And we unpacked Model Number 1 and PDP-1 of the Digital Equipment [Company] and did our first work on that. It was 8K of memory, 4K basically being the system; we had four partitions of 2K each. And you had to write very tight code for that type situation.

JA *At what point was that? You were talking about the two years, a really difficult period.*

OB Oh, '63, '64, something like that—maybe '66? Somewhere in there. Well, I was still running my lab. I had not yet given up [the possibility] that maybe I could have two careers. I wasn't sure this hospital career was going to work out, anyway. And I would hire students from MIT to come work over here. And then [try to keep them] when they graduated. I had two of them: one was Neal Pappalardo, and the other was Kurt Marble. They did their degrees under me, and they had to do a thesis project in their fourth year. Neal Pappalardo's thesis [involved] trying to look at the incidence of EKG arrhythmias, and particularly EKG premature beats, after a myocardial infarction.[36–38] We built tubes that were crude analog computers that would look at the width and count the number of EKGs and store them. The trouble was,

> # Well, through most of my life, the best of things happen when people ignore what I say.

we had the individual connected to the computer by wires, and to get up and walk around, they had to push sort of a cart with a long tail connected back to the electricity. And so they'd go around the floor with their little computer working on a 19-inch cart on wheels. We kept people with myocardial infarctions for up to six weeks, so we had them there for a long time. But that was his thesis, counting the number of premature beats after a myocardial infarction.

JA *This was an undergraduate thesis or doctoral?*

OB Undergraduate.

JA *Undergraduate thesis at MIT?*

OB Yes.

JA *Wow.*

OB Yeah. Well, the stories go on.

JA *I want to hear more about him.*

Octo Barnett, circa 1970s.

Source: From the personal collection of John Barnett.

OB Well, I'll tell you about the next site visit we had. It was a humorous thing where we're showing them time-sharing on a little computer, and one of the site visitors was sure there was someone in the next room who was typing back into it. [laughter] The computer was a new thing at that time. At the site visit, there was a very good individual named J.C. Shaw who worked for Rand Corporation. He had actually been a programmer [and] helped do the early work for [Allen] Newell and [Stuart K.] Card. He was talking about that he had developed a language called JCOS that was not a compiled language. This sounded quite interesting. One of my MIT students heard about this and decided he would go back and try to develop a language over at MIT. So he actually brought up a very early version

of the language. Well, this got Neal Pappalardo very interested, as well, and he was saying, "Look, stop working on what we're now doing. We ought to develop our own language here." And I said, "Neal, look, we're a hospital lab. We're not the type that should be doing a thing like that." Well, through most of my life, the best of things happen when people ignore what I say. And so basically he and Kurt and a couple of the other MIT students I had here started working on it, and they developed an early prototype of it that really did look very interesting. And the thing was, you could actually bring out programs fairly well, and when they didn't work, you could really tell what was wrong with them.

DS *This was replacing your assembly?*

OB Yeah, replacing the assembly language.

DS *That was a big step forward, wasn't it? [laughs]*

JA *And how!*

JA *And how old was Neal at this point?*

OB Well, he just graduated from MIT, so he probably was, what, about 21, or something like that. Brilliant guy. Unbelievably brilliant. And so I then had the job of going down to NIH and persuading them that we should basically cut loose of the contract from BBN [Bolt Beranek & Newman, Inc.] and do the work ourselves, with our own programming language.

DS *Wow!*

OB And you think I didn't have to do a sell on that line!

DS *Goodness!*

OB We could basically bring some sort of the evidence of what [we] were doing and how it was, and they finally [said], "What the heck. Instead of going [along] the other way, we'll try them."

> I've been a fairly good snake oil salesman—that's the main thing I do—and persuaded them that this was sort of the thing to do. And so by about '66, we were up and running with our MUMPS [Multi-User Multi-Programming System].

JA *Why did you go to them and ask for that change?*

OB Oh, because I was changing a very big contract that was going to both BBN and MGH, and I was saying, basically, we were going to drop the BBN part of it, we're going to do it all on our own, and changing very radically the technology under which MGH thought they were supported. And luckily the people at MGH were adventurous enough. For that time, it was a very large—up in the couple of million dollars— contract, and that was huge money in those days.

JA *How did BBN feel about that?*

OB Well, BBN had decided they were going to go commercial. They thought they had a good deal going, and they sort of lost interest in the medical part of it. They persuaded GE to set up a very large enterprise of making a commercially available time-sharing system for medical care, and Jordan basically persuaded them to hire about 30, 40 programmers, [and was] well on his way to doing a good job there. They got caught in one of those terrible things that happen. The accounting office at GE, somehow, in doing the analysis of cost benefit, etc., had decided that they were losing money very badly, and projected they would never make any money. And so in one week he had to close down the whole operation. They later analyzed the data: there's an interesting article [that's] been written on that. It turns out they had made a gross mistake in how they had done the calculations, and they were actually in good shape. So GE lost an opportunity way back yonder, to get going.

JA *Interesting. But NIH was convinced by your—.*

OB Well, convinced is probably not the best word. They were, I think, willing to sort of tolerate it, and they were willing to take gambles, and it was clearly a gamble. I mean, I've been a fairly good snake oil

salesman—that's the main thing I do—and persuaded them that this was sort of the thing to do. And so by about '66, we were up and running with our MUMPS [Multi-User Multi-Programming System]. And there's a long history of MUMPS. We were one of the first open source systems, if you will. We gave the tape away to anybody who wanted it. We had six or nine different versions of MUMPS around the nation, and formed a MUMPS users' group who helped standardize the language so there was one standard of activity. With a lot of effort, I basically persuaded DEC [Digital Equipment Corporation] to support MUMPS. It took them a long time to get—. It is an obscenely different language from almost anything else, so they had a hard time believing it would ever be commercially viable. But they basically ended up supporting it and making it available.

JA *Let's go back, because you said in your paper that you couldn't remember where the acronym MUMPS came from?*

OB That's right, still don't.

JA *You still don't?*

OB That's lost. I mean, I can't even find anybody in the community who remembers. It stood for Mass General Hospital Utility Multi-Programming Systems. I don't have the slightest idea which came first, but I suspect the "MUMPS" came first. I mean, at that time we were fairly loose, if we had to have a name for something—.

JA *And it sounded a little medical.*

OB Yeah. Of course that was a disaster from the rest of the community—anything named that couldn't be any good. [laughter] There's a lot of that story I don't remember very well.

JA *What happened to Pappalardo?*

OB Oh Pappalardo basically became a multimillionaire. Somewhere along the line, around '68, '69, he left the lab with Kurt and they formed a company called Meditech. He had a very clear vision of what he wanted to do, which was to have a standard
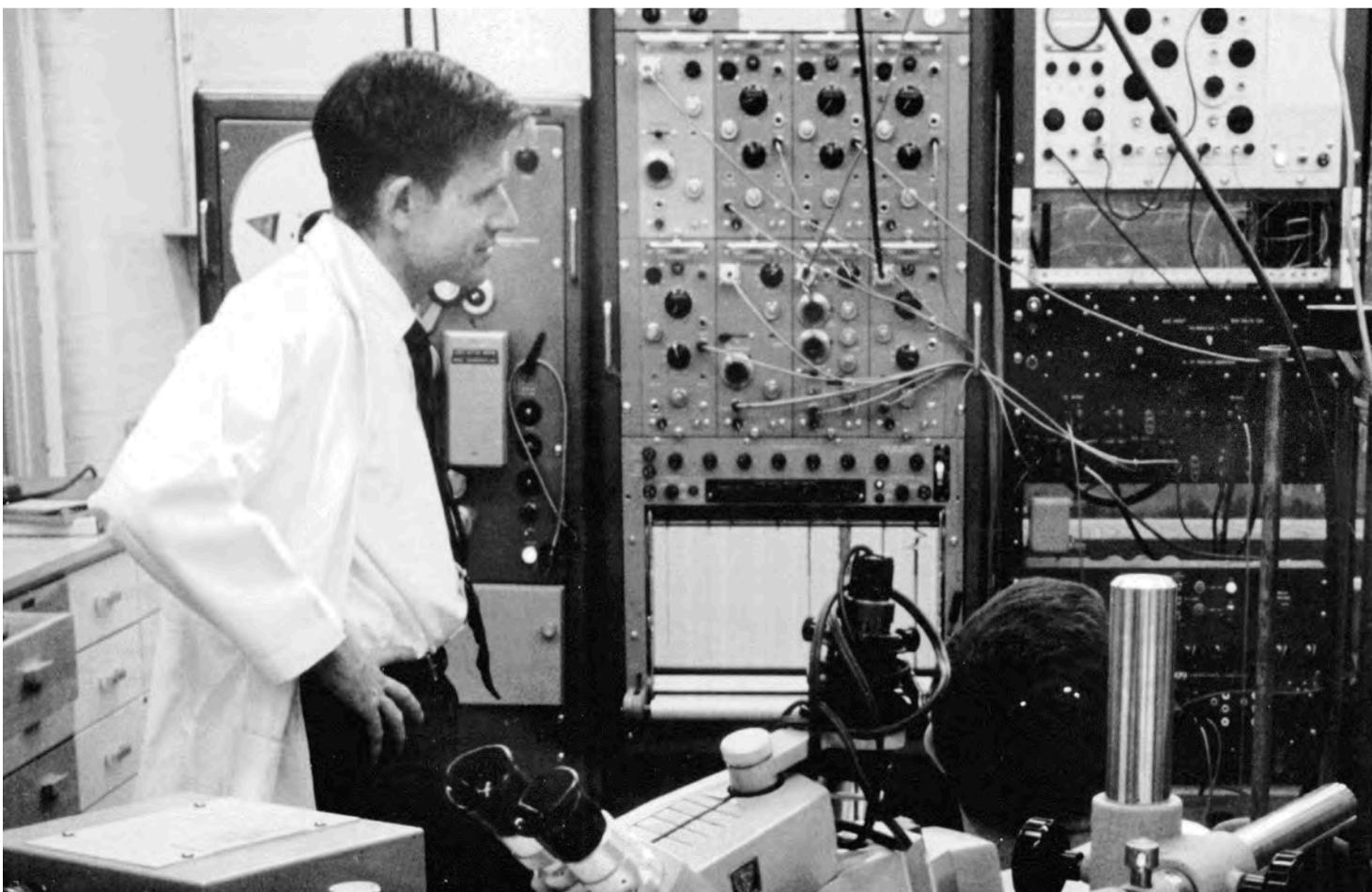
Octo Barnett standing next to the computer in the Massachusetts General Hospital Laboratory of Computer Science, circa 1966.

language, a standard set of applications, and sell it to small hospitals. He didn't want to have any problems with having a language that was open domain, and so he basically redeveloped part of it and then started off with a language called MIIS [Meditech Interpretive Information System] that was sort of—well it was a better version of MUMPS at the time, I'll put it that way. It has some good ideas. He developed a business plan and got money. He and Kurt and one of the physicians working in my lab, called Jerry Grossman, had a fair bit of private money and I think basically founded this company that has been widely successful. They probably must have the great majority of small hospitals, and they sell a system—. They have a business plan which is very good. They say, "You take our system for what it is, and we don't change it." So they could support it very well themselves, very cheaply, and do a very good job of it. They don't go after the big university hospitals, and big hospitals don't want them, because they won't do modifications.

DS *So is that the Jerry Grossman now that's the head of New England Medical Center?*

OB He was. Jerry got pushed out of that. Jerry got caught in a bad idea, which was that medicine was going to greatly expand, and there'd be a huge inflow of money into it. And so he sunk a whole lot of money into building new buildings and new services. Then all of a sudden, the bottom dropped out of the reimbursement, and his hospital got in deep financial problems. He now is working over at the business school.

DS *But he started in your lab, too?*

OB Yes.

Life is pretty much made up of fortuitous circumstances.

Octo Barnett, circa 1970s.

From the personal collection of John Barnett.

DS *Just one of the many. He was at the Mayo Clinic for a little while?*

OB He got his PhD and his MD at the Mayo Clinic. I always kid him, he got a cheap PhD.

DS *I always thought so, too. [laughter] Of course you did some nice work.*

OB Yeah, he was mainly in intensive care. But he was an actual cardiologist.

DS *Right, exactly. You never made it to the cardiologist?*

OB Oh! I'm the most overtrained, underqualified doctor. [laughter] I had five years of fellowship.

DS *Oh, good! [laughs]*

OB Well, Ted [Edward H. Shortliffe] worked here as a student for two years.

DS *Is that when he was a student at Harvard?*

OB Yeah. He decided he wanted to go to med school, and I told him to go to Stanford. At Stanford, he could get much more freedom to do what he wanted to do than [he could at] Harvard at the time. Bob [Robert A.] Greenes did his PhD here—he was one of my first PhD students. Tony [Anthony] Gorry did his PhD here—and he's down at Rice. Ed Hoffer was here, as an MIT student 25 years ago. He's still down there, working. Don Studney is a professor at Columbia. Jerry Grossman—. Richard Friedman was head of the Lister Hill Center for a while. He's now out in Hawaii. Henry Lowe is head of the computer activities at Stanford. Michael Somad is medical director of the Henry Ford Health System. Bart Harmon is chief of medical informatics at Walter Reed—actually, for the whole Army now. Jim Cimino is a professor down

at Columbia. Chris Cimino is a professor at Albert Einstein. Diane Oliver was at Stanford—I don't know what she's doing now. Gerald Kahn was chief technology officer of World Care. Henry Chueh is now the director of the lab. Robert Jenders is a professor now in UCLA. Bruce Forman is down at Columbia with Stan [Huff]. Joe Bormel was the chief architect at Cerner Corporation.

DS *Joe Bormel? Oh yeah, he's at QuadraMed now. Just left [Cerner].*

OB All right. I've got to try to get in touch with him.

DS *Yeah.*

OB Michael Barnes, you remember, he's project manager down at Regenstrief. John Tou is director of health systems at Loyola University. That was just the list that I can remember right there. There's about, I don't know, 30 others.

DS *I was going to say, those are just the good ones, aren't they?*

OB Well, those are the only ones I remember at the time. Still up there [points to his head].

JA *So did they pick you or did you pick them? How did this relationship happen?*

OB You know, I have a philosophy that basically life is pretty much made up of fortuitous circumstances. It's a little bit of being in the right place at the right time. It's a little bit of—most of these were individuals that in one way or the other we crossed—. A lot of the later ones came because we have a formal training program here, and they would apply to that. Whole batches of them came through that program over the last 10 or 15 years.

DS *So you were one of the first NLM training programs, weren't you?*

OB Yes.

JA *And you were the director?*

OB Yeah.

JA *And you did the selection of the fellows?*

OB Yeah. One of the things we do when a new fellow comes here, they spend a lot of time talking to the other fellows. In other words, it's like a college. A college stays good, if it ever once gets good, because the students then attract other good students. So what you try to do is to basically have them really get an understanding of what the fellowship program is like, and what the fellows do. And the fellows can do a much better job of selling than I can because it is their reality. The fellowship program has been very, very wonderful for the lab, brings a lot of new ideas, fresh blood. We have, I think, eight of the former fellows here now on the faculty. We try to keep them. I mean, it's very hard to leave a place like this.

JA *So let's see, let's go back. We're still talking about MUMPS and what was happening after that. I'm going to go back to what was happening in your personal life during that time.*

OB All right. Well, let's see, we started having kids, which was—. I'm sure that I must not have paid as much attention—. Looking at my grandkids I can't believe that I had kids who were as active as our grandkids are. Or else I blocked out completely what it was like. At the time we were living in a small apartment and I had a teletype in the bedroom because that was the only space we had for it. And so the kids sort of grew up to the clicking of a teletype. It was certainly a very enjoyable family life, although I really don't—my wife must have done most of the care of the kids. I can't remember ever spending the amount of time that our grandkids seemed to require. It's all blanked out.

> **A college stays good, if it ever once gets good, because the students then attract other good students.**

> **I was very much opposed to the Vietnam War, very active early-on in that.**

Another part of my personal life, I was very much opposed to the Vietnam War, very active early on in that.

DS *Yeah, you were telling me the other day about the draft dodgers who used to come to the lab.*

OB I did a minimum amount of draft counseling, and I got to know a lot of the draft counselors on the East Coast. If they had an individual who was a conscientious objector, who needed to find a place for alternative service, who was trained in mathematics, they gave me a call and said, "Hey, can you take him on?" So they would come up and interview. At one time, I think I had seven or eight of them working here in the lab, doing their alternative service. The funniest one was a probate officer at one of the local courts here, who called up and said that he'd heard about me, and they had an individual who wasn't a conscientious objector, because he wouldn't even register for the draft at all; he was not going to have any participation. And so [he] wanted to know if I would be willing to take him on. I said, "Well, have him come by the lab and I'll talk to him." The next day, I got a call from the office of the judge saying he had been sentenced to work here at the lab. [laughter] I said, "What?!"

DS *I like that one!*

OB "Yes, we've sentenced him." I couldn't find that I had any responsibilities, so I said, "Oh." He was flaky. I've had a lot of guys who were somewhat flaky, and we try to make a computer operator out of them, which worked out only modestly well. After three or four months, he sort of disappeared. I wasn't sort of his probate officer, so I don't know what ever happened to him. But he moved on to something else, I suppose.

I was very active in the Unitarian Church, and later on in the Friends—Quakers—Meeting. Both of those got me heavily involved in anti-war activities. About three or four years of my life are just one large blur because of the intensity of what that was. At one time, we had an individual who sought sanctuary in the church. It was an old sort of early tradition of churches having sanctuary. He was in the Army, and he basically didn't want to be in the Army. It was really a mob scene around the church. I mean we were inside

> # You can be a nurse and still be a computer scientist.

the church, six or eight of us with him, and there were people banging on the doors, trying to knock the doors down. The police weren't at all sympathetic.

JA *What church was this?*

OB Oh, it's a big church, Arlington Street Church. It's right near the Boston Garden. We basically negotiated with the FBI and we arranged that he would get an honorable discharge. It was a time of some turmoil in my life. I'd say in my personal life, I have been very fortunate that these engineers that I lived with, basically we all got married about the same time, to girls that we had always sort of known. And we have stayed in very close touch with each other. We've done many, many hikes, and summer vacations, and canoe trips, and ski trips, and sailing trips together with our families, so our families have all known each other. The kids have formed very close relationships, and now our grandkids are basically getting to know each other. It's been a wonderful experience of really a bunch of close friends, and my family over the years have had just very, very wonderful people to have around. It's truly, I think, a fairly unusual situation of having such an extended family. Each year, we try to get together down in the Vineyard for Memorial Day. And now we have to rent five houses to hold the people, the kids, and the grandkids. It's a great community, and I very, very much enjoy that. We all celebrate each other's signal birthdays. We've had two of the men now reach their 75th birthday, so we always have to have a big blast and have a big party and all get together and tell stories. We often write and read poems to each other, but it's always an issue, writing a poem. We have weddings, and we have more weddings—it keeps on going on.

DS *You used to go visit Homer Warner. Didn't you go sailing with him a couple of times, too?*

OB Oh, yes. Well, Homer and I really have lovely [times]—he is such a fine person.

DS *Yeah, I know.*

OB We would go sailing. Well, another good story is about Homer, who, as you know, is a devout Mormon. And so on site visits, if we could, we would go to a

Quaker meeting first, and after that one, we'd go to a Mormon meeting. So we'd both go to both things. It was a good privilege of working with him.

DS *Good discussion, I bet.*

OB Oh, yes. Well, Homer always gave me a hard time on sailing because I have the tradition that each morning, I get up and I swim around the boat.

DS *You told me about that!*

OB He says that's crazy, but I did it, so lump it! I admit that the water up off Vancouver is a little cold. [laughter] I used to love to go out and meet his family. I was always impressed how nice his kids were. I mean they were very, very sweet; they would not sit down until I'd accompany them. And here I've got my kids [laughs], exactly the opposite. They inherited all my bad traits. [laughs] How do you raise kids like that?

DS *I don't know.*

OB But Homer Warner, Jr., I got to know him, because he beat the heck out of me in tennis.

JA *Any of these MIT friends, or any of your children, involved in medicine or medical informatics?*

OB [laughs] Well, my two oldest both went on to business school. My oldest [John] went on and got a master's degree in computer science. IS [Information Science] is his strongest suit. Finally—I don't think he liked it much, and he finally went to MIT and Sloan, got his degree. He now is in financial management-type activities. My middle son, Andrew, went to Chicago business school. He's down in Australia now, working in financial activities. I asked my oldest son, "What happened to this tradition? Why not follow in your father's footsteps and become a doctor?" As I say, he did inherit every one of my bad traits. He said, "Well, Dad, you were never much of a doctor, anyway. [laughter] And I had to admit, he was right on. My youngest son, Robert, works on computer activities support for the Red Cross down in Washington D.C.

Sarah and Octo Barnett, Boundary Waters Canoe Area (MN), circa 1980s.

He's by far the only do-gooder we have. He's a world-government type, from way back.

DS *I have another question: You know, one of the things that impressed me when I was looking over your c.v. was how many papers you wrote with Rita Zielstorff.[19,39–44] I know that both of us have worked with her, and I just wondered if you could tell me something about what she's meant to the lab. You've worked with her for a long time.*

OB Rita is a very effective and competent person, and is a wonderful advocate for the nursing profession. Rita and I used to have these long discussions: why couldn't I call her a computer scientist? And she claimed she was a nurse. I said, "Well, that's okay, you can be a nurse and still be a computer scientist. And she was also a very good author, and also was very good at dealing with the—. Oh, you have to get Rita to tell some more stories sometime.[45] We brought up a doctors' ordering system. That must have been, I don't know, probably late '60s, maybe late '60s. And we got permission grudgingly, from the chief of medicine, and nobody really understood what we were trying to do. We installed a teletype where the doctors would have to put in the orders. Now, we really took very seriously the idea that an order had to be a legitimate order. We'd look for drug-drug interactions. Three major problems happened to us. [light in office goes out] That often happens when I talk. [laughter] I've never quite figured it out.

JA *The light just went out.*

OB Yes it does. Sometimes when that happens in the meetings, people say it's time for me to stop talking. [laughter] There was no tradition, at that time, that orders had to be good orders. My classic remark is

that one we went back and looked at the orders the residents had been writing, and one was "give some morphine."

DS *Good idea.*

OB We sort of said, "Hey, the orders have to be complete [include dosing instructions]." More than half the orders were not complete orders. And they were saying, "Hey, the nurse could do that, she can figure it out." They really did have a sense that the nurse can take responsibility. You don't have to say whether it's PO [per oral, or by mouth] or IM [intramuscular], they'll know how to do it. And we were saying, "No, you can't do that, you've got to write a complete order." Now here's basically a computer system telling a group [what they've] got to do. The chief of Medicine had left for sabbatical. The director of the hospital didn't really care what we were doing. They sort of let me do the experiment because I wanted to do the experiment. But there was no support from any sort of administrative hierarchy. So I was really rather exposed.

The second thing was we tried to really look at drug-drug interactions. Basically, knowing what y'all know about doctors' ordering systems, you know that it's awfully hard to know when a drug-drug interaction is serious, and when do you require them to do something different? When do you even tell them about it? Well, we were just in the beginning of it, and we were maybe too compulsive, because we would flag orders. One of them I remember. There were two orders for digitalis. I said, "No, you can't do that." Well, basically, it was their way of getting so you get sort of a balanced load of it. And there were all these sort of intricacies about drug ordering that we were

Octo Barnett on the tennis court, circa 1960s.

The physicians were the only ones who could put the order in.

uncovering because we were actually trying to use the system.

The third thing was that we got caught in the crossfire in the issue of the sociology of nurses and physicians, and who does what. At that time, there were standing orders from the Nursing Department that there were no verbal orders. You know that problem still exists 20 years later, thirty years later. Well, what the nurses did was to say, "Since you have a computer system, we're not going to put the order in. We don't want to learn how to use the computer." And so the physicians were the only ones who could put the order in. Now, what happened was the residents who were reasonable people, they would go ahead and put the order in. But when the residents who were the bastards—and we have them always, among the residents and staff—would say at two o'clock in the morning , "Mrs. Jones needs a medication, the response from the nurses was, "Well, you have to come down and put it in the computer." You can imagine the computer getting caught in that crossfire.

JA *The nurses told the doctors to come in to place the order?*

OB Yeah. I mean, they were using it as a stick to beat the residents who were giving them a hard time.

JA *Hmm.*

OB This led to one of our major breakthrough technologies. "Well," they said, "we don't want to have to go back to a computer located over here to put an order in." And so we put a computer on a cart and we built our own little radio station on the cart, and then the order could get sent over to the other computer. Basically it would broadcast what they were typing in over to our little station.

DS *Wireless!*

JA *Yeah!*

OB Wireless. [laughter] To say the least, our technology may not have been as good as what one could do now. And we would continually get interference from Logan Airport and from taxi drivers driving alongside. But it worked modestly well. We had the first sort of remote connection of the wireless communication. The chief resident at that time would spend half his life for the several months just protecting me from the onslaught. He's a good friend of mine. He's now senior faculty, and he still reminds me about the resistance we had on that one. One time, they actually threw the terminal out of the window, they got so mad at it.

JA *Are you serious?*

OB Well, you know, I can't document that. [laughter]

DS *You don't have a picture of that? [laughter]*

OB That's the story that is told. Anyway, after about three to five months, the residents said, "We're revolting. We are not going to practice on this floor if you keep this thing here." And so basically they just took it off. A number of [reasons I think it failed]: it was badly done, it was slow technology—I mean at 10 characters per second, you can't do very much. We did understand the sociology of the practice of medicine. We certainly did understand how you handle drug-drug interactions. It was taking them more time; it was frustrating to everybody concerned.

DS *I don't think much has changed!*

Octo Barnett, circa 1970s.

Source: From the personal collection of John Barnett.

It was taking them more time; it was frustrating to everybody concerned.

Computerized self-assessment is AMA/NET's newest feature

The computer describes the following scene: It is 8 p.m. and a husky, Irish policeman is helped into the emergency department by two companions. He came there because of mild, generalized abdominal pain that started more than a month ago.

The next message on the screen invites the physician to "examine" the simulated patient who has been described by AMA/NET, the nationwide telecommunications network of the American Medical Association.

"How long do the pains last?" is the physician's first question. He can type that question on the keyboard of any ASCII-compatible computer terminal, including his personal computer at home. The American Standard Code for Information Interchange (ASCII) is used widely for transmitting messages from one computer to another and is accepted by most terminals that can be hooked up to telephone lines.

The "patient" — actually a computer at Massachusetts General Hospital (MGH) in Boston — answers: "This pain is at me all the time. It never goes away."

Vomiting? "When the pain gets real bad, I vomit."

Fever? "My forehead does feel pretty hot."

THE PHYSICIAN may continue to ask about vital signs, distention, enlarged organ(s) or mass in the abdomen, or tenderness to palpation. If he requests them, results for hematocrit and plain film abdomen are supplied instantaneously. At any time he can offer a diagnosis, and if his suggestion is tuberculous peritonitis, the computer confirms it.

The exercise is part of AMA/NET's newest feature. Computerized self-assessment courses that were developed originally for Harvard Medical School will become available this month for physician subscribers to the network. The courses carry continuing medical education (CME) credits toward the AMA Physician's Recognition Award.

Although the machine keeps track of the physician's performance, the MGH/CME program is not a test. Instead, it creates a confidential learning environment for the busy physician who wants to practice his skills. More than 20 modules are available in subjects as diverse as abdominal pain and meningitis, coma and

Octo Barnett, MD
. . . Education should entertain.

'The point isn't to get the right answer every time,' says G. Octo Barnett, MD. 'Part of the fun is the ability to experiment.'

Course lets MDs practice skills by computer

cardiopulmonary resuscitation.

"The point isn't to get the right answer every time," said G. Octo Barnett, MD, who supervised the development of MGH/CME. "Part of the fun is the ability to experiment."

The computer automatically guides the physician through simulated clinical problems, critiques his problem solving, and suggests alternative approaches he might have used. If the physician disagrees with the computer, he can interrupt the course at any time to send a question or comment to MGH through a built-in electronic mail system. A day later, the physician can turn on his computer terminal, access his mail, and read a response from an MGH physician.

"This system emulates a worthwhile educational environment and also is fun. It has a sense of movement; it doesn't bore you. You don't feel you are just turning pages," said Dr. Barnett, director of the MGH Laboratory of Computer

Some courses present cases at increasing levels of difficulty. The central computer in Boston keeps track of the physician's progress. As he demonstrates mastery at one level, the computer challenges him with more difficult cases and extra complications.

In an interview, Dr. Barnett emphasized that he did not object to comparing the self-assessment modules to arcade video games such as Pac-Man or Donkey Kong. "Game-playing is a wonderful thing. I'm all for it," he said at a recent computer conference sponsored by the American Board of Medical Specialties.

"There is no question that education should be entertaining, attractive, and visually exciting," he said. "There is nothing that says that education should be boring. If I could (make CME courses) as good as some of the video games, I would think that I had done a wonderful job. I wish I had the graphics that they do."

Ideally, the MGH/CME programs should be exciting enough that a phy-

realistic patient care simulations and establish a format that gives the impression of working with a wise colleague, perhaps a professor.

They try to anticipate how physicians will respond to a situation, and to build enough knowledge into the computer that it can handle mistakes. "This is not just a linear sequence of questions and answers. The computer has to be able to let the physician pursue some courses of action that might not be as useful as others," Dr. Barnett said.

The design takes a minimum of six months. To get the bugs out, new programs are field-tested on Harvard medical students and faculty for three to six additional months. Every two years, MGH reviews the programs to determine that they are up to date.

The programs are revised constantly in response to questions and comments from users. MGH receives as many as 100 letters per week.

"We get back a tremendous number of

able to do," he said.

Current programs cover the following subjects: abdominal pain, anemia, anticoagulant simulator, arrhythmias, arterial blood gases, basic life support, bleeding, cardiopulmonary resuscitation,

Computers in medicine

Octo Barnett featured in *American Medical News*, October 28, 1983.

OB Exactly! [laughter] You don't notice me doing doctors' orders systems anymore, do you?

DS *I see that.*

OB Rita was sort of responsible for that part of the work.

JA *Ah! I think we will need to talk to her about that. This is an early CPOE system?*

OB Absolutely. It was very early—"system" may be too strong a word. [laughter]

JA *Attempt?*

OB Attempt. Yes. I have to tell you my other type of technology breakthroughs. We were going to try a new way for doctors to write progress notes. Bob Greenes, in fact, did his Ph.D. thesis on developing that here for hypertension. We wanted to basically have some way of interacting that wasn't keyboard. And so we decided to make a touch screen. Now, the thing was, there were no touch screens available. And so we made it—basically, Kurt did this. We had aluminum strips in two dimensions, going across, and each of them was connected as an oscillator. And when you touched it we could tell which oscillator you decoupled, so we could actually tell what you had touched on the screen. It worked very well, except in days of high humidity or if you sweated too much, you picked up a few milliamps when you touched it. So it made the notes very short. [laughter]

> # We decided to make a touch screen.

JA *Ouch!*

OB But we were actually using it for radiology, to do some radiology reporting. We did some for the hypertension-type thing. I'm afraid a lot of what we tried to do, we were way ahead of technology, way ahead of understanding. And we just thought, "Let's see what we could do about this." And if I'd understood half of what the problems were, I probably never would have done it. So ignorance was a useful thing to have at that stage.

JA *What about commercialization? Was there any idea at all that this could be useful?*

OB My attitude has always been that we don't do— we basically make it available as an open source activity.

DS *So you've given away COSTAR [Computer Stored Ambulatory Record]?*

OB Yeah, COSTAR was basically an open source. We gave the tape away to anybody. And a number of small companies started up, trying to sell COSTAR. Some of them actually survived for 10 or 15 years. It actually is still the system used in public health care in Finland. It's called FinStar over there. It was in Sweden for a long time as SwedStar. We came very close to getting installed as an application, but just about the time that they got the thing up and going, they changed managers out there, and they decided they had different priorities. Working with a lot of what, well, INX—is it INX or IDX?

JA *& DS IDX.*

OB A lot of the IDX technology was stuff we developed here. And the radiology reporting system remained fairly close to what we developed here. A lot of the radiology reporting systems came out of the ideas that came from here.

DS *So did they give you funding while you did that?*

OB My idea was that I almost had to buy them, much less give them funding. It was a sale issue as much as anything. One of my great delights in life was a time I remember with Larry Weed,* who I've always felt was sort of the great evangelist [for medical informatics]. Larry is also a guy who is sort of like a Shakespearean tragic figure who has one fatal flaw, which is my way as well. At one time, he would not make available the database for his problem-oriented medical record. Somewhere down in Tennessee, somebody wanted to get it and couldn't get it, so he got in touch with his senator. The senator got in touch with William Proxmire, a senator from Wisconsin, who was a fiend on trying to say that government money was being wasted. He used to give a thing called the "Golden Fleece Award."

DS *Right, I remember that.*

OB So Proxmire got his folks basically looking to see what was going on here. Were government funds paying for stuff that you couldn't get? Some of them came here to the lab and wanted to know, "Well, hey, you've got one of the biggest contracts down here. Are you making stuff available?" I said, "Look, I plead with people, I give it away, I pay them to take it!" So they finally decided they would not give me the Golden Fleece Award.

DS *I guess! [laughter] Well tell us a little about the clinical decision support system you developed, called DXplain.[46] That's another thing we haven't touched on—a great accomplishment. When did you start that and why?*

OB It was probably somewhere around, let's see, the early or mid '70s.

DS *Really?*

OB I was on the site visit when Jack Meyers was getting up into it.

DS *Oh, and you thought, "That's a good idea," huh?*

OB I thought it was a great idea. I had to fight for that in the study section in spades to get them to fund it.

DS *Is that right? Huh.*

OB I told them, "Look, this is clearly the way to go in doing things." Well, that must have been the early '70s. And then somehow I was on an AMA hierarchy-type committee or something, and they wanted to know what you could use computers for. And I said, "Well, maybe computers could help in diagnosis." The other people on the committee said, "Show us how you do that." And we came back to the lab, and we put together a system, and they said, "That does sound sort of reasonable." A guy named Dan Harris, who was the head of technology for them. One of the things I was very different from Randy [Randolph A. Miller] on was insisting it had to be absolutely very simple to use. I did not believe you could train the doctors, and they will not read documentation, so it has to be something simple. I totally agreed with Randy that the computer doesn't make diagnoses, it basically provides ideas about what you could do. We put it out on a private network, well before there was Internet, and then we had it on a commercial network called TelMed. When the Web came up, we transformed for the Web. And we've been working on that sort of continuously for about 15 years. It's always a developing system. We continually add new diseases, new findings, and we continue to change the database. Randy believes you can find truth—what is the incidence of a particular disease. I say there's no way you can do that. That's one of our standing discussions, particularly when I get enough to drink.

We basically had had a variety of delightful experiences. Completely crazy. We made it available on stand-alone systems, but that didn't work because nobody ever took the updates. In fact, there's one stand-alone system still running, I think, at one of the Chicago med schools. For the past few years, Merck basically has paid us to make it available to the website. So we had 15,000 physicians using it last year. And we use about 30 or 40 med schools across the States. It's a fun project. Right now, we are working on how we make all the functions available with API [application programming interface], so you can integrate it into your [electronic medical] records system. In our own hospital, any abnormal lab test has a little icon beside it that basically sends that abnormality over to DXplain it. If you click it, you're told the diseases that

> **In our own hospital, any abnormal lab test has a little icon beside it that basically sends that abnormality over to DXplain it.**

> **One system was not big enough, so we actually had two PD-15s and computer-to-computer Interactions, so we had sharing across two different systems.**

can cause that. And we're basically working on trying to get more diseases in that now. Of course, the golden thread that completes all of these, the Holy Grail, is basically how you integrate it in with a medical order system. We're working very hard with DXplain to try to move forward on that.

DS *That's a great idea. I want that idea! [laughs]*

OB It's clearly the direction we should go.

JA *So this is a project that started when?*

OB I hate to say this, but some of the COSTAR, if you look at the actual code, some of the stuff I wrote over 25 years ago. Now you've got to worry about the system getting outdated. It's being transformed tremendously because of what Henry Chueh's been doing with it—updating the front end to it and all. The underlying structure of the medical records system is still very much the structure we had in COSTAR. We did some things right. And that has been going on now for over 25 years, the COSTAR project.[5]

JA *The lights just came back on!*

OB Well, it likes COSTAR.

DS *It likes COSTAR!*

OB Yes. And the COSTAR project was, again, one of those side things. The dean of the med school was starting up the Harvard Community Health Plan, one of the first HMOs. He was doing computer developments with medical education, which was another whole part of my career. He basically wanted the HMO to be concerned not just with care, but also with research about what care was, and how well it worked. And so he said what he really needed to have was some sort of automation of the medical record. And, you know, I said, "Well, that's a good idea, let's try doing that." I had tried it three to five years earlier,

Octo Barnett, circa 1970s.

From the personal collection of John Barnett.

over in one of our community health centers, before there was a hard disk. Each patient had their own deck tape. As they came in, we'd load that deck tape up to get the medical record.

DS *That was a good idea.*

OB A great idea, if I may say so myself. [laughs] And so, basically, he said, "Okay, go ahead, start trying to develop it." We had some NIH funding that would cover some things sort of like that. I think they had 80 patients enrolled with the medical record system when the doors opened on Day One for the new HMO.

DS *This was in '68 or something, '69?*

OB No, no, that was probably '75, maybe even later. That system ran continuously, and they just now, I think, are finally replacing most of it with Epic, many years later. But it was probably one of the better things we've done. One of the technology things we had to do was figure out how to get systems to share. One system was not big enough, so we actually had two PD-15s and computer-to-computer interactions, so we had sharing across two different systems. That was sort of state of the art.

DS *Yeah, I guess!*

OB We learned a lot from that. A lot of the ideas of that, of the problem orientation, the way we do it, is still very much, I think, relevant. We brought it over to our own hospital about five years after that, so it's been here now, in our clinics for 15 years, probably. The on-call system is still based on a lot of the same type structure, the same architecture. So I think we made some monstrously good decisions about planning, how to do it. And that's still running, I'd say, reasonably well.

DS *I was reading some of those early papers you sent, and I was struck by a paper you wrote in the '60s where you were talking about computers and their effect on manpower and productivity. I'm*

involved in lots of projects where we're arguing about whether the computers are saving any time or money or anything like that. I was just wondering, do you think we've achieved any measurable improvements in using the computer?

OB In many ways, certainly. I don't think there's any question that our medical record system saves them time now. No question about that. And many of them are actually doing their own data entry. Now, that's partly related to the fact that the demands for documentation have changed radically, so that if we try to meet those demands with the manual system, it would be chaotic as all get out. A couple of examples:

we automatically generate patient letters about lab tests. Saves a lot of time. One area I'm really most pleased with along this line has to do with just-in-time knowledge management, how you get information through position, time, place. We have what we call PCOI [Primary Care Office Insite], for reasons that were terrible. It basically is a system that combines together knowledge access with workload support: knowledge access in terms of guidelines, patient instructions, referrals, and formularies. Each year, we do a survey of the 350 primary care physicians, and we get back about 230 responses—a 70% return on the paper survey. Almost 60% of them say our system saves over 30 minutes a day in their work and

MGH unveils diagnostic computer

By Judy Foreman
Globe Staff

Beginning this week, doctors – and even lay people – across the country will be able to hook up their personal computers by telephone to a big computer at Massachusetts General Hospital, punch in a number of symptoms, answer a few questions and in a matter of moments, receive a list of possible diagnoses, ranked in order of probability.

Like other technological advances, the new system, designed to aid doctors in making difficult diagnoses, is likely not only to advance the practice of medicine but also, further down the road, raise new ethical and legal questions, specialists say.

Will the system, for instance, become so commonplace that a doctor who does not back up his diagnosis with a computer be con-

AP photo

Dr. Octo Barnett, developer of the computer-based diagnostic system called DXplain, introduces the system at the AMA meeting in Chicago yesterday.

Boston Globe reports the launch of DXplain, a computer-based diagnostic system, which Dr. Barnett introduced at the June 1987 meeting of the American Medical Association.

it helps them give much better patient care. It's heavily used. I traced some data on it, and I think it's basically a very impressive thing. The hospital and the primary care physicians swear by it. There's never any question about funding that. I mean, they all feel that's absolutely a very essential part of their care. In terms of saving time and helping improve patient care, I think that's true.

DS *That's good! Another question I wanted to ask has to do with the UMLS project, which has been one of the longest-going, biggest projects in informatics. What are your views about it, and what's been your involvement in that project over the years?*

OB Well, I was on the steering committee that put it together in the first place. I spent about five years on it—a lot of time. Some of our fellows, like Jim Cimino and Chris Cimino, worked on that the UMLS. A lot of the clinical data in it was basically the COSTAR vocabulary or the DXplain vocabulary. I'd say one of the things that I think they've done a tremendous job on at NLM is that I fought for very strongly early on and I think successfully, was viewing the UMLS as a clinical care database, not just as an indexing process for literature. And it's come more and more and more to be viewed that way.

DS *Oriented to clinical care.*

OB In the last few years, I haven't been as active at it as I should be, because I think a lot of what they're doing is very useful. But there are a lot of very good people working on it, so that's no great loss. I think working on it was a wonderful experience. I enjoy extraordinarily much working with

From the personal collection of John Barnett.

Octo Barnett, circa 1980s

I've always been interested in sort of a just-in-time knowledge management, how you get information through position, time, place.

I view[ed] the UMLS as a clinical care database, not just as an indexing process for literature.

Betsy [Humphreys]* and Don [Lindberg],* I mean, they're two people I really love, and I think they're really great. I think that was a very, very imaginative and very good effort that was put together.

DS *I agree with you. Reed [Gardner]* was my advisor, and I know one of the things he's most proud of is having been to all of the AMIA or SCAMC meetings. And I was looking through your c.v., and I saw you had a paper in the second one. Were you at the first one.*

OB I don't know, I don't know.

DS *Have you been to all of them, do you think?*

OB No, I don't think so. I remember one year I missed the AMIA meeting because I was in Australia visiting my son. I'll tell you a thing that I'm most proud about there. At one time, I was on the boards of the membership organizations of SCAMC [Symposium on Computer Applications in Medical Care], AMIA, and ACMI [American College of Medical Informatics]!

JA *At the same time?*

OB At the same time.

DS *There weren't a lot of people who were on all those boards at once, not too many.*

OB At one of the committee meetings, I basically said, "Hey, this doesn't make sense." And so during the break, I went around and lobbied for the groups to combine, and I got enough votes. SCAMC deeply resisted that for a while because they had a cash cow. I finally persuaded enough of the board—basically, it was the outsiders of the board, the non-

Washington-type people—who agreed we really ought to try to change that. It was a fight, a really tough fight, lasting about a year. We finally got them to agree to make the three organizations go together as one. I'd say that was my only real contribution to that one.

DS *That's a good one.*

JA *We've covered a lot of your accomplishments, but I really want to know what you think your greatest accomplishment has been—maybe more than one.*

OB [laughs] In some sense, it's hanging in there. Well, I have to put this into a context. I have been extraordinarily fortunate to live in an institution that had a great deal of flexibility, and a great deal of ability to attract and willingness to support very good people. I suppose my greatest accomplishment, in some sense, is making it possible for—and attracting some—excellent people to work here. There's very little I can really point to and say, "Boy! I did that!" Everything I've always talked about, it's always been a group of us working together in doing it. An important part of Mass General and Harvard is basically attracting very good people and finding a way to make the community. I really am proud of the community we have here as a laboratory. I'm very proud of the way we work together. We have almost zero turnover. We have people who've been here 25, 30 years. And it's that type of community that I think we maintain together and bring together.
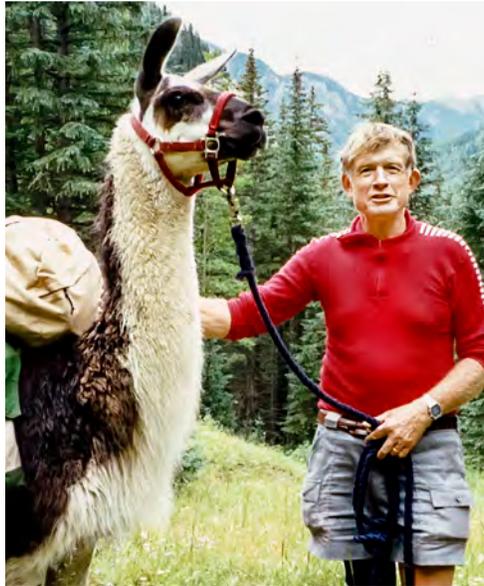
JA *What has personally been the most fun for you?*

OB Personally been the most fun? I suppose it's three things. One is the field continually evolves and

Octo Barnett, Yellowstone National Park, circa 1990s.

From the personal collection of John Barnett.

> I suppose my greatest accomplishment, in some sense, is making it possible for—and attracting some—excellent people to work here.

changes. You don't get sort of bored, because there's some new type of application. Certainly the most fun has been working with these people. I really enjoy that, I think they're very good. And in some sense also it's the field itself. I really do enjoy the field and the people in it. It's the larger-scale national community that has had some tremendous people over time. The type of fellowships and friendships and tennis games, you know, we've had over the years are tremendous. I don't know of many other fields that had this type of camaraderie on the national scale.

DS *Yeah, I agree.*

JA *You won the Collen Award in '96.[27] I want to ask you what that felt like.*

OB Well, it was a complete surprise at the time. I was supposed to go down there and introduce somebody. I must say, I usually don't stay to those awards ceremonies, because at the end of the meeting I'm heading back out. I was pleased. I think I was honored since the two before me, Morrie Collen* and Homer Warner,* there's no two better people one can be compared with. You know, at the time I asked all the people in the audience who I'd worked with on many projects to stand up, and a large number of people stood. And that support—. I think it was an award not just for me, but for the fact that there were a lot of us working together, for recognition of that sort of activity. I do have a strong sense that a lot of the things that happened are because of very, very good people working together. I would say it was, in some sense, recognition of a set of ideas and our way of approaching things.

JA *We wanted to ask you about the future. [OB laughs] Dean wants to know about the future of the lab. And then I'm going to follow up asking you to predict the future about informatics.*

DS *I guess, you know, I'm just getting worried about the field. I'm seeing fewer and fewer of these academic, clinical, computing, research-type facilities that seem like they're—like you said during our break—that your lab is going great, never better. And that's good to hear. When I'm out working, I see a lot of people buying clinical information systems and thinking that they can't afford it, or they don't know how to build them, and even Partners [HealthCare system in Boston] is saying now, "We're not sure we should be building these systems ourselves." I just wondered what you thought the role of the academic informatician is going to be or is now?*

OB You know, I'm going to pontificate on a lot of things. That's a toughie. I think there's always going be a role for an academic approach to medical informatics, because of so many things that a company cannot afford to do, and cannot recruit the people to do, or supply the type of freedom that's needed. What would fit in the medical school environment, the academic environment, is still work that we don't know how to handle. We're still somewhere between a service opportunity and the academic approach. And I don't know the answer to that. I mean, Tess Yogurf has done a tremendous job of formulating an approach of an academic thing that I would never have been able to do, and never, in some sense, would have been that interested in doing. I turned down, early on, any attempt to make this a separate division or separate thing. To me, it seemed like additional paperwork without a lot of benefit. As long as I had the type of

freedom I wanted to have, I didn't need that. But I think I'm wrong, in certain ways—it's been hard to get academic promotions even here in this hospital. That's probably true of many places, but right now it's all about genetic activity, bioinformatics, and that type of thing, which we're not very much involved with. I think we're getting more into it. This is a wonderful and probably a fairly unique place.

I don't know that I have the experience or the insight to make some statements. You probably have a much better understanding, from going around the country, from what I do, about knowing what it is like out there. I'm not worried about it here, because I think we've played a major role in helping make the hospital aware of what it could do better, and I think we're respected for that. I think there is, there will always be, a problem with academic promotions, that's always part of the system. Sometimes it's easier in some places than it is in others.

JA *Before I ask my Grand Question about the future of the medical informatics, you mentioned Don Lindberg.* Could you explain the relationship and the role he's played in what you've done.*

OB Well, certainly. I mean, I used to be a regular site visitor to these places. For some reason, I was on three or four executive site visits. It must have gotten very tiresome. More important than what he's done for me, is what Don has done for the field. He really has been enormously imaginative and enormously effective at getting Congress to put money up, formulating ideas and plans, generating ideas, and setting up the training programs. I mean that's always been extraordinarily effective. He's done a job that I can't imagine anybody else doing as well. I live in fear of when he retires. I think because of the study section type of involvement, Don can't, in some sense, direct funding very much. That's just not what

> # I don't know of many other fields that had this type of camaraderie on the national scale.

> # I think information and information management decision making are fundamental parts of medical care and of the running of a hospital and a medical care system.

he's up to. But I think the way he runs the shop, and the way the study sections run—. I can say personally, as a friend, he's tremendous. I mean, I really like the guy, I like his family, I love being with him, and I have a tremendous admiration for him. I would say that type of leadership in that area has been tremendous with the field in general, and I think a lot of what the field has done and become is due to his leadership and what his type of funding capabilities have been.

Octo and Sarah Barnett with their first grandchild, Elizabeth Barnett, 1995.

Source: From the personal collection of John Barnett.

JA You had one of the early training programs. Whose idea was the training program?

OB On a national level, it was probably Curly Dobbs. I was already training—I mean, I already had fellows. I'd always had physicians here, so it was just a more pro forma way of getting funding for it. I think Bob Renas was very important in getting the training program here at Harvard, because he's much better than I am at organizational activity—much better, much more willing to spend the time and effort it takes to do the paperwork-type stuff that's required by a training program. He does a very good job of coordinating that. I think the training program was primarily Don's idea, the best I can understand it. And I think what Milt Corn over the years has done with it has been very, very good.

JA And the future of the field?

OB Well, the bottom line, I think, is that it has a very good future. I think information and information

management decision making are fundamental parts of medical care and of the running of a hospital and a medical care system. I mean, it's impossible for you to imagine that we could continue meeting the needs and the problems that are ahead of us without much greater investment in information technology. I mean, there's tremendous need. All of us involved in the practice of medicine are basically information handlers. The field is medicine, but the field is also information systems. And so I think it's got a tremendous future in that sense. Now I don't know that I can predict very well the implications of the sort of question you asked me about the tradeoff between the industry and academic worlds. I think as long as there's a medical care system, there will really be a very major place for information systems. I think an area that I really don't feel particularly competent in is evaluation, of how do you find the P value to demonstrate something.

JA Are you saying that that's needed?

OB Well, some people certainly say it's needed, say it makes it easier at the study section level. When site visitors come here, they have a very hard time with me, because I don't have much to offer in that sense. My standard evaluation repertoire method is three questions: Do real people use it for real things? Does somebody pay for it with real money? Do other people take it to say they invented it? And if a system passes those three tests, I don't

> **There's always going be a role for an academic approach to medical informatics, because of so many things that a company cannot afford to do, and cannot recruit the people to do it, or supply the type of freedom.**

care what the P value is. I mean, I really get much more sense of evaluation from seeing what users say about it, do about it, think about it, and how they use it. I mean, their feedback and their evaluation. I think doctors often criticize me for being protective of the information technology. And in my years of experience, doctors rejected a whole lot of things I've done. It was quite correct they did it. I think they are very, for the most part, rational and critical individuals who are trying to do a very hard job under difficult circumstances. And it's very hard to stop—in that environment, it's very hard to do something, to do a bad thing initially to try to improve it, and get it going. You have to come in with a very good system, and that's hard to do. But

> ## I really get much more sense of evaluation from seeing what users say about it, do about it, think about it, and how they use it.

I'm optimistic. I'm also optimistic about the field, about the quality and the experience of the people coming into it; the fellows coming to the lab now are enormously competent individuals—very, very. They are trained, they are superior individuals, and they will do well—no question about that.

DS *Yeah, that's interesting.*

JA *And if you had some advice to offer one of these young new fellows about being an informatician, what would you say?*

OB Oh, gosh! Well a couple of important things is to basically have fun while you're doing it, because your fellowship years are some of the best years you are going to have. Be willing to take

Sarah and Octo Barnett with their sons, Robert, Andrew, and John, circa 1990s

some degree of risk, and work hard at doing it—it is very hard to quite know what's the right thing to do as you go. It is certainly to get to know your fellows, your other fellows, your other peers, to get to know the people in the field, and to listen and to learn from them; to go to meetings and try to be open to a whole variety of different viewpoints and projects; not get discouraged too easily because there's going to be some bad times; and to somehow, you know, hope that in some sense you're lucky, that basically things work at the right time and place, because it is very much fortuitous circumstances. It's very much a time for questioning. I mean, I could certainly never have planned my career on any sort of rational, "Okay, here's what I'm going do: Step 1, Step 2, Step 3."

> **I suppose the best you can do with serendipity is be aware it's an opportunity when it's your time.**

JA *So serendipity obviously played a great role in your life. Do you think future informaticians will benefit from serendipity, too?*

DS *I hope so! Please!*

OB You can't demand a hope for serendipities. That's the problem, you can't plan for them. I suppose the best you can do with serendipity is be aware it's an opportunity when it's your time.

DS *You've got to be ready to accept it. Sometimes I project it.*

OB Yeah, and to be willing to take chances on something and say, "Well, gee, that might work out," because it's very hard to predict.

JA *And these hard times that you just mentioned, that all informaticians go through, what did you mean by that?*

Octo Barnett at his retirement party, 2013, with his wife, Sarah. Standing: grandson Gannon, granddaughter Elizabeth, son John, and daughter-in-law Sheila Barnett, MD.

OB Oh, there are things that don't work out. I mean, I remember when the Chief of Medicine here one time asked me, "Octo, I really don't know what you do." That caused me a little bit of concern—a small amount of fear. But he turned out to be one of my great fans and supporters after three or four years, but I got nervous about that. Oh, you'll get grants turned down, you'll get a project that doesn't work, or you'll get a paper that's not accepted. It's not all like a bed of roses, that's for sure.

JA *Now, you just mentioned someone who was fairly influential, I think, who helped you along. Who were your mentors and who were your supporters at MGH?*

OB Well, I would say that basically some of the hospital directors have been very good, very supportive, of me. Two of the chiefs of Medicine, were very supportive of me. And I think lately, the tremendous interactions I have had with departments of caregivers and that type of activities have been very good. I think that some of the units we've done work with over the years have been very supportive. But I think, in some sense, having the international support and fellowship over the years of people like Don [Lindberg]* and Homer [Warner]* was an important part of giving me some confidence that it was worth doing.

DS *It's interesting how you mentioned the clinical people. You know, maybe I'm doing my career wrong, but I've always been aligning myself with the IT department. I noticed you don't seem to align yourself with the IT department.*

OB Yeah. Well, early on, that may have happened. The IT department was not very keen on me coming here and doing what I was doing. I used to try to say, "Well, we could generate charges for you out of our computer reporting system." And we would generate a tape for them, and they would play it back and punch punchcards off it then, to feed to their system. I felt the IT department basically has a very tough job, and

I'm a great believer that you make progress by a series of step-wise functions.

I'd raise the hell out of the budget of the National Library of Medicine.

the IT department here was never much interested or involved with what I was doing. Sometimes there were some here that I was a threat to, and that did cause me some trouble sometimes. I think, by the way, when you ask a question like that, it would be John Glaser [CIO of Partners HealthCare in Boston] who really knows how to look at those two problems simultaneously. I mean I would never be able to explain one iota of the role that he played. You know, I could have joined into the Partners' IS [Information Sciences] department when I first came here, but I chose not to. Basically, I wanted to remain sort of independent and have the part of a small fish in a big pond. John, in that group, however, [had] unbelievably tough responsibilities, a set of tough challenges. You know, I've got enough in my life just with the stuff I do here. So I wouldn't be the best one to ask about a thing like that, because I think there are people who know it much better than what I do.

DS *So the one other thing that has been interesting to me, is that it seems like it's happened over the last year, that nationally everyone's talking about information systems, and we've got the national coordinator office, and we've got the Secretary of Health and Human Services talking about informatics—and the President. Do you think any of that's going to help?*

OB You know, I don't really know. See, I don't have any knowledge of the politics. I think the thing that bothers me is the only institution that I have a lot of faith in is NIH. And they're not being funded to do this. And I don't know whether you could do it by large steering committees and people on the Hill [in Congress] speaking great things about it. We go through fads in this. We're in a fad now with doctors' order systems. That's the heart of all informatics type stuff. And I think that fads come and go. I think that there probably is a thing developing here which I don't understand very much, which is how you actually try to gather the information on a national basis to make decisions,

and how you coordinate, and how you fund. I mean there are areas they are funding and reporting, and some things that are even tougher like quality. We're being increasingly required by certifying agencies to really look at the quality of care.[47] And that's opening up new opportunities and new challenges for how you separate out quality from what the patient factors are. And what's the relative risk? So there are some challenges coming up that we have not had before, and those challenges usually do result in people providing funding for doing it. So that's interesting.

DS *It worries me that policymakers think they know all the answers, and it's just an implementation problem, and that they're just going to force everyone to put this in. And, you know, when I read your old papers, I see you saying we've only got three problems here: the physicians don't want to use it, we don't know how to fund it, we don't know how much time it saves. And we've still got those problems 30 years later. And now they're just saying, "Well, put these systems in." And I'm a little worried we don't exactly know what we're doing yet.*

OB Yeah, I think probably your worry is correct. On the other hand, I don't think we ever knew very much about what we're doing. In some sense, we learn by doing it. That's one of our major issues, I would say, is I don't think we learn by putting 12 wise men around a table to make a big plan. I'd better say wise men and women.

JA *Thank you.*

DS *Yeah, you'd better. [laughter]*

OB I finally learned that over the years. I'm a great believer that you make progress by a series of stepwise functions. You would like to have as good a ratio as you can, of successes to failures, but I don't know how really. I have to be very careful. I would not have the slightest idea, if I were in that office, what I would do. So I'm not about to say how. I think it's a very tough position. If I were to do anything, it would be primarily just a copout, because I'd raise the hell out of the budget of the National Library of Medicine. And the study section. Then Don will worry about it.

DS *Yeah, that's a good idea. I'm all for it! [laughs] I think I've asked as many questions as I can think of right now.*

JA *Thank you. I'm going to turn off the tape recorder.*

[Published April 17, 2015; updated September 4, 2015]

For additional Conversations with Medical Informatics Pioneers, please visit:

http://lhncbc.nlm.nih.gov/project/medical-informatics-pioneers

References

*.   Ash JS, Sittig DF, interviewers. Conversations with Medical Informatics Pioneers. Goodwin RM, Ash JS, Sittig DF, editors. Bethesda: U.S. National Library of Medicine; 2015. Available from: http://lhncbc.nlm.nih.gov/project/medicalinformatics-pioneers

1.   Barnett GO. Computers in patient care. N Engl J Med. 1968;279(24):1321-27.

2.   Greenes RA, Barnett GO, Klein SW, Robbins A, Prior RE. Recording, retrieval and review of medical data by physician-computer interaction. N Engl J Med. 1970;282(6):307-15. doi:10.1056/NEJM197002052820605.

3.   Grossman JH, Barnett GO, Koepsell TD, Nesson HR, Dorsey JL, Phillips RR. An automated medical record system. JAMA. 1973;224(12):1616-21. Available at: http://www.ncbi.nlm.nih.gov/pubmed/4740074. Accessed February 20, 2015.

4.   Barnett GO. The application of computer-based medical-record systems in ambulatory practice. N Engl J Med. 1984;310(25):1643-50. doi:10.1056/NEJM198406213102506.

5.   Payne TH, Goroll AH, Morgan M, Barnett GO. Conducting a matched-pairs historical cohort study with a computer-based ambulatory medical record system. Comput Biomed Res. 1990;23(5):455-72. Available at: http://www.ncbi.nlm.nih.gov/pubmed/2225790. Accessed February 20, 2015.

6.   Morgan MM, Goodson J, Barnett GO. Long-term changes in compliance with clinical guidelines through computer-based reminders. Proc AMIA Symp. 1998:493-7. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2232093&tool=pmcentrez&rendertype=abstract. Accessed February 20, 2015.

7.   Barnett GO, Winickoff RN. Quality assurance and computer-based patient records. Am J Public Health. 1990;80(5):527-8. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1404638&tool=pmcentrez&rendertype=abstract. Accessed February 20, 2015.

8.   Barnett GO, Jenders RA, Chueh HC. The computer-based clinical record--where do we stand? Ann Intern Med. 1993;119(10):1046-8. Available at: http://www.ncbi.nlm.nih.gov/pubmed/8214984. Accessed February 20, 2015.

9.   Barnett GO, Chueh H. Just-in-time knowledge management and patient care. AMIA Annu Symp Proc. 2006:1165-6. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1839494&tool=pmcentrez&rendertype=abstract. Accessed February 19, 2015.

10.   Barnett GO, Cimino JJ, Hupp JA, Hoffer EP. DXplain. An evolving diagnostic decision-support system. JAMA. 1987;258(1):67-74. Available at: http://www.ncbi.nlm.nih.gov/pubmed/3295316. Accessed February 20, 2015.

11   Barnett GO, Hoffer EP, Packer MS, et al. DXplain--demonstration and discussion of a diagnostic decision support system. Proc Annu Symp Comput Appl Med Care. 1992:822. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2248011&tool=pmcentrez&rendertype=abstract. Accessed February 20, 2015.

12.   Detmer WM, Barnett GO, Hersh WR. MedWeaver: integrating decision support, literature searching, and Web exploration using the UMLS Metathesaurus. Proc AMIA Annu Fall Symp. 1997:490-4. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2233429&tool=pmcentrez&rendertype=abstract. Accessed February 20, 2015.

13.   Barnett GO, Famiglietti KT, Kim RJ, Hoffer EP, Feldman MJ. DXplain on the Internet. Proc AMIA Symp. 1998:607-11. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2232149&tool=pmcentrez&rendertype=abstract. Accessed February 20, 2015.

14.   Bauer BA, Lee M, Bergstrom L, et al. Internal medicine resident satisfaction with a diagnostic decision support system (DXplain) introduced on a teaching hospital service. Proc AMIA Symp. 2002:31-5. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2244203&tool=pmcentrez&rendertype=abstract. Accessed February 20, 2015.

15.   Hoffer EP, Feldman MJ, Kim RJ, Famiglietti KT, Barnett GO. DXplain: Patterns of Use of a Mature Expert System. AMIA Annu Symp Proc. 2005:321-5. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1560464&tool=pmcentrez&rendertype=abstract. Accessed February 19, 2015.

16.   Elkin PL, Liebow M, Bauer BA, et al. The introduction of a diagnostic decision support system (DXplainTM) into the workflow of a teaching hospital service can decrease the cost of service for diagnostically challenging Diagnostic Related Groups (DRGs). Int J Med Inform. 2010;79(11):772-7. doi:10.1016/j.ijmedinf.2010.09.004.

17.   Barnett GO, Hoffer EP, Schneider E, et al. Distribution of a primary care office information system. AMIA Annu Symp Proc. 2003:61-5. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1480021&tool=pmcentrez&rendertype=abstract. Accessed February 19, 2015.

18.   Barnett GO, Barry MJ, Robb-Nicholson C, Morgan M. Overcoming information overload: an information system

for the primary care physician. Stud Health Technol Inform. 2004;107(Pt 1):273-6. Available at: http://www.ncbi.nlm.nih.gov/pubmed/15360817. Accessed February 19, 2015.

19. Estey G, Ford-Carleton P, Thompson BT, et al. The PA Catheter Waveforms Troubleshooting System: a demonstration of simple graphical knowledge access for clinical care. Proc Annu Symp Comput Appl Med Care. 1994:1052. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2247830&tool=pmcentrez&rendertype=abstract. Accessed February 20, 2015.

20. Murphy SN, Barnett GO. Achieving automated narrative text interpretation using phrases in the electronic medical record. Proc AMIA Annu Fall Symp. 1996:532-6. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2233147&tool=pmcentrez&rendertype=abstract. Accessed February 20, 2015.

21. Murphy SN, Morgan MM, Barnett GO, Chueh HC. Optimizing healthcare research data warehouse design through past COSTAR query analysis. Proc AMIA Symp. 1999:892-6. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2232518&tool=pmcentrez&rendertype=abstract. Accessed February 20, 2015.

22. Barnett GO, Souder D, Beaman P, Hupp J. MUMPS--an evolutionary commentary. Comput Biomed Res. 1981;14(2):112-8. Available at: http://www.ncbi.nlm.nih.gov/pubmed/7273712. Accessed February 20, 2015.

23. Hoffer EP, Mathewson HO, Loughrey A, Barnett GO. Use of computer-aided instruction in graduate nursing education: a controlled trial. J Emerg Nurs. 1975;1(2):27-9. Available at: http://www.ncbi.nlm.nih.gov/pubmed/1097779. Accessed February 20, 2015.

24. Hoffer EP, Barnett GO, Farquhar BB, Prather PA. Computer-aided instruction in medicine. Annu Rev Biophys Bioeng. 1975;4(00):103-18. doi:10.1146/annurev.bb.04.060175.000535.

25. Barnett GO, Link DA, Feldman MJ, et al. Clinical assessment--a computer-based aid to assessing the clinical problem solving ability of medical students. Proc Annu Symp Comput Appl Med Care. 1994:1045. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2247763&tool=pmcentrez&rendertype=abstract. Accessed February 20, 2015.

26. Barnett GO. Information technology and medical education. J Am Med Inform Assoc. 1995;2(5):285-91. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=116268&tool=pmcentrez&rendertype=abstract. Accessed February 20, 2015.

27. Greenes RA. Presentation of the Morris F. Collen Award to G. Octo Barnett, MD, by Robert A. Greenes, MD, PhD. J Am Med Inform Assoc. 1997;4(2):155-60. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=61506&tool=pmcentrez&rendertype=abstract. Accessed September 10, 2014.

28. American Medical Informatics Association (AMIA). Morris F. Collen Award of Excellence Recipients - Video Tributes. Available at: http://www.amia.org/programs/acmi-fellowship. Accessed September 10, 2014.

29. Barnett GO, Teague RS. The antagonism of salicylate to diethylstilbestrol upon liver glycogen in the rat. Endocrinology. 1958;63(2):205-11. doi:10.1210/endo-63-2-205.

30. Abel RM, Beck CH, Abbott WM, Ryan JA, Barnett GO, Fischer JE. Improved survival from acute renal failure after treatment with intravenous essential L-amino acids and glucose. Results of a prospective, double-blind study. N Engl J Med. 1973;288(14):695-9. doi:10.1056/NEJM197304052881401.

31. Greenfield JC, Patel DJ, Barnett GO, Fox SM. Evaluation of the pressure time derivative method for estimating peak blood flow. Am Heart J. 1962;64:101-5. Available at: http://www.ncbi.nlm.nih.gov/pubmed/13901538. Accessed February 20, 2015.

32. Barnett GO, Jackson WD. Measurement of instantaneous blood flow. Prog Cardiovasc Dis. 1963;5:543-56. Available at: http://www.ncbi.nlm.nih.gov/pubmed/13969388. Accessed February 20, 2015.

33. Piemme TE, Barnett GO, Dexter L. Relationship of heart sounds to acceleration of blood flow. Circ Res. 1966;18(3):303-15. Available at: http://www.ncbi.nlm.nih.gov/pubmed/5904320. Accessed February 20, 2015.

34. Baruch JJ, Barnett GO. Real-time shared on-line digital computer operations. J Chronic Dis. 1966;19(4):377-86. Available at: http://www.ncbi.nlm.nih.gov/pubmed/6004868. Accessed February 19, 2015.

35. Barnett GO. Electronic network in hospitals. Science. 1966;154(3756):1504. doi:10.1126/science.154.3756.1504-a.

36. Mulley AG, Thibault GE, Hughes RA, Barnett GO, Reder VA, Sherman EL. The course of patients with suspected myocardial infarction. The identification of low-risk patients for early transfer from intensive care. N Engl J Med. 1980;302(17):943-8. doi:10.1056/NEJM198004243021704.

37. Singer DE, Mulley AG, Thibault GE, Barnett GO. Unexpected readmissions to the coronary-care unit during recovery from acute myocardial infarction. N Engl J Med. 1981;304(11):625-9. doi:10.1056/NEJM198103123041101.

38. Feldman MJ, Hoffer EP, Barnett GO, Kim RJ, Famiglietti KT, Chueh H. Presence of key findings in the medical record prior to a documented high-risk diagnosis. J Am Med Inform Assoc. 2012;19(4):591-6. doi:10.1136/amiajnl-2011-000375.

39. Barnett GO, Greenes RA, Zielstorff RD. IAIMS development at Harvard Medical School. Bull Med Libr Assoc. 1988;76(3):226-30. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=227113&tool=pmcentrez&rendertype=abstract. Accessed February 20, 2015.

40. Zielstorff RD, Jette AM, Barnett GO. Issues in designing an automated record system for clinical care and research. ANS Adv Nurs Sci. 1990;13(2):75-88. Available at: http://www.ncbi.nlm.nih.gov/pubmed/2176071. Accessed February 20, 2015.

41. Zielstorff RD, Cimino C, Barnett GO, Hassan L, Blewett DR. Representation of nursing terminology in the UMLS Metathesaurus: a pilot study. Proc Annu Symp Comput Appl Med Care. 1992:392-6. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2248038&tool=pmcentrez&rendertype=abstract. Accessed February 20, 2015.

42. Jenders RA, Estey G, Martin M, et al. Indexing guidelines: applications in use of pulmonary artery catheters and pressure ulcer prevention. Proc Annu Symp Comput Appl Med Care. 1994:802-6. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2247719&tool=pmcentrez&rendertype=abstract. Accessed February 20, 2015.

43. Zielstorff RD, Estey G, Vickery A, Hamilton G, Fitzmaurice JB, Barnett GO. Evaluation of a decision support system for pressure ulcer prevention and management: preliminary findings. Proc AMIA Annu Fall Symp. 1997:248-52. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=2233550&tool=pmcentrez&rendertype=abstract. Accessed February 20, 2015.

44. Zielstorff RD, Barnett GO, Estey G, et al. A knowledge-based decision support system for prevention and treatment of pressure ulcers. Stud Health Technol Inform. 1997;46:291-5. Available at: http://www.ncbi.nlm.nih.gov/pubmed/10175412. Accessed February 20, 2015.

45. Zielstorff R. Nursing Informatics Pioneers: Rita Zielstorff Interview [Video]. Am Med Informatics Assoc Nurs Informatics Hist Proj. 2008. Available at: https://www.amia.org/nursing-informatics/nursing-informatics-pioneers-rita-zielstorff. Accessed April 7, 2015.

46. Barnett GO. The computer and clinical judgement. N Engl J Med. 1982;307(8):493-4. doi:10.1056/NEJM198208193070808.

47. Barnett GO. Quality assurance through computer surveillance and feedback. Am J Public Health. 1977;67(3):230-1. Available at: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1653562&tool=pmcentrez&rendertype=abstract. Accessed February 20, 2015.