

>> From WXXI News, it's 1370 Connection.

[Background Music]

>> I'm Bob Smith. You're here to join me at a journey to the frontiers of scientific and technological inquiries this hour. We're delighted to welcome University of Rochester Physicist Dr. Esther Conwell for her return visit to 1370 Connection. She is one of the most recent recipients of the National Medal of Science honored at the White House by President Obama last November in recognition of her pioneering work in the science of semiconductors. The chips that give everything from your desktop computer, to the office copier, to the fuel system of your car, the power to calculate and to do their jobs. She's speaking at this year's Caroline Werner Gannett lecture series, Visionaries in Motion at RIT's Carlson Auditorium at 8 o'clock tonight. And she's joining us right now. Dr. Conwell, thank you very much for taking the time to be with us again today. I wanna ask you first of all, last time we talked, we talked mostly about what's happened over the last 60 years and about your pioneering work and understanding how semiconductors, how those computer chips that we all know, that we all work with daily operate and how they can be made obviously to work better. I guess we probably should say thank you for our desktop computers at this point?

>> Certainly.

>> And thank you very much for that. Looking back at it and having played a major role in making all of that possible, what do you think we've done in terms of how we've made use of the technology, how we've made use of the knowledge and how we've made use of all the devices that it's all made possible? Are we doing a good job with it, are we using it to the maximum benefit for ourselves? Could we do more?

>> I haven't thought about it in those terms. We certainly are using it tremendously and it has revolutionized communication obviously. I don't know. I don't know what more it could do. I haven't thought that way.

>> Of course you yourself in your own work use it all everyday to help you out as I do with mine because I find that, especially when I'm on the internet using the World Wide Web that it's just a god sent. I don't have to spend literally half my waking hours in a library to accomplish. Not that I have any disdain for libraries, mind you they're essential, they do things that nothing else could do. But I feel like I've got a whole library at my fingertips at any given moment and could pull in information from everywhere. Once we can do that, it's up to us just whether or not we do anything good and worthwhile with it but nonetheless, we have it in a way we never have before. It's empowered us in a lot of ways to do things that we couldn't have done or couldn't have done so easily. And that being the case, should we expect then with all this extra power in our hands in a little desktop device or even something that you can carry along with you, a little handheld smart phone, should we expect then that we'll be able to make even more rapid progress and empower ourselves even more in the future? Will we be able to maybe solve just about any problem we can think of?

>> Well, it certainly has helped in solving problems in my research and in everybody's research. It is a wonderful research tool to be able to go to the

internet and find everything that was done in the field you're working in or answer questions about particular things in the field.

>> I'm gonna ask you for a moment to step back, as I mentioned, this is 6 decades of progress that we've had since the time in the late 1940s when your research career started which just happen to be right at the same time with a very rudimentary, some would say, kinda clunky transistors were being developed at Bell Labs and when you think back to how it all started and how it was getting--going in the early stages, what were the things that you and your colleagues were trying to do back then with these new devices that some people thought would replace vacuum tubes but they hadn't thought much further than that I guess, if it all.

>> I was at Bell Labs in those days actually. I was in the office that was vacated by Bardeen who was one of the inventors of the transistor. What they were looking for was better electronics, more efficient electronics. And particularly, they were looking for an amplifier that was the quest that Walter Brattain was on. And of course he found something. He found the point contact transistor which wasn't very practical actually. I guess it amounted to an existence here. And then Bill Shockley picked up the bowl there and invented the junction transistor which is a lot more practical.

>> And of course from then on, everything from transistor radios to printed circuits to, I guess, the integrated circuits that everything we use today kind of sort of moved along from there but that's really fast forward, again simplifying the story an awful lot. I mean, again, you had to do a lot of things in between to make all of this that we know today possible. Tell me a little bit about that.

>> Oh yes. When I was there at Bell Labs which is for a year, their vision was that they couldn't see that this would be useful for anything but hearing aids. Hearing aids obviously needed small components. And that was what the vision was at that very early stage.

>> Nobody was even thinking about turning them into little portable radios or anything else then?

>> Not yet, not yet.

>> When did they start talking about, gee, we could do a lot with this. Like, for example, Chris, I'm holding a small cellphone in my hand right now. I mean really gonna fast forward to get to where that comes into play but when did it start to occur to everybody that, you know, we can do a lot more with this?

>> Well, at the start, they were only individual devices. So you had maybe one transistor, one amplifier. But the big advance was made when they realized that you could put a whole lot in them, circuits on a chip. And that took a few years after the transistor was initially found.

>> Of course. Could they have done that really or could they have even contemplated that if it hadn't been for some of the things you did in finding out just how these materials behaved and how they could be made to work? Because a lot of your research, if I'm not mistaken, gets down to the very physics and behavior of the materials from which all of these things are made?

>> Well, that's how it had to begin. But once they understood how the electrons and holes moved, the big thing to make use of it was to understand how to put it into a circuit. And I can't say that I've made any big contribution there. It was on the materials that I contributed.

>> That's the foundation of it although really. I mean, because you can't figure out how to develop something without knowing how what you're going to make it from is going to behave once you try it.

>> That's true.

>> So, I mean you are right at the beginning of the basic science on all of these, without which none of it would have happened. And everything again from the fuel system to the computer to the cell phone I'm holding in my hand which is actually kind of a dinosaur today because it's small as it is, there're a lot smarter phones that we have out there nowadays just as a result of a micro circuitry that we're able to develop with our knowledge. Thinking of that then, if we've made a more efficient world and maybe made a lot of our research and a lot of our work easier to do and enabled ourselves to cooperate with each other and sort of merge our knowledge better than we did before, is there anything we won't be able to do in the future as a result of all these or can we just say the sky is the limit? Use our imaginations and figure out if we can think of it, we could do it?

>> Well, I think applications to biology might be a lot harder to come by. But you were talking about before about influencing a cancer inside the body.

>> That's right, which gets to something that you're gonna talk about tonight which I want to spend a lot of the hour on. And incidentally, I'd like to invite everybody who's got questions about how the frontier of the electronics signals of circuitry of everything and yes, we're gonna get biology into this momentarily, comes together. You were talking with the right person when you talk to Dr. Esther Conwell of the University of Rochester, most recent recipient of the National Medal of Science and tonight's speaker at the Caroline Werner Gannett Visionaries in Motion lecture series in RIT's Carlson Auditorium. I'm Bob Smith, this is 1370 Connection, you can reach us at 263-WXXI, 263-9994 or write to us, asktalk@wxxi.org is our in-studio e-mail address, which of course is made possible by our guest of the hour in a very fundamental scientific way. Let's look at what's going on right now on what you're gonna be talking about tonight. You keep talking about DNA in a context of semiconductors and semiconductor behavior. I have to admit I had never thought of some of the building blocks of our genetics in that context before, never thought of it. This is something new to me, certainly not something new to you 'cause you've been working on it for a while and really starting to begin to plow this particular field. How did it get started that you wanted to explore DNA in the same way that most of us think of things like germanium and silicon?

>> Well, I guess, around 15 years ago now, somebody got the idea of seeing whether DNA could conduct electricity. And the first experiments--well, it is a very difficult experiment to do. And in the first experiments, some of the people thought it was a great conductor in which case you could make--they figured you could make devices out of it. It wasn't long before people realized that you could put electrons, free moving electrons into the DNA and you could also make holes by taking an electron out of the bonds that keep the atoms and molecules together in the DNA. And so when they realized that you had electrons,

mobile electrons and mobile holes. People started to think about circuit right away. But they were not really encouraged because the electrons and holes in DNA do not move fast enough. They really are rather and the advantage of maybe a very tiny circuit, the ultimate tiny circuit wouldn't get you very far if the carriers, the electrons and holes didn't move fast.

>> To give kind of a relative understanding of this, when we think of electrons moving through a circuit, most of the time we're thinking of electrons moving at or near the speed of light. We're not giving that kind of fast action here I guess from this kind of biological material, are we?

>> Not at all.

>> So how fast actually does it go? Does it--is it as slow as electrical impulses through the nervous system, which seems fast but in terms of electronic speed, it's pretty slow.

>> Well, as a result of years of effort, they have actually measured the rate at which a hole moves and the idea is that the hole jumps from one part of the DNA to another part. In particular, they measured the rate at which holes jump between adenines which is a constituent of the DNA. And they found it was about a billion hops per second.

>> Sounds fast in a way. A thousand million maybe cycles per second. But of course, I guess, that'd be like about a thousand megahertz if you were to transfer it to clock speed on a computer. But I guess it's not so simple as that because--I mean that--it's not really moving as fast as a computer chip at a thousand megahertz. There are lots of Pentium chips that do that. But I guess we're not talking about the same kind of speed are we?

>> Well you're certainly not controlling the motion. I mean, when I said hops, it's not like--well, in a semiconductor circuit, you can control the speed of the electron by changing the voltage of the electric field. These holes hop back and forth and nobody has made much of an effort to control the speed or would know how to make an effort to control the speed.

>> And this is kind of the one thing that differentiates this from a thousand megahertz Pentium chip then?

>> Oh yes, it certainly is.

>> Well, is it possible that someday somebody will figure it out or is this just one of those barriers that's more trouble to try it across than it's worth?

>> Well, people are making some effort. One of the latest things that's happened, they modified the DNA in really a fairly small way. They've replaced a nitrogen in the ring of an adenine with a carbon and the hydrogen. And that made the hopping rate 30 times as fast, which is still not nearly enough to make it of device interest but maybe they will think of other ways of changing the structure of DNA to give you something faster.

>> Is this kinda like the same way they put what they call impurities or just addition of little elements into the silicon structure of a chip to make it move faster or move differently?

>> Well, when they, when you put the impurities and the idea is to get more carriers, more electrons or more holes, that's the main function of the impurities. And it was my work, my thesis work with a--with Professor Weiskopf that established that the impurities hindered the motion of the electrons and holes. So you couldn't have too many of them. But I don't see, I don't see that kind of control in the DNA circuits.

>> So we have to do a lot more work on the science before we can start talking about applying DNA as a semiconductor the way we apply silicon or the germanium compounds or anything like that. We gotta do a lot of more work on this.

>> Right. And it may not happen. I mean, it's not obvious that you will increase the speed by a large enough factor so that it could really be useful in the device.

>> So we may then not necessarily have this as the path by which we're going to create bioelectronics circuits or anything like that. This may not be the path to making command data of Star Trek possible then?

>>I agree.

>> If that's the case though, I'm sure a lot of people are probably asking you from time to time, well, what will be the best way for us to do this? How are we gonna make it happen and what role might organic devices play in future circuits, maybe even future computers and logic devices? Do they have a role? Are these all gonna be--remain, they have a role in inorganic?

>> Well, I don't see a clear path to their having that kind of a role.

>> Uh-hmm. So these are gonna be then for the future, at least as far as we can see right now. These are gonna be inorganic devices and they're gonna continue to be inorganic devices for quite sometime to become that.

>> There are organic semiconductors that do not rely on DNA.

>> What are they? And how do they work? And how might they help us out or do some specialized things that--I hesitate to say garden variety semiconductor because they're all fascinating devices but the normal semiconductors can't do?

>> I don't know whether you're familiar with the Kodak displays, those are based on semiconductors that are not silicon or germanium, that they're compound semiconductors. There is nothing that special about a material being a semiconductor. All that it means is that there are not so many free electrons and to get more free electrons, well, there is an energy gap that you have to raise the electrons over in energy in order to have more free electrons and holes. And unless it's metallic most materials are semiconductors.

>> And some of them are better for electronic circuits than others and some of them do different things than others.

>> Right, right.

>> Interesting that you mentioned the Kodak device which I think of mostly as kind of like a sensing or a display device.

>> Yes.

>> It's something, something similar to the LCD or LED televisions sets that we are--we're all getting in our homes.

>> Yes. But it's relying on properties that are essentially properties of a semiconductor.

>> Uh-hmm.

>> It creates light when electrons lose their energy in jumping from a higher level to a lower level.

>> And as a result, control them just right and you get a picture.

>> Yes.

>> And they say that that's--that some of the Kodak work, if they ever figure out a way to bring it to the public in a commercial application, but some of it's gonna be really exciting and maybe a big leap forward. And some of it actually was a building block for what we have now.

>> Yes. I have, well, they--I think they are using these commercially in displays, in the TVs and whatnot. Unfortunately, Kodak couldn't seem to get its act together there. Other people have carried it further.

>> That seems to be kind of a story of our local business life around here lately, but that's another story that we've told or undoubtedly will tell again in the near future. Meanwhile, of course, you're invited to be a part of our conversation at 263-WXXI. We have to take a short break but we'll be back in a moment with more of our conversation with Dr. Esther Conwell who'll be speaking tonight as part of the Visionaries in Motion lecture series, the Caroline Werner Gannett Series at RIT. I'm Bob Smith back in a minute on 1370 Connection from WXXI.

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>> 1370 Connection continuing at WXXI, I'm Bob Smith. We are talking with Dr. Esther Conwell who is the recent recipient of the National Medal of Science and is going to be the speaker that kicks off this year's Caroline Werner Gannett Visionaries in Motion lectures series at RIT's Carlson Auditorium at 8 o'clock tonight. We're going to talk as well with Keith calling in in the city, hello Keith, you're on the air and welcome to the program.

>> Yes sir, I just wanted to ask, what about the whole concept of superconductivity and what I'm calling unrestricted plasma just simply beating down all resistance. Some years ago, I heard of a Paul Chan [phonetic] at the University of Texas and he was going even great guns on this work and I've tried looking him up several times and it's like he and other researchers, their work has been put on hold and Louis Loder [phonetic] is always talking about bringing in this high magnetic--magnetivity trains in which like the Japanese trains work on a certain kind of superconductivity. Mr. Smith was asking about transistors and the conductors themselves, what about this whole idea of just what I'm calling super conductivity that even in the context of the guest yesterday on the materials of just this getting away from hard fast materials into usually a

thermoplasma that would do away with what I'm calling the whole need for conductors to begin with, superconductivity.

>> Well, that's a whole other ground, isn't it?

>> Yes. In the early days when people were just starting to make measurements of conductivity in DNA, one group reported that they had found it to be a superconductor. That did not last long. There was a mistake in their experiment. The DNA is a semiconductor rather than a superconductor, which means it does not have many carriers and it will never be a superconductor.

>> Which, I gather from our point of view as beings based of DNA is probably is a good thing rather than a bad thing. I don't think we'd function too well as superconductors, would we?

>> Well, we'd be quite different from what we are.

>> Yeah, exactly. Hey, thank you Keith for calling. It is an interesting question nonetheless. The physics of what DNA does is interesting from a lot of aspects, not the least of which is maybe what we could do in terms of dealing with our own health, dealing with perhaps manipulating DNA to improve our health and longevity. Is there, just for starters, something that we could use this knowledge to do to maybe more effectively treat either cancers or genetically created diseases?

>> Well, the knowledge is really on the other side in a sense that you do know how, for instance, skin cancer comes about from exposure to sunlight and you--well you know about some other cases where defects in the DNA cause particular things. But generally, I don't think we have yet much control over these, well, mistakes in the DNA.

>> Because I mean, if I'm not mistaken, and tell me if I am. I guess when you're dealing with cancerous tumors, it's kind of a case of the DNA and of the cells going nuts in replication and getting essentially out of control in the way they replicate resulting in a tumor. Is there something that we can use this knowledge about DNA's properties maybe to figure out a way on a real granular microbiological level to get in there and control it to some degree and figure out a way to attack some of these problems on the very lowest fundamental level of life and of biological process?

>> There certainly has been some of that. I am familiar with one particular example. I don't remember the man's name at the moment but somebody figured out that in order for the cancerous cells to keep on growing, they have to have a blood supply. And if you could take away that blood supply somehow, they would stop multiplying and stop functioning. And that actually worked, they have managed to control some cancers by getting rid of their blood supply.

>> And starving them out basically.

>> Starving them out, okay.

>> So we may be able to go in there and perhaps do some manipulation in this respect, but this, this is pretty granular microscience at this stage. Are we gonna have to learn a lot more about the whole process and even how DNA works in replicating itself to create cell division, we're gonna have to learn a lot more

about that kind of building block just to be able to get that kind of control at a routine basis, the way we want to in any medical application. Or are we getting close?

>> Well, this is the case that what I mentioned that was really worked out and well, you can't use it on old cancers but on some. But what people are finding out is that these processes are--in DNA are all a lot more complicated than was thought. As the research goes on, they find more and more new things and strange things that are happening in the DNA. So it's hard to predict what kind of control they might ultimately get.

>> We're gonna find out more maybe by going this deep into the mechanism of it and how it behaves, are we gonna find out more about how mutations happen and how changes happen in cells or maybe even in full-sized beings perhaps or are we gotta get to the level that we could figure out just why we change, why we mutate, why we are different from generation to generation and well, maybe even learn a little bit about how we evolve?

>> Well, that is something that is understood, the mutations in general terms, in the process of finding new--of making new pairs, to make new pairs of guanine and cytosine or adenine and thymine. Well, there is a lot of randomness over which you do not really have control. The DNA itself is proofread while it's being--while a new duplex DNA is being built up. It's proofread by atoms or molecules that run along the DNA and they can excise wrong bases that are put in. But even so, you do not get perfection. It's all happening pretty fast on an atomic or molecular scale.

>> What's scary is we may all be walking around with typos. Basically, [simultaneous talking] typographical errors within us too.

>> We undoubtedly are.

>> Yeah.

>> And most of the mutations that's understood are bad but sometimes there are god ones. We may be improved by our typos also.

>> One hopes. We're crossing our fingers of that score certainly. But I guess the more we understand about this, this kind of fundamental electronic process that's going on within the strands of DNA that make up our genes and chromosomes, are we going to get a better understanding perhaps of how the whole process works. And maybe get a better understanding of how we or any other being were interested in studying comes to be precisely how we are and how we function?

>> Well, certainly our understanding will increase whether it will mean control as a result. That remains to be seen.

>> Yeah, control is a funny thing because if you're talking about control in terms of preventing those typos as we are talking about, preventing errors that can harm us, that's one thing and that's good. Control also can have, potentially, a more sinister dimension depending on how we use that understanding and science to manipulate our future. It may not always work out well and so we're getting--the more power we get the more carefully we're gonna have to use it, aren't we? Are we thinking about that, I wonder?

>> Not yet.

>> Should we? Should we start now while the science is in its infancy, I wonder.

>> Well, I think you're right.

>> Yeah. But it looks like we're getting to the stage where we're gonna have a lot more understanding and maybe a lot more power over our own structure and our own future than we ever had before. Is this maybe understanding the sort of physics of DNA and the chemistry of it, physical chemistry of it. Is this gonna get us closer to really having the drop on just about every aspect of every being, every biological being? Is this really fund--really, really fundamental stuff?

>> Oh, it is fundamental stuff and I guess it gets us closer but I don't see anything like complete control.

>> Nor would we probably want it, but nonetheless, it's interesting to be able to think of all the, I won't say applications but about the uses for this kind of research and understanding that we might have to improve our own lives. Who knows maybe even improve our longevity.

>> Well, there are people working on that too.

>> I remember a popular science fiction writer and editor Ben Bova who once appeared on this show, maybe about 10 or 15 years ago, and absolutely predicted that we would find in research something, wasn't exactly like this, but he said the same area, kind of granular research into--in the biological processes in the cellular level, became convinced that we would find the fountain of youth, the secret of immortality and even to stop or reverse the aging process. And he was convinced he might even live to see it. Now he's a guy I think in his 70s right now but he was convinced that he would live to see it. He's still around, so he may be right. And I--and I'm thinking is this going to be, this kind of science, this understanding of DNA's physical properties and its properties in the electronic sense, is this going to help us get there if that's where we want to go?

>> Well, there is more than one way undoubtedly. One of the speakers in this series was Kurzweil and he had a different way in mind for having infinite life where he was going to make use of a big computer or big--more than one big computer and sort of in some way coupled with it so that at least all of that thinking process could be carried on.

>> I remember a conversation I had with Ray Kurzweil about that and it reminded me of another conversation I had with a popular science fiction writer Robert Sawyer who lives up in Toronto. And he comes to visit from time to time, visits this program from time to time. And he wrote a book, one of his novels was actually about how you basically uploaded your consciousness and then had it downloaded to a durable and perhaps even for all practical purposes immortal biomechanical clone of yourself. And that is kind of chilling but, I guess, could it be? Is that the way we're going to go or are we going to find some way to use processes within ourselves to simply just extend our own practical life as we are?

>> Well certainly, people are working on that ladder and it's talked about the telomeres extending them so that they don't just drop off and make us mortal.

>> So, not only cutting edge but a little bit scary but it's fascinating how this science is going to go. Meanwhile, looking at what we are learning just about DNA in a more, I won't say practical sense but in a more immediate sense. Where do you figure that our analogy is likely to take us first? Is it going to take us in a sense of again finding some kind of practical application for it? Is it going to take us toward improving our health and well-being and longevity in some way? If you had to place a bet on it, obviously, you must have some thoughts as to where this is going to take us next and where we're likely to find something first, where do you think it's going to go? Where do you think the news is going to be made?

>> Well, the place where I think the most effort is being made is against cancer. Many people are working in that kind of area so I would assume that that's what will happen first, that we become able to stop or cure different kinds of cancer.

>> That would certainly be great news. Are we going to be able to go from there since we're talking about DNA, obviously, which essentially controls and programs our own ultimate development, are we going next to take a look at whether or not we can control or change or somehow prevent genetically driven diseases?

>> Well, certainly people, some people are thinking along those lines.

>> And as you are working in a lab every single day, what kinds of problems are you working on the most, either in this area or in some other area that relates to both the biological and the physics of semiconductor activity? If I were to go into your lab and sit with you for a typical day, what would I see you working on, what problems are you doing at the moment?

>> I don't have a lab as such. I do calculations and simulations using big computers. That's the kind of thing that I do. I do not do experiments.

>> So take me then to that process and tell me how it works on a day-to-day basis. When you begin a day, what kind of problem will you be taking on and how do you do it?

>> Well, the--it's a very big problem in principle because if you're looking at a microscopic sample you've got to worry about the interaction of all of the atoms with each other and with the water that the solution, that the DNA is in and the interactions with water are very important. So you need supercomputers that can handle the interactions of large numbers of individual atom's charges. So we are very much limited in what we can tackle these days by the speed of the supercomputers. It will get a lot better, the information will come a lot faster, results will come a lot faster when we have bigger supercomputers.

>> Are we talking about bigger physically or just bigger in terms of their ability to perform so many calculations per second?

>> The latter, exactly.

>> Who is building these super machines right now and are they the kind of thing that maybe one day will even be available to us the same way that yesterday's supercomputers that would fill a room are now equivalent to the computing power of a typical laptop. People are pushing in that direction. There are rumors that the Chinese have the fastest supercomputer now but they are still building them on the same principle that maybe that they can find other ways of getting all these calculations done.

>> That gets to something that I don't know whether it applies here but I've heard it said that we are getting closer. Every generation of processor, it seems like it was a new generation every year and a half to 2 years that we are getting closer to the time when we're gonna hit the physical limits of the capability of the materials we're using now. We gotta use something else. Are we getting maybe to the point where we're about to hit a wall in terms of computing power and speed unless we just build them to tremendous size like the old UNIVACs?

>> Well, I think you are thinking about the limitations of silicon, for instance. When you put the individual transistors or circuit elements too close, you can't get rid of the heat from them fast enough. But they have--you always hear that they're at the limit now but somehow somebody comes up with something that pushes it further.

>> So every 18 or 24 months we'll probably get a more powerful one.

>> Well, I can't think that they can go much further with silicon. But as you said, you can put more of them in parallel, fill a bigger room and get more computing power.

>> Just keep stacking them and stacking them until you've got what you need.

>> I suppose it's a limit but I don't know what it is to how much you can stack the computers we have today. And there may be a new principle that someone comes up with that enables you to do it faster. But we're still a long way from doing real calculations on biological things.

>> So we're not quite there yet except at [inaudible].

>> Right.

>> When you think ahead, are we going to be able to do that kind of calculation though within the next few years or maybe before the end of the decade at least.

>> I don't think that there are enough resources being put into this search for faster computers. There are certainly some but they're not really pushing it so I don't see it happening within the decade.

>> That's unfortunate. Do we need maybe to perhaps devote more not only corporate resources and educational research but maybe public resources to put this on the job so that we could have that kind of power, be able to solve all the problems we need to solve? Should this be a job for the government?

>> Well, you have to choose your priorities. I don't think there are many people who would choose this as a priority.

>> Although it's a shame to hear that in a way because--

>> Well, I mean you look at the republicans are anti-science.

>> Yeah. Whenever you're against progress in any area, you're gonna end up having to pay for it, then having to turn around and double the effort later on. So the faster you act, the better you get the results. So hopefully people will see that and see the logic to it. But are we going to need in order to get this job done the real commitment of public as well as private resources to make it happen like we needed to do to develop the first computers that needed to do later on to develop the aerospace program the way we did. Is this kind of a similar job really right now as it got a similar urgency to it too?

>> Well, I'm not making the decisions and I think there are more important things to do as regards people's welfare.

>> So what can we do, I mean looking at it from just the technological and scientific point of view, where should we really concentrate our efforts at this point that would give us the most return, give us the most benefit?

>> Well, I think you have to push in both directions. You have to push the computing power to do bigger calculations but you have to continue looking in the laboratory at what happens to the DNA when you do this or that.

>> And every year, presumably, we're gonna get closer to understanding what's going on.

>> I hope so.

>> Right.

>> And if you had to look ahead say to the end of this decade and what you might see kind of got on the laboratory by 2019 or 2020. What do you think will happen then?

>> Well, I imagined we'll be further ahead in cures for cancer for one thing. I don't think other things are being pushed to that extent.

>> It's gonna be interesting to see what happens. I wish we had more time but this is a fascinating area, feels like it's right on the very frontier of what we know and I appreciate you're taking me there. My thanks to Esther Conwell of the University of Rochester who is kicking off this year's Caroline Werner Gannett Visionaries in Motion series. She'll be speaking at RIT's Carlson Auditorium tonight at 8. We're happy she was able to join us here on this hour of 1370 Connection. You're in WXXI AM and FM HD2 Rochester. For Dave Campo, our technical director, I'm Bob Smith. God bless you.

[Music]