>> From WXXI News pre-recorded this hour, it is 1370 Connection, I'm Bob Smith. This segment of the program is about how our understanding of our biology, as it expands at micro and at the macro levels, could really well shape our future. Dr. Lee Hood is founder of the Institute for Systems Biology. He's part of the Caroline Werner Gannett Lecture Series in RIT taking us inside the world of how we understand ourselves as a biological system. A biological knowledge is itself kind of a network, a system of knowledge being constantly exchanged, added to, distributed. He's one of only 7 people simultaneously holding membership on the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine that's found in more than 14 biotechnology companies. His current work, which is new ground in systems medicine, applying the systems approach to human disease, and we're gonna find out how that all may shape our lives. Dr. Hood, thanks for joining us.

>> My pleasure.

>> Now when we talk about a systems approach to conquering disease, to enhancing our health, what really do we mean by that?

>> We mean that in the past, biology and medicine have worked primarily by looking at things one at a time, one gene and one protein. The systems approach looks at everything in a global and comprehensive way. It's holistic as opposed to atomistic.

>> That's makes a lot of sense because we've been trying at least, though imperfectly, to run everything in our lives from business structures to universities to governments by that way, and as we get more systematic, the results arguably get a little better as we move forward. What took us so long I guess to do this in what obviously is one of the most elegant systems that there is?

>> I think the major thing that took us a long time is we needed both information and technology before we could do it proper. The human genome project gave us a complete parts list of all the genes and proteins and the individual human being, and in order to do systems medicine, we needed to know all of those chains in proteins. Equally important, we needed advancing technologies that could make measurements and could image biological systems far more effectively than we could even 5 or 10 years ago, so the convergence of the genome project with new technologies and computational tools has placed us in this position to think about a systems approach to medicine.

>> Now I'm gonna divide those two approaches which are obviously interrelated intimately into two separate parts and look at each of them in turn, starting with the genome project and what it learned about us, our blueprint so to speak. Were there surprises that maybe in some ways changed what we expected to know and what we expected to understand about ourselves?

>> Well, there were and there weren't. I think probably the biggest official surprise was we learned that we have about 25,000 genes rather than the 100,000 that we'd expected. So to make up for this deficit of genes, the body has employed very elegant systems for diversifying those genes and adding to our information. I think what was less surprising is we learned that all living creatures are interrelated one to another. We share genes with the most

primitive of organisms and that--that says quite clearly that men has needs to have a responsible stewardship in taking care of other creatures and other organisms. We learned even more spectacularly that humans don't really differ from one another very much. There are no race specific genes and the idea that there are distinct abilities associated with different races is patent nonsense. What--where the difference has come from are different kinds of environmental opportunities and that too says a great deal of the social responsibility we have to fellow citizens.

>> All of those observations are interesting. I think the one thing that I have to admit surprised me was finding out how much simpler we were in terms of the number of constituent parts we were made of. And hearing in high school biology that there were over 100,000 genes and then finding out there were only about 25,000 or so, give or take a few thousand, was a little bit stunning in and of itself, but did that force us first of all to learn more about how the way each gene plays with all the others in the genetic sandbox?

>> Well, it did two things. I mean how the genes play with one another is really the purveyance of this thing we call systems biology, how they interact and communicate one to another. But the other thing it made us realize is because genes can modify their information so many different ways, the precise definition of what a gene is, is extremely fuzzy these days.

>> So in a sense, first of all, can genes be thought of more like switches that can go one way or another as opposed to linear hardwiring that only goes a certain direction and takes you in a certain path?

>> Well, I think the important point is genes all make proteins that work together in networks. There is no simple linearity about biology, whatsoever, and all of the interesting properties of human beings are a consequence of a multitude of interacting networks. And again, how these communicate with one another, interact with one another is one of the central arenas of systems biology today.

>> Of course, if you imagine 25,000 genes each interacting with each other at all kinds of different ways, I mean how many different kinds of human being can result from that? I mean is--are their numbers big enough?

>> Well, certainly if you had that many different genes interacting in all the different ways, that would far exceed the number of atoms in the universe and, of course, what nature has to do is make use of just a small amount of that potential diversity.

>> So in a sense, is a lot of the exploration, how these genes either express themselves or just sit there?

>> I think the essence is how the genes encode interesting features of human beings. One, how do we develop from a small baby to an adult and how does our brain become more mature. Number two, how do we respond to our environment? How does a malarial parasite come in and infect us. And of course number three, one of the most interesting arenas is, what happens when we get sick? What are the nature of the changes these networks must necessarily go through to lead us down that transition pathway from health to disease.

>> Once you know that, what are the possibilities for making use of that knowledge?

>> The possibilities are absolutely endless and in fact, we just published a paper about 2 weeks ago on the first real systems approach to a disease in higher organisms. And that not only revealed that we can look at these networks and come to understand the deepest mysteries of what the disease is but it gave us new insights both into diagnosis and to therapy as well.

>> And this opens up a diagnostic revolution, doesn't it?

>> It opens up a diagnostic revolution. I've argued that in the next 10 to 20 years we'll see an enormous transformation from our currently largely reactive medicine to one that's I call P4 medicine, predictive, personalized, preventive and participatory, and the biggest part of this revolution will occur over the next 10 years and that will be a revolution in our ability to make predictions, that is diagnostic medicine.

>> It occurs to me though even in our current paradigm of medicine which is reacting to a disease once we get symptoms, a whole new world opens up for rapid response, doesn't it?

>> It does. And in fact, what you'll find in the future is I would argue in 10 years, you'll go in twice a year and you'll have a little finger prick and we'll take a fraction of a droplet of blood and we'll measure 2,500 proteins in your blood and they will let us assess all the 50 or so major organ systems and say, "Are you healthy or are you diseased? And if you're diseased, what disease do you have?"

>> Will we then begin by seeing the impact on preventive or early stage intervention to catch things before they get out of hand?

>> That's exactly the case. And in fact, we've demonstrated beautifully in this model disease that we looked at that we could do blood test and we could actually predict the onset of the disease more than 10 weeks before any clinical science showed up whatsoever, where that's really going to be important as with cancer. Because as we all know, if you detect cancer early enough, in many cases, you can actually cure it.

>> Now, I can imagine the family practitioners, the internal medicine people who are the frontline of the medical practice, playing a whole new role because they're going to be able to do a lot of things in this paradigm that end up getting relegated to specialists when things get really out of hand, aren't they?

>> That's absolutely correct, but in hand in hand with that, we'll go this idea that we will have to educate physicians that have been trained before this [inaudible] this revolution in medicine and actually occurred, and I would submit that training adults, changing people's way of thinking about things is one of the most challenging tasks will have in realizing P4 medicine.

>> Although I have a feeling, having talked with a number of people who are family doctors that they'll embrace this, they'll look forward to it because it'll give them a whole new role to play, they'll do it eagerly. I have a feeling you'll get a good reception.

>> I hope that's the case. I must say with a little more sophisticated scientists and physicians, there is skepticism as to how rapidly this is going to come and what its implications are but, you know, there is skepticism with any new idea, you have to expect that.

>> Could the specialists be worried that they'll be relegated to the background in a lot more cases?

>> You know, I think it's less worried about, they'll be relegated to the background, and one just not convinced is really gonna make a difference. They can't believe things are gonna be any differently than they are now. And two, many physicians are just so hurried and rushed, they don't really have time to think about new things and they don't frankly wanna think about new things.

>> But, it occurs to me if we embrace this paradigm, in which you get very early diagnosis and very early intervention at a very low level micro stage before a disease really manifested itself, won't that cut the cost of health care and as well as increase the beneficial outcomes tremendously?

>> You know, that's really a good point. My prediction is that with the emergence of P4 medicine, we'll see that somewhat undefined point in the future an enormously sharp break in the ever escalating cost of medicine, and I would argue it will turn around and decrease to the point where in time will be able to export medicine, our medicine, P4 medicine to the developing world, and indeed that will become a framework for global medicine. So in its sense, for the first time, we can really see a historical period where the democratization of healthcare may be realized where we may be able to bring good healthcare to even the poorest of nations.

>> How will other sciences play a role in this in helping make it happen? Are we gonna be depending a lot of computer science or other science is going to play a role as well?

>> I think all the sciences will play a role. There are 3 things that are gonna catalyze this big change in medicine. So one is, are the system's views of disease and how we have to study them. I think a second or the development and the emergence of new technologies for measurement, for visualization, for synthesis and so forth that will transform all of our ideas about how we can make measurements on patients. For example, my argument is within 10 years, we'll have billions of data points on every patient. And then, the third thing we need that is the IT for healthcare must reduce this enormous data to simple hypothesis about health and disease. So with systems approaches to disease, it's new technologies and it's new computational and mathematical tools, and they're gonna be the foundation of this revolution.

>> That gets to the other aspect which I want to discuss soon. As a reminder we're gonna be--you're listening to 1370 Connection, Dr. Lee Hood, founder of the Institute for Systems Biology here in Rochester as part of the Caroline Werner Gannett Lecture Series at RIT. He's visiting us this hour to take us into the near future of our understanding of ourselves and the systems that make up us as individuals and as a human species. I'm Bob Smith, this is 1370 Connection, pre-recorded on WXXI AM and FM HD2. When we're looking at how we're going to go just beyond reactive medicine to the next phase of predictive medicine, taking that little sample of blood and not only finding out whether

you have a cholesterol problem or whether you have diabetes or anything like that, but whether you might be heading in that direction without having gotten there yet, what do we do at that point?

>> Well, what systems medicine is going to allow us to do is understand in a deep mechanistic sense how disease arises. What it will at the same time do is suggest completely new ways for developing drugs that can catch disease at the very earliest stage and abrogate any of its deleterious effects. My prediction is if we use these approaches effectively, the cost of drugs will go down. The cost of producing drugs will go down by 1 to 2 orders of magnitude.

>> So, could we possibly read that blood and say, "You're going to have a little problem with heart disease, you're gonna have some clogged arteries within a little while. You better do something about it right now before things get out of hand." Will we first of all get to that level and then maybe eventually predict incipient potential for cancer or something else?

>> Well, we haven't talked about an important component in prediction, and that is I would predict again in 10 years it will be possible to seek, sequence everyone's individual genome, that is to learn the order of their 6 billion letters of the DNA language. From those analyses together with other information, we'll be able to chart and predict exactly how your future health history is going to go. From that information, what we might well say is what? By the time you're 35 to 50, your possibility for cardiovascular disease or a particular type of cancer gets to be very high. And I would predict we'll actually be able to design preventive drugs so we can say to that individual. And if you start taking these pills when you're 30, you'll never have to worry about that kind of disease.

>> Which of course is almost like a medical nirvana in many respects? But it also will mean that it could put some physicians, some specialists out of business, correct?

>> Well, I think the whole question of what a physician will be in the future is absolutely a fascinating question. And I think the best physicians will be a grand integrator of medical information for the individual and he'll be a teacher to instruct the individual on choices and opportunities and responsibilities and so forth. And that's going to be somewhat of a different role than they played in the past.

>> Again, putting the primary care physician really front and center to a degree here she hasn't been up to now.

>> That's absolutely correct.

>> And at the same time, of course, requiring that primary care physician to be much more knowledgeable about a broader spectrum of things than has ever been required before.

>> Well, you know, as a physician you often see patients who will come in, have Googled their disease and actually know more about it than you do although they can't discriminate what's right from what's wrong, and that's the role the physician is going to play in spades in the future I think.

>> So don't believe everything you Google.

>> There's a lot of wrongs about health. There are many wrong things out there, absolutely.

>> But we know more but not everything you know is right.

>> Right. That's right.

>> And so--but not everything you know is wrong either, so the question is somebody's got to tell the difference and in other words, leave it to the professional still.

>> Well, I think one of the responsibilities for information technology for healthcare in the future is going to be to put together websites of reliability. So that when you go to the diabetes website, you know everything there is bona fide, and when they make suggestions and predictions, those are correct. Or if you go to the Alzheimer's site or if you go to whatever site, you'll be able to pick up the latest information on these sites. That isn't what we have now at all. We've got everything from complete quacks to very, very sophisticated people saying things in ways that the lay public often can't understand.

>> So, we're going to have to refine our communications to help us as laypeople understand it, as well as to help you as professionals communicate what we all need to know.

>> And we're gonna have to go one step further. I would argue that we have to think about fundamentally changing education in the schools. K through 12 science education should allow our graduating citizens to come away with a deep understanding of biology and this new kind of medicine and so forth. The question again of adults, who will be the patients, how we educate them I think is a fascinating puzzle.

>> Now, of course, a lot of what those of us who were adults in midlife think we know even from the classes we took in high school and college is way out of date, and some, it's absolutely flat wrong now as a result of what we've learned. What are some of the most common misconceptions that we're all walking around with about ourselves, that could conceivably even get us into trouble?

>> Well, I think there are many misconceptions. I think one of the biggest one, this is many people seem to believe that your genes determine your future and that just isn't true at all. In living organisms, there are two kinds of information we have to deal with thinking about disease. One is your genetic background, your genome, but the other is what the environment has done to change it. For example, think about the development of the brain. When your brain develops as a very small child, it makes an enormous number of connections, one nerve cell to many, many other nerve cells. But what happens as you mature is only the connections that are useful are kept. In fact, that's why when we learn language as young, we have the connections that let us speak fluently, and when you try and learn it as an adult, you always end up mapping the language on to your mother language. So, we have to be aware of the fact that the environment plays an enormous role in making us who and what we are, and that means we all can do a lot about our health if we control our environment in proper ways, and I think that's a really important message.

>> Of course, when you're very little, basically those who control your environment are parents and immediate family members, so they had better do the right job from the start. It's got to start with teaching the parents how to do it right.

>> You know, that's absolutely right and there's a big revolution coming in, in the idea that you should be educating your kids from 1 year to 5 years because that may be the most determinative and impressionable stage of their entire life.

>> So if mom and dad sat you on their knee and read to you from the get-go, that's a good start.

>> That's a terrific start.

>> And if you had a stimulating environment right from the get-go, all the better.

>> All of the better.

>> So we are, in a sense, systems that absorb everything that surround us, and if there is more to absorb, that does us better.

>> That does us a lot better. That's right. The richer variety of experiences particularly we experience as a young child, the better off we are in the long run.

>> So, does it boil down to simply keeping your kid busy and engaged from the very earliest moment you possibly can, every waking minute keeps something going on?

>> You know, I don't think you have to carry it to that extreme but I think the idea that you can sit the child with a babysitter who maybe has different cultural and social values from your own and may well ignore the child for most of the time, that isn't a good kind of experience for the child.

>> So, you got to pay a lot of close attention to nurture the child right from the get-go.

>> Exactly.

>> And that's part of the system of the child's absorbing the best environmental influences presuming that you know what you're doing, of course, to begin with as a parent.

>> Well, I think you can start just by giving enriching experiences in music, in reading, in taking them places and responding to their natural curiosity. Those are all things any parent can do.

>> And in terms of the physical environment, what do we know about the most salutary kind of physical environment?

>> Well, I would say the salutary physical environment really is a salutary mental environment that is, I think we want to be--we want to place our children and give them experiences that are challenging, that open up new dimensions of

possibilities that interact them with different kinds of people and different kinds of things.

>> And does that put a special importance on--

>> Well--

>> --there I say it, the socioeconomic health of the family as well. Are we going to have to do more to make the families just healthier environments for living, and in order to do that, do we have to improve the economic standing and where withal the family?

>> Well, you know, I must say one of the things I really like about Obama is I would argue he's one of the first politicians practicing a systems approach to politics that I've ever seen. And his basic idea is you have a multidimensional problem. You're worried about education, about healthcare, about certainly financial circumstances now, and about the environment in you have to optimize solutions where all of these build together in the most effective way. And it means for any one of the problems, you may not get exactly what you or the advocates for that problem want, but you kind of have to integrate over and ask what the best general approach to this is. And I think that's how we have to think about education as well. Well, how can we optimize all of these opportunities for the greatest glory? And if we think about that, then we get back to healthcare for--as a fundamental right because look, if you don't have health, you're not gonna be in a good environment to learn and you have to get back to socioeconomic opportunities so that you can provide kids with fundamental needs as well. And it's a matter of philosophy and many people disagree with that point of view quite obviously.

>> Dr. Lee Hood is Founder of the Institute for Systems Biology. He's here with us at this portion of 1370 Connection at WXXI AM and FM HD2. I'm Bob Smith, and we're back with more of this pre-recorded hour of the program in just a moment, so stay right with us.

[ Music ]

>> 1370 Connection continues on WXXI AM and FM HD2. I'm Bob Smith, and in this pre-recorded segment, we're talking with Dr. Lee who is the founder of the Institute of Systems Biology. He's here in Rochester as part of the Caroline Werner Gannett Lecture Series at RIT, taking us inside the world of how we understand ourselves as a biological system and how biological knowledge is itself a network, a system of knowledge. I want to talk about that network of knowledge and how well constructed it is at the moment, because a lot of that that is concerning biological science seems to focus on the tabloid levels stories, the breathless headline about a man who, as we speak, is claiming to be on the point of cloning human being. First of all, does that serve a useful purpose aside from giving the tabloids and the infotainment shows on television something else to shout about and sell some commercials on?

>> Well, I think the cloning of human beings would be an enormous technical achievement. Whether in fact it will have a big impact on humankind, I have to be, you know, somewhat skeptical about. Remember if you clone another individual, you've got to let them go through the same developmental process. So, if you wanna clone 10,000 Sergeant York soldiers, it's gonna take you 20 years before you get those people ready to go. So, I think what will be far more

important about cloning is, one, we will be able to do animal and plant husbandry that will be spectacular for our food needs in the future. And I think, number two, it will lead us to a very deep understanding eventually of how to use stem cells that's perhaps the most powerful therapeutic reagent of the 21st century.

>> Which gets, of course, now that you raised the question of stem cells to the interplay of science with society and even with politics, because as we're speaking right now and recording this broadcast, there are new rules being promulgated by the Obama administration about stem cell research which are different significantly from those imposed by President Obama's predecessor, George W. Bush, but they're not totally open to all possible avenues either. What's your reading on the effect of these new rules and what kind of environment that they will create for research?

>> Well, I think it's a little difficult to say what impact the new rules will have because we're not completely clear about all the constraints that they will impose on us. But in general, what I would say is a new advance in stem cell biology that's occurred over the last couple of years is a deepening of our understanding of how we take a normal adult cell and convert it to a stem cell for you.

>> And in fact, I see in the future as a fundamental part of medicine our ability to create for every individual stem cells that can then be differentiated to tissue that maybe diseased in you and we can study it in the test tube in ways we could never think about doing now.

>> If you wanna speak metaphorically, that's talking about taking a well-differentiated adult cell and essentially rewinding the tape back to the point of it being undifferentiated and shapeable into just about any kind of tissue you want. Are we really going to be able to do that and if we can, how well will it really work for us?

>> So there is no question that we can do that. We've already done that. I think the question is can we do it in an easy and reproducible and economically effective fashion. My prediction with this is within 5 to 10 years, we'll be able to generate stem cells from the differentiated cells of every single individual and that they could become a really invaluable part of both diagnosis and a therapy in the future for the individual.

>> I'm imagining how this would be done. Would you just harvest say either a skin cell or maybe a white blood cell or something like that, rewind the process back and eventually grow cells that would turn into cardiac tissue to help you do surgery to repair the heart or the aorta or some part of the cardiovascular system that goes wrong?

>> That's exactly right. We're working now with a small stem cell company in Madison, Wisconsin called Cellular Dynamics and what we're attempting to do is to be able to take a nucleated white blood cell and convert that back to a stem cell for the individual and then in a very effective way differentiate that cell to nervous tissue or heart tissue or prostate tissue, depending on what type of disease that individual may have.

>> Could you conceivably, eventually down the line, take that white blood cell and create just about any organ or system that you want?

>> You could create any--virtually any type of tissue that you'd like to create, that's correct.

>> Eventually harvest something like a new heart for a transplant so that you don't have to worry about rejection of a donor heart?

>> Well, my argument would be in the future we'll do early diagnosis before you've done massive damage to any organ, for example, the heart and we'll actually be able to infuse in some of these differentiated cells and replace the defective ones very early on in the process so we don't have to think about replacing a whole heart but we think about turning around the disease process that is occurring in that part.

>> So then you're not even letting it get to the point where you've got to do bypasses or insert stents or anything else?

>> We'll never do those again in the future.

>> This is going to be extremely good news for folks who are very afraid of major invasive surgery. Is major invasive surgery itself going to become not completely a thing of the past 'cause the ER's are always going to do that for trauma victims but a thing of the past for people who don't suffer physical trauma?

>> I think in large part that it will. I think we'll be able to intervene with most of the major diseases that we think about today through cellular process, injecting cells into the blood stream that can hone to the right organ and reverse disease processes and so forth. This is science fiction for many but I'll guarantee it'll be a reality in 20 years.

>> Now speaking of science fiction and jumping off from the claim of cloning power which may or may not be authentic and genuine, but speaking of science fiction and of course these topic fiction predictions of armies of especially bred soldiers, warriors, what have you, are we ever going to be able to do something like that and if so, what's going to stop us from doing it in such other way that we create the kind of dystopia that people make us afraid of.

>> Well, my guess is that there will, as is true of many of these new advancing techniques, be enormous social societal approbations and there'll be laws that will prevent large scale, inappropriate kinds of applications. So I think there's little doubt about that but I think the more important thing is there are a lot more efficient ways to do it than cloning. As dictators in Africa have demonstrated, you can take 12 or 13-year-old kids and you can have terrific armies from them. You irreversibly damaged those kids but if you wanna do it, there are many ways dictators can do it.

>> Well, we're going to get pretty much a demonstration of that in an upcoming federal court case in New York City as a result of the apprehension of one of the very young pirates who maybe 18 or 19. But how do we prevent things like this from becoming the fruits of science rather than just of social disintegration as we're seeing right now?

>> Well again, I think at the heart of it is what we have to do to deal with terrorism and we don't deal with terrorism by armies and force, you deal with

terrorism by getting people at the source of those terrorists the right kinds of educational opportunities and economic opportunities and health opportunities. And until we understand this, we're never gonna be able to deal with Pakistan or Afghanistan or even really effectively Iraq. I mean I think the solution to terrorism really has to do with creating fair societies that have the advantages that we have here on the Western world. As long as they can look to us and never inspired them, they can feel jealous, they can feel angry, they can justify the horrible kinds of things that they do but if we bring them into our world, it's a very different thing.

>> So essentially, our work has to be to try to evolve our societies and our social values to the point that we've already evolved our scientific capability?

>> You know, I think the essence of this system's thinking is just exactly that, it's thinking about society and how we can move it forward in a trajectory that maximizes the benefits and at the same time attempts to solve these very different kinds of problems that all go together to create a society, health education jobs and the like.

>> Looking at our society like the living being?

>> It is a living being, there's no question about that.

>> One thing, as we continue our conversation with Dr. Lee Hood of the Institute of Systems Biology here on 1370 Connection and that is some of the possibilities as well that we might use for ourselves and for future generations. Once we've got the backwards and forwards of our genetic blueprint, the temptation will always be there to manipulate it, to play with it for our own advantage to give ourselves or our children or grandchildren perceived advantages, that's a pretty heavy power if we acquire it. How do you think it might be used once we do acquire it, which inevitably we will, and how should we use it?

>> Well, I would say, one, we will inevitably acquire that power. I think, I mean unless society becomes entirely disrupted by things that are happening. But two, the question of how we should use it is a fascinating one. So let me give you two examples of how we might use it and you can answer whether these things are good or bad. We're learning now a lot about short term memory and there is a real possibility in the not too distant future we could, in a very general way, make almost everyone short term memory far more powerful than this now by some simple--it's the equivalent of engineering. So is that a good thing to do or is that a bad thing to do? I mean society is gonna make that decision. But I'll give you even a more spectacular example. Let's say that human kind survives for the next five billion years, and I picked that time because we know that the sun will turn into a nova and destroy earth at that period in time. Suppose that we knew to keep the continuity of the human raise we had export ourselves to worlds outside our own and suppose we knew they were going to be very, very different kinds of environments, would it be appropriate for us to reengineer ourselves so we could live on a water environment or a very hot environment or one that is oxygen poor or we can--we could design individuals that could optimize these kinds of possibilities? Would that be a bad thing to do?

>> Or will we opt instead to take what some people might think of as the easy way, just develop our transport capability so that we could get to a more hospitable world, which undoubtedly is out there somewhere, quickly and simply adapt the world to ourselves?

>> I guess both will be possible. We'll have some choices to make, won't we?

>> Well, I think finding one that's exactly like ours would be a very, very low probability event given the limitations of space travel and there--I think there's even in the future will be real limitations. But how ever you do it, when you send someone to a new place, they may have to adapt themselves in some ways, any break--any case.

>> So I guess looking at things to evolve for the next few hundred years exactly as Gene Roddenberry imagines it, maybe not.

>> I think it's very unlikely we're going to fundamentally change ourselves over the next--I think society is intrinsically incredibly conservative. I think science gives us far more options than we'll ever use at any given point in time.

>> Will we, though, if we aren't even put to the test of having to substantially reengineer ourselves for survival, tinker with ourselves to enhance some characteristics whether they maybe athletic talent, ability with mathematics to the degree that that's genetically rather than environmentally determined, blue eyes, a certain hair color? Are we going to be playing those sorts of games? Are we going to want to play those sorts of games or just continue to accept all the variety that we've got around us now?

>> Well, you have to realize that in talking about genetic engineering there are two distinctions. So in one case, we can modify you as an individual any way we'd like and you can't pass that on to your children. So that's a one of a kind experiment and people can make their choices about what they'd like to do. Will that be possible? I really think so. The second kind of experiment would be actually to alter your sex cells so that you could pass on these changes to your children and there, I would argue, we should be incredibly cautious and incredibly conservative because even with all the new knowledge we're acquiring, we don't know as we pass things on to kids and they go through development, what the consequences of many changes are going to be. So I think in the short term, we will change the individual. I think we should be very cautious about changing the whole race.

>> But you're predicting them that we might have the capacity to customize ourselves as individuals the way you customize a car?

>> Well, we could do many things. For example, we could think about ways of improving short term memory for the individual and not have that passed on to all the individuals of the race.

>> Would we also be able to attack, through these means, certain afflictions which many of us are afraid of, especially as we age like Alzheimer's?

>> Well, I would think the way we would attack Alzheimer's is we would prevent it from ever happening. So we could look at your genome and do some simple tests and together we could say you had an 80 percent chance by the time you're 70 of having Alzheimer's but if you take these pills at 35, you'll never get it.

>> Which, of course, would be a very desirable thing to happen from many points of view not--the least of which is the social and economic, and that gets to a

question of economy. Are the thing we are talking about which do show a long term possibility of savings going to initially be very expensive and maybe limited in their access only to a relatively fortunate few?

>> Well, I think in the beginning before this breakpoint in the cost of healthcare turns around, things will be increasingly expensive. But one of the points I would make is that we are going to see a digitalization of the measurement tools of medicine that will have exactly the same impact the digitalization of communication and information technology had. Namely, those measurements will become dirt cheap and let me give you an example. We're developing tools now for making measurements on blood proteins. A typical blood protein can cost--a single measurement can cost 40 to a 1,000--40 dollars to 1,000 dollars. We envision the time within less than 10 years when we can do hundreds of protein measurements at pennies a piece. So those are the kinds of changes that are coming.

>> So a 5 or 10-dollar test would cover a multitude of possible variables?

>> It would cover all of the possibilities and it could cover the 25,000 proteins we need to assess, all 50 of your organ systems.

>> And bang, you've done it for maybe 10 bucks a pop?

>> 10 bucks a pop would be a very reasonable price.

>> That certainly cuts the cost quite a bit. Are we also going to see similar reductions in the cost of whatever therapies we choose or that we need to do in order to attack problems we find once we find them?

>> Well, I've argued that as we develop these new systems approaches to identify new drugs, that would bring the cost of drug discovery down by one to two orders of magnitude. So they'll obviously be enormous savings then. There is always the question of how much of the saving gets passed on to the consumer and of course, that's where policy and legislation come into effect.

>> How powerful is the consumer or how powerful are his advocates in the public sector?

>> Correct.

>> That's the key sector, isn't it?

>> It is correct. But you can manipulate with social policy the requirement for cost. That is, the government can have a big influence on insurance companies and how much they're willing to pay for things and thereby forcing the use of these newer, more powerful, less expensive approaches.

>> Well in that context, does that make some things like, oh, let's say the passage of a bill like John Conyers's Universal Medicare H.R. 676 a potentially important landmark if it happens?

>> I think Universal Healthcare is an incredibly important--incredibly important and landmark event for the US if you--to imagine that there are 40 million uninsured people out there I think is an enormous indictment of American society.

>> Now since there are other countries within the western industrial sphere that have already dealt with this problem, is it possible that they'll benefit from some of these advances first before we do?

>> It could very well be so. I mean it's interesting. We've recently fashioned an agreement with the State of Luxembourg in which together we're going to take on two of the deepest problems of P4 medicine and they're putting more than a hundred million dollars of research money into these two research projects. That's an integrated, coordinated systems attack on P4 medicine that couldn't be done here in the United States because our granting system tends to award people things in bits and pieces and clearly, Luxembourg will with a small nation and one of their objectives was to transform their economic situation, bringing in healthcare and biotech, but it was to transform the healthcare of their people too. So they may well be the first model system for looking at P4 medicine.

>> Are other countries with a public health financing system like Canada starting to knock on the door and ask some questions on this?

>> You know, I don't think so. I think Luxembourg is, in my experience, unusual in every single dimension and that is it's a small country, it has a very small core of leaders that I think have pioneered absolutely amazing transitions and they're willing to take big risks and big gamble in a way no other countries have done so. Before we ran into Luxembourg, I'd gone to 4 other countries and explored varying possibilities with them and in the end, nothing ever worked and it usually got bogged down in bureaucratic constraints of one sort or another.

>> Can we afford to let that happen indefinitely?

>> We can't and the fascinating question is how you take current organizations whose history is really the bureaucracy that we have to deal with and how can you make them change and how can you move them forward innovative directions and I'm of two minds on that. My experience, I've been involved in 4 paradigm changes in science now and in all cases, these paradigm changes were met with enormous skepticism but in the end, they won out, they changed science in major ways but in every case we had to create a new organizational structure to achieve that end. So I think we have to think about new organizational structures that can free themselves from the constraints of the past, if we're the cause revolutions like this.

>> Eventually though, will that happen? Are you optimistic that we will do the institutional changes that are necessary to fulfill these possibilities?

>> So, I'm what's known as a determined optimist and I'm going to work as hard as I possibly can to make sure that is at least a possible outcome.

>> In the end, there are so many factors in a big country like the US. I think the good changes will inevitably happen. What I'm worried about is they'll really take a long time to happen.

>> But does that mean that those of us who are in the middle of our lives right now, at least, can look forward to living to see a lot of these things come to fruition?

>> Well, my prediction is that P4 medicine will emerge over the next 10 to 20 years. My prediction is by the 20-year scale, we will have turned the cost of healthcare around and my prediction is that the P4 medicine and what it means together with stem cell therapies together with really spectacular new research on neural degenerative diseases and even on the process of aging, I can really see the time in 20 years where the average person will have at least 10, if not more years, of productive period. And what this means is society really has to totally rethink the whole process of aging, that is, forced retirement to make way for the young and so forth. How do we keep--how do we keep the creativity, the productiveness of a 90-year-old who's still perfectly capable of functioning? I think we're gonna have to restructure a lot of organizations in society.

>> We're to borrow a phrase from Mickey Mantle, "Be careful and take care of yourself, you never know of how just long you might end up living."

>> That's absolutely true.

>> Alright. Thanks to Dr. Lee Hood, the Founder of the Institute for Systems Biology, lecturer at the Caroline Werner Gannett Lecture Series at RIT, coming to Rochester to share his perspectives on the future and how we will change the way we deal with our own health and the health of our society. I'm Bob Smith. You've been listening to 1370 Connection pre-recorded on WXXI AM and FM HD2 Rochester.

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