



Nanotechnology: Past, Present and Future

April 21, 2005, 12pm, University of California, San Francisco

Christine Peterson - Foresight Institute

George Khushf - University of South Carolina

Michael Krasny (moderator) - KQED-FM

PERRY: Good afternoon, everyone. Welcome to this installment of SAGE Crossroads, a series of ongoing debates about how science and emerging technologies will affect our human experience with aging. SAGE Crossroads focuses on how advances in medical science will have an impact on not only how we age, but also the subsequent impact on our economy, our social institutions and our bioethics and even sense of family, of who we are.

We are very proud, as the Alliance for Aging Research, to be a co-sponsor of this unique program. My name is Dan Perry, and I'm the executive director of the Alliance for Aging Research, a not-for-profit advocacy organization based in Washington, D.C.

The Alliance is very proud to share in the partnership and co-sponsorship of this program with the American Association for the Advancement of Science, the publishers of *Science* magazine.

Now in our third year, we have hosted more than two dozen of these webcast discussions, panel discussions, debates, such as you will hear today. We also have posted on our website the entire archive of all two dozen web programs. I invite you to write this down—the address for SAGE Crossroads—www.sagecrossroads.net.

You also will be able to access more than 120 in-depth articles written and edited by the publishers of *Science* magazine on this intersection of science, technology and our hopes to be able to age better than people have in the past.

Today we are going to continue our discussion about the emergence of the new science of nanotechnology. Nanotech is the emerging ability of scientists to affect the structure and matter and materials at the level of individual evidence.

The Alliance's interest in this technology is primarily in the area of health and medicine. In other words, nanomedicine. Will we one day be able to cure disease by making precise corrections in individual cells? What are the potential risks to ourselves and to our environment as we tinker with human biology at its most basic level?

Nanotechnology: Past, Present and Future

We have on hand today two outstanding, very interesting and thoughtful experts who will explore with us both the promise and the concerns about the future of nanotechnology and nanomedicine. I will leave it to our very able moderator, the well-known and highly regarded Dr. Michael Krasny to make those introductions.

But first a couple of program notes. The event you are witnessing today will go live at sagecrossroads.net one week from today on April 28. Then, on May 26, our next program will be on Aging and Disability and that will be posted May 26 on the same website.

That program will be an examination of the current trend of people with developmental disabilities now surviving to unprecedented old age. How will the networks that sustain them fare when these individuals begin to enter Medicare and other traditional service programs for the elderly? What will be the disconnects? How will we integrate services for those with lifelong disabilities now who will be moving into being elderly?

Then on June 21, SAGE Crossroads' program will originate in Seattle with a discussion informed by the Women's Bioethics Project. We will be looking at problems specific to women later in life, including changes in the status and powers that may accompany aging, gender issues relative to health care, support for women as caregivers, and challenges specific to women at the end of life.

Today, of course, we are fortunate to be webcasting from the University of San Francisco Medical School, and pleased to be here.

Please remember, as you leave, to fill out one of the blue cards, and leave your information with us so that we can send you electronic reminders and updates on future SAGE Crossroads webcasts. Also, in your folders, there is a summary of the upcoming webcasts that I've mentioned.

Now, it's a great pleasure to introduce Dr. Michael Krasny, the very popular host and senior editor of the award-winning Forum on KQED radio. KQED's Forum covers the landscape of contemporary issues with a concentration on topics of health, business, technology, arts, and culture.

Dr. Krasny has hosted many radio and television programs. He's also a professor of literature at San Francisco State University and is a widely published critic, magazine correspondent, scholar, and successful fiction writer.

In his career, Dr. Krasny has interviewed some of the world's most fascinating figures and leading cultural icons of our times, including Caesar Chavez, Jane Goodall, Carl Sagan, Gloria Steinem, and Archbishop Desmond Tutu. He's been prized as the best talk show host in the Bay area and we are looking forward to his role today in today's program on nanotechnology and nanomedicine. Dr. Krasny, welcome to the Crossroads.

KRASNY: Thank you so much.

[Applause]

Just one slight correction. Successful fiction writer depends on how you measure success. But I am delighted that you are all here for what I think will be not only an informative but also an important event. I can tell you that the two speakers you are going to hear today will be exceedingly, I think, enlightening to hear.

The way we are going to work this—let me, in fact, kind of give you a brief outline. Each of the speakers, whom I will introduce to you momentarily, will speak for about ten minutes, and then we'll have a discussion, with me moderating the discussion, for about twenty. After that we will give you an opportunity to ask any questions you might have. I know there may indeed be some questions.

I am also delighted to see a range of different ages here, and I think that's important.

Then we'll have closing remarks from the two participants.

A word about the participants. Did any of you hear the program we did yesterday on nanotechnology on Forum? A couple of you. Great. Well, then you heard Christine Peterson. She was with us. She is the co-founder and vice president of public policy of the Foresight Institute. In fact, someone said in an e-mail during the course of the broadcast that he was a member of the Hindsight Institute, which—I think we have to check on the web to find out if that actually exists.

We are very fortunate to have Christine with us, and please welcome her.

[Applause]

We are also equally fortunate to have Professor George Khushf with us. He is a philosopher by trade—actually trained as an engineer, but is a professor of philosophy at the University of South Carolina—and is the humanities director there at the Center for Bioethics. We are, again, delighted to have him here with us as well. Please welcome him.

[Applause]

Now Dr. Khushf is going to give you a presentation of what some of his thoughts and reflections are and some of the significant issues he feels he wants to bring to your attention. Then Christine Peterson will do likewise. So without further ado, Professor Khushf.

KHUSHF: Thank you. It's a great pleasure to be here.

The word nanotechnology means different things to different people. So I'd like to begin by characterizing how I'll use the term.

“Nano,” as a prefix, is used to designate a billion. And “nanotech” generally focuses here on size—a billionth of a meter. At the bottom end of “nano,” say a tenth of a nanometer or an angstrom, you have the diameter of an atom and you are in the strange quantum world. As you come to about one hundred nanometers, you are at, say, the size of components in computer chips, or the small structures in cells. Here you have within the range one to a hundred nanometers the building blocks of life—say, DNA proteins.

Now, in the loosest definition of “nano,” what I’ll call the all-inclusive definition, nanoscience and -technology concerns the scale alone—one to a hundred nanometers. That ends up including all chemistry, molecular biology and so on. Everything becomes “nano.” This is not a useful way of characterizing current developments.

On the other side, you have what might be viewed as the futuristic definition—the assemblers of Eric Drexler and Christine Peterson. These are the nanobots that you often see featured, say, in science fiction discussions. They would radically transform everything. Aging is cured, environmental sustainability solved.

Now, if the first definition is too inclusive, mundane and present-oriented, I’d like to suggest this definition is too much on the far-distant horizon.

Between these we have something like the definition provided by the National Nanotechnology Initiative. This definition includes the scale range one to a hundred nanometers, but it also attempts to capture the opportunities that have only recently emerged; namely, the newly developed capacity to directly image and control matter at this scale, and through these tools, to understand and create new devices or systems that exploit the properties that emerge at this scale.

For aging-related research in medicine, “nano” thus designates a complex set of new tools, strategies and possibilities that enable an unprecedented level of understanding and control of the molecular building blocks of life. It can then be taken as a general designation of the new science integral to realizing the promise of a new era of molecular medicine.

I am going to use “nano” in this third middle sense. With this as the focus, I want to turn now to ethical and social or political challenges at the intersection of aging research and nanotechnology. I’ll lay out quickly five challenges that I see.

First challenge: We need a realistic, forward-looking, interdisciplinary reflection on nanomedicine and aging. By realistic, I mean it needs to link up with the current science and specific research initiatives of the countless teams and agencies dedicated to making the vision of nanomedicine a reality. It should not selectively focus on certain aspects of the wilder side of “nano.”

By forward-looking, I mean we need to consider the larger vision and emergent capacities on the horizon, and not just the immediate problems. By interdisciplinary, I

mean to specify the complexity of the issues and the full range—we need a large discussion that includes many people with different skills.

Now, second challenge: We should not look at science and technology in isolation from broader communal and social context. Here is an example. I'd like to point to the National Cancer Institute, and its goal of “eliminating death and suffering from cancer by 2015.” It seeks to do this by “harnessing the power of nanotechnology to radically change the way we diagnose image and treat cancer.”

Put bluntly, I think this is not a responsible way for them to state their goal. They speak as if the task is simply a function of scientific research and technological breakthroughs, and ignore the social, institutional and cultural conditions for realizing their goal.

The problem with this approach is apparent if we turn to a series of reports of the Institute of Medicine on error in quality. These reports highlight the lag between new research and its implementation in practice.

Usually well over a decade, and often as much as two decades, this shows how we could already take steps toward, for example, personalized medicine, simply by changing the cultures and systems of care.

If we really want to eliminate suffering and death from cancer, we need to pay more attention to the social systems and cultures, and not just look at the technology.

Third challenge: We should not look at “nano” in isolation from other technologies. We should consider some of the more radical capacities that these make possible. Here, I refer to something like what's called NBIC convergence—the convergence of “nano,” biomedicine, information technology and cognitive science.

We find here emergent capacities for what could be called human enhancement, or completely different ways of approaching issues and disability.

Fourth challenge: “Nano” has new risks. It also heralds opportunity. People tend to focus on these in isolation from one another. That's a mistake. We need to address the two together, realistically and honestly—not downplaying the risks and not hyping the opportunities.

Fifth challenge: In discussion of “nano” and aging, people often see aging as a problem to be solved, and technology as pure power or instrumentality. They look at individuals in isolation and see scientists, also isolated in labs, coming up with a magic pill, or say a nanobot. This is a mistake, descriptively and ethically. Humans age. Function peaks and then declines. New dependencies are created. Transitions in the life cycle take place. New generations are intertwined with old in complex ways.

When we look at nanotechnology and aging, we need to consider the full range of issues, not just the technological fix associated with nanotechnology or “nano,” in isolation. To

this extent we should even challenge the pervasive, acute-oriented, fix-it mentality of medicine, and bring into view the issues of chronic medical conditions, disability, and adaptation to altered functional capacity.

We also need to consider the communal and cultural conditions for responsibly addressing the realities of an aging population. When we look at nanomedicine, and we look at aging, we need to see these together as a part of a much broader approach.

KRASNY: Thank you, Dr. Khushf. We'll now hear from Christine Peterson.

PETERSON: Thank you, Michael.

Starting with the definitions—first let me agree with George that the definition that you will hear of anything in the one to one hundred nanometer range is really not useful. As he mentioned, this includes chemistry, biotechnology, material science. It includes a good deal of applied physics. It's just too broad.

However, a minor disagreement is, as far as I can tell, this definition has won the day, so regardless of how much I may dislike it, this seems to be what has caught on.

So how do we come at this, then? What we do at Foresight is divide up into timeframes—near-term, mid-term and long-term. If you look at the things happening in that size range in terms of timeframe, then suddenly you have a handle on what's going to happen.

I want to share with you two examples of what's happening right now that I find extremely exciting. First, for a long time, my favorite example of medical nanotechnology happening today was the following: some researchers at Rice University took silica nanoparticles. Silica is, of course, just like sand. So that is not an exotic material, but they're nano size, coated them with gold, and then they manipulated the ratio of the thicknesses of these to give different optical properties.

They then coated them with the biological materials that bind two breast cancer cells. They injected those into—I believe they are using animal models. I don't think we've gone to human trials with this yet. But into animal models—they bind to these cancer cells. It turns out—then you can image the tumor. First of all, you image the tumor, which is great. Then they shine, I believe near-IR light into the body, which heats up these things, heats up the gold, and it kills the cells.

Now, is that elegant or what? This is beautiful science with tremendous potential. So for a long time, that was my favorite nanotechnology example.

But just this week there's been a new announcement, so we have a new candidate for the most exciting, in my view, medical nanotechnology advancement. This was work done here, at USC and Children's Hospital of Los Angeles. They took sugar nanoparticles, used them to bind up some short interfering RNA strand, and used transferrin, which usually transports iron into cells, to attach these things to cancer cells. Then these sugar

nanoparticles go into the cell. They release their short interfering RNA, when that has been designed, of course, to bind to the DNA that's causing the problem.

In this case, it was Ewing's sarcoma, which is a childhood cancer, so it binds to this thing and stops it. Now how elegant is that? That is so wonderful!

So I'll let you decide in your mind which one is the more elegant and exciting nanotechnology development today. Frankly, they are both fantastic.

This is the kind of thing that is happening already. I would be very surprised if this doesn't come on board—I mean, I'll bet you there's someone in this room who'll be treated with this kind of treatment some time in their lifetime. We have a number of younger people in the audience and I think this is going to get fast-track attention from regulators, because this is just too exciting.

That's the kind of thing that is happening already in nanotechnology for medicine. That's the near term.

What's coming in the long term? Well, the goal would be to develop nanosystems that work at the molecular level, that combine the benefits of both surgery and drugs. In other words, surgery—three-dimensional rearranging of tissues and cells.

Now today's surgery is, compared to the molecular level, very crude. But even so, we do a lot of good. Then we have the chemical action of drug molecules. They don't rearrange things. They do chemical actions. These are the tools we have today: surgery, drugs.

The problem with drugs is we don't have total control over their three-dimensional location. You know, that's the big challenge—drug delivery. How do you get the drugs to go where we want?

We want to bring this together and say, “No, we want a system that works at the molecular level, that gives you the benefits of surgery, three-dimensional control, bring it all the way down to the molecular level, and combine it with the chemical action of drugs, to change bonds, do the kinds of things you need to do to actually heal the patient.”

OK. Is this ambitious? Oh, it's incredibly ambitious. I mean, you are talking about trying to get complete control of the most complex object that exists in the universe, as far as we know. The human body—this is incredibly ambitious.

On the other hand, that's just what makes it exciting. Here we are at UCSF. We are at one of the best research institutions in the world in medicine. So that's the long-term goal.

You can read about this in a series of books, for example, which start with the word “nanomedicine.” If you were interested in the future of medicine, in the long-term future, the books on nanomedicine would be a place to start.

One thing that George would like to see is discussion, I believe, of the mid-range, both the ethical issues and, of course, in order to talk about the ethical issues you have to talk about the technical issues.

So how do you come at that? Not too many people are looking at this mid-range. Foresight is working on a technical roadmap to look at this mid-range. We hope to have a draft by the end of the year.

So what are the ethical issues that come up in this very ambitious pathway between today and this long-term? Lots of ethical issues, but we'll just take two, or I'll take two right now.

One is access. Who's going to have access to this technology as it comes along? I expect that these things will probably follow the standard pattern, which is very expensive early on; longer-term the prices come down.

Our organization has been looking, and we talked a lot about this with Michael yesterday on the radio show—a number of people are very concerned about the patent situation in nanotechnology. It looks as though the patents may result in what we call a patent thicket, or they may be being issued in such a way that competition is inhibited. This is going to delay the costs coming down, which we want to see and which patients need.

Foresight is working on this. A number of folks are addressing this issue. So I certainly invite you to join with us in looking into that.

That's one issue. I think it's a current issue. We need to address it soon.

Let's look, for a moment, at a longer-term issue, which is this question of extending the human life span. Actually, this is—here at UCSF the idea of making people healthy may not seem too controversial, but it turns out in Washington, D.C., it is controversial.

I have brought three props with me to help explain this issue. I doubt that our UCSF folks need this, but I have found tremendous confusion in the public and I want to use these props to make a point.

I brought three longevity pills with me. OK? Here is the first one: what this one does is take the last day of your life, which I would argue may very well be the worst day of your life—there's a good chance you are in pain and pretty miserable—and gives you one more day of those. OK? You get two of those days instead of one.

Now, I don't think anybody is interested in this pill, OK? But when you say longevity, this is what people think they are going to get, and they say, "No, thank you." Very understandable, right? They don't want that!

That's sort of what they get now from some medical research I read. It will say, "Well, we tested this new drug for cancer and it gave the cancer patients two more weeks." Oh, great.

Maybe those are two good weeks. I hope they are. But a lot of folks think they are going to be pretty bad. So this is a pill people do not want.

I brought a second pill. This pill gives you immortality and lets you live forever. This pill is physically impossible. I think these words "immortality" and "forever" are not helpful. Talk to any physicist, I think they'll tell you your atoms are not immortal and will not exist forever. So it's unlikely your body will last forever.

I brought the third one, which, of course, is the one that I want. Here's the way to think about it. Let's say you're healthy. I'm pretty healthy. What it does is it gives you—it inserts another day, but it inserts it tomorrow. In other words, it takes your current state and says, "No, no, we're not tacking it on the end when you are really ill and pretty miserable. No. You just get another day just like today. You are as healthy as you are today. It's inserted tomorrow. Every time you take a pill, you just get one. OK. So that would be health extension, not miserable life extension, but health extension. This, I would argue, is what people would prefer.

But there are folks who are against this pill. Francis Fukuyama, prominent writer; Leon Kass, who runs the president's Bioethics Council, is opposed to health extension, morally opposed. I heard a talk by him. One of his points was—and I think he has some good points; I'm not saying he doesn't have any good points. But this is the kind of point he makes: he says, "Wouldn't it be sad if the sons could never exceed their fathers in physical ability?" OK.

How sad is that? Well, I brought my mom. Mom, wave to the audience. I want you all to know that my mom has better upper body strength than I do, and you know what? I've been working on it! The fact is it's just going to be this way—she's just good at this. I have grown used to this concept, and I think it's OK.

So I disagree with Dr. Kass. I don't think this is a big deal. I think we can live with this.

To conclude here, looking at this question of health extension and the morality of it, the ethics of it, I think there are at least five issues—I think there are five reasons why we could argue that it's a positive thing.

The first two are very individual; they're based on what's good for an individual. The other three are about society.

So the individual one—you know, I would argue that, if you can give somebody an extra day of true health, it's good for that person. One person has benefited. The second one would be that person's friends and family are tremendously benefited. I certainly have relatives I wish that I had around today—very much so.

Those are the individual points. You'd think they are fairly obvious. But they sound selfish, perhaps.

I grew up in the seventies and eighties, when the big concern was overpopulation. Remember? You know, hurting the environment, don't have children, all those things. You saw a big family and you thought, "Oh, those people are—that's not good for the environment."

Let's look at the other side. What's the benefit to society? First, I would argue there's the value of the knowledge these individuals have. You know, every time someone dies, we lose about a book's worth of knowledge. It's like burning books, in a way. Every copy of that book is gone forever.

What's next? Well, we hear about the problem of Social Security, right? All those people who weren't born—and now they are not around to support those of us who are moving up toward Social Security age. Actually, the problem isn't Social Security. The bigger problem is Medicare and the medical costs of the babyboomers, are going to be absolutely huge—a huge burden. I would say the size of the burden is so large you can argue that it is almost unethical and immoral to put this on our younger generation.

There's no way to make these people exist. They weren't born and they aren't going to exist. We can't import them fast enough. There is plenty of competition for these—we can't bring them in from overseas fast enough to solve the problem.

If we don't solve this problem, then the younger generation who are burdened with this heavy cost, they are going to feel poor, and what are they going to do? They are going to not have as many children because they are feeling poor. So it just—it's a vicious circle, which I think is an immoral thing to be burdening our young people with.

Finally, what else do people do when they are feeling poor? Well, they trash the environment, like they drill for oil in the Alaskan wildlife refuge, which I guess we were about to do. If we were feeling rich, we wouldn't be doing that.

So those are some cases I would make in favor of longevity for society. The final point: I'd say the human body is one integrated system. Eventually, we are going to find out how to slow aging, and I would argue eventually we will find out how to stop aging.

I don't think it's really productive to try to not deal with this issue. I think George would probably agree with me that if we see something coming, we should step up to it and deal with these ethical issues in advance. That's it. Thank you.

KRASNY: I'd like to pick up that last point and ask both of you to opine a bit on—especially George, since you were talking about the necessity or the imperative of bringing together ethical issues with the technology as it advances. I think you were, as well, Christine.

So one has to ask the question, particularly since—if you heard the radio broadcast we did the other day, there was a lot of concern about the lack of money for R&D in nanotechnology. There's a lot of education. I mean, there's a big bar here in terms of what the public needs to know. Not only educating the public about nanotechnology, about its possible applications, about it not being overhyped, what it can represent in the future, short-term and mid-term and long-term; but creating a greater awareness about some of these issues, because when you talk about extending longevity, you are talking about limited resources, you are talking about a health-care system that is already overburdened, you are talking about a population of older people now and as the demographic continues to increase, that really can't be sustainable, at least from what we can see now, unless nanotechnology can also find ways to sustain.

So my question to you would be, how can we make these kinds of issues simply more understandable to the lay public? How can we make them really palpable so that the lay public realizes what's at stake here, because a lot is at stake here? I mean, health, longevity, our loved ones, ourselves. Any thoughts from either of you on that?

KHUSHF: Well, the idea of an informed public discourse on nanotechnology, nanomedicine, and aging—it seems there are certain conditions for it.

First, involvement of the people that are doing the research in the larger public discussion. So those that are doing the work in nanomedicine, to have them as a part of this discussion, to give a realistic sense of the things that are on the horizon.

But beyond that there is another kind of challenge. I think it is not just one that we will see in “nano,” but it's challenge that we face with the kinds of technologies that are on the horizon. That is we've sort of separated things—the skills of the scientist, right, and the role for scientific expertise, versus policy social reflection as a kind of disconnected thing from the science.

We need a kind of debate that forges—you could say a common language—between these communities that have addressed these problems in isolation from one another.

KRASNY: They are speaking different languages, aren't they really, in many instances?

KHUSHF: Exactly. To learn how to sort of convey the information and the concerns in a way that's broadly accessible. I think as these different communities forge that common language, they also forge an ability to directly communicate with the public, because we no longer speak in this technical language that tends to isolate the discussion, and make it so difficult to enter into it. But we start to develop a language that communicates to those outside of our individual fields and our more isolated focus.

KRASNY: The synchronicity you are talking about is really the pith of your—a lot of your message here today, that there needs to be that mutuality and communication and so forth.

But science tends to be fairly isolated a lot of times, particularly when, you know, people are working in a laboratory doing research and trying to, sometimes, make a profit or make full professor, whatever the case may be.

The fact is that you've got within the society the desire for a lot of this magic bullet type stuff or these "pills" like you have here, right? So you've got these appetites that are moving along different tracks, isolated from each other, but both wanting the same kinds of things. Both moving kind of relentlessly in many directions, aren't they?

PETERSON: Very relentlessly. I think in terms of engagement, and I agree this is a tough issue—if you look at the types of folks who have, in the past, developed products and services that directly affect the public—these are engineers, these are physicians, they tend to have pretty clear codes of ethics. Both of those professions have clear codes of ethics that encourage them to think about these issues.

If you go off into the more "pure" sciences, the physics, the chemistry, these folks often go into their field for the love of exploration of the natural world, and they don't necessarily—they don't go into it because they wanted to think about ethical issues. These are seen as very separate things.

The problem is that now these folks, the chemists and the physicists who went in for the love of "pure" science, now suddenly they are very close to developing things that are impacting us directly. They are just not used to this role. That's not what they signed up for originally, normally.

Getting those folks to step up to this, I don't have any easy answers there.

In terms of public involvement, though, I should say there was survey of the U.S. public and their ethical concerns on nanotechnology, and they actually were surprisingly sensible and well-informed. I mean, I was thrilled, since our organization has been working on this for a long time.

Number one was surveillance and privacy issues. Very realistic and normal—and a good concern to have. That is a near-to-mid-term issue.

Number two was an arms race. That's a mid-to-long-term issue, but a very important issue.

Number three was concerns about nanoparticle toxicity. That's an immediate issue and a very realistic issue.

Number four was economic disruption and potential job loss. Not an immediate issue, but perhaps a long-term issue to look at.

I thought—it's amazing, but the American public is, I think, doing pretty well in terms of their ethical understanding so far.

KRASNY: We could hope that that will continue of course. In the best of all possible worlds, it will continue. But most of the public is probably not terribly well informed on this subject, not really realizing what the possibilities are. In fact, I think we were talking about how overhyped and inflated those possibilities are.

I mean, you heard Christine, for example, disabuse everybody of the idea that immortality is possibly in the cards here in terms of nanotechnology—when atoms die and there is just a kind of essential mortality that is linked to all of our existences. Yet I think there people who look at nanotechnology probably and think, “This could be what Ponce de Leon was looking for,” right?

PETERSON: They are certainly looking for longevity. The hopes are up for extended health spans; and those hopes, I think, are plausible.

KRASNY: Plausible.

PETERSON: I think we can—let’s see which one of those was I using? The yellow one. I think we can probably do those inserted healthy days. For the long term, I think we can do that.

KRASNY: Yes, George. Go ahead.

KHUSHF: I share the confidence that, in terms of life extension, we will continue to advance. But it’s sort of how we frame those issues, and understand them.

First, I think we share an interest in looking at sort of the full range, from the near-term, mid-term to far-term.

Perhaps in assessing what the prospects are and what counts as far-term, there may be some difference in emphasis. So at least in the past, with Foresight Institute and some of those involved with that—Ray Kurzweil and others—the idea of extension of life span is not in terms of, say, a few years or to 120. It’s if we can make it past a certain threshold, say within the next thirty years, we can live to a thousand. The idea is in many ways very much like that of a pill, right, where in the early stages it’s certain mechanisms for knocking it out far enough, say, fifty years, until science has that full breakthrough. Then, nanomachines that sort of clear up the cells and everything else are going to just make this threshold where you go to the thousand years.

While I wouldn’t want to completely discount these radical developments that might lie on our horizon, the question I think needs to be asked about sort of how we understand nanotechnology and these prospects—what it means to have this mid-term discussion that I think in terms of moving toward it, there is very much an interest in that mid-term discussion and some real leadership in framing broad issues, say, you know, now on patents, on reflecting on sort of what it means socially in a responsible way to think through this.

But I think it's still sort of on that—what you might say the more radical prospects, the thousand-year life span, with the magic pill—that's where there are some differences in how you find the answers.

KRASNY: Well, it's good to hear you talk about a thousand-year life span because I did an event at the Museum of Technology in San Jose with Stewart Brand, the founder of *The Whole Earth Catalogue*, and he said, "I just hit middle age." He said, "Today's my sixtieth birthday," because he was convinced that we would be extending longevity, at least in his lifetime, so that he would live to 120.

A number of months after that I did an event at Gordon Rohr's estate with James Watson of the double helix fame, and Hea Wilson, two famed Harvard scientists. We started talking about gene manipulation and extending longevity.

Watson was pretty funny because he was saying things like, "Who would want to? You know, the quality of life..." and you know. The kind of people who once they get past a hundred years old they are drooling all over. You know, all they can read is *USA Today*. I mean it was almost like he was doing schtick, you know?

Yet he was raising for real one of the fundamental questions that, at the mid-term, or wherever we are now, we need to grapple with that, quality of life questions, don't we?

PETERSON: Yeah, and you know, it's kind of sad, because that was Jim Watson?

KHUSHF: Yeah.

PETERSON: Here you have what truly is one of the most brilliant men that has lived in the last century and he is still having confusion about the three pills. You know, I want to sit down and say, "Jim, there are three pills, OK? Here's the one you don't want. That's what you are talking about." It's really—there's tremendous confusion about it. I think one thing that triggers—what I have found—you notice when I went through the three pills, I don't think I used a number, you know, a number of years. I have found that there are certain cut-off ranges that just trigger all kinds of emotions. The logic shuts down?

What I have found helps people think about this more clearly, is not to use the numbers and talk about one day and that helps people not get emotional and to try to say, "No, we don't have to panic about this. It's not too weird to think about. We can think about this."

And you know, if you think about all the changes our species has gone through since we were in the caves, we can get through this one, we really can, you know? Just because we live longer, it doesn't mean we have to panic. It really doesn't.

KRASNY: Thinking of nanotechnology, you always miniaturize, right? (inaudible) with a thousand years to one day. What's your response to that, George?

KHUSHF: Well, I guess—first, on the one day and how we understand it, I think even there—one of the ironies of the extension of life that we’ve had is that—we’re living longer, and we’re healthier. But with the graying of America, we also have, in some ways, a shift from the older, acute care problems as central to chronic illness, adjustment to functional decline as a part of this graying of America.

With technology we seem to view it as kind of either/or, the technology solves the functional decline. Then, say, with successful aging model you sort of just move it out forward, you know, and then ideally it drops off when you die.

But it seems we have to start also thinking about—we may have both. That’s not bad. It’s not just one day at the end of life, right?—in an ICU delaying it a couple days further.

But it’s many years within each stage, you know, a little bit of loss of function, adjustment to that, and think through technology and think through aging and think through life in terms of these adjustments, and that’s—

KRASNY: What you were saying before when you were kind of kidding—the American Cancer Society, thinking that they could just—or giving the hope that they could just eliminate cancer through nanotechnology in the long term, but not necessarily taking into account all that that would bring with it, and all that it would require us to be thinking about ethically and personally. They say ten years; 2015, right, to eliminate suffering and death from cancer.

PETERSON: That’s right.

KRASNY: It was that way of framing it.

KHUSHF: But then, of course, you could say that that—

PETERSON: Let me just—

KHUSHF: That’s a good goal, isn’t it?

PETERSON: Well, I think—one thing that helps me think about this is to go back in time and replace the word cancer with polio, and we could have said, we could have had a little panel and talked about, “Well, you know, is it really just about curing polio and don’t we need to have these ethical debates about curing polio?”

Well, maybe we didn’t, you know. Maybe we should just cure polio and the heck with it. It’s gone! So now, we could probably make a case cancer is different in some fundamental way. But oftentimes, when you hear, let’s not speak of George here, but perhaps of some of the actual opponents to this, such as Francis Fukuyama and Leon Kass, some of their arguments you could—you again replace the—you know, extending human life span with getting rid of pain in childbirth. I mean, this was a big issue. It was a very controversial thing and was seen as a morally bad thing.

Another thing that was seen as ethically bad was anesthesia during operations because what if you died during the operation. Then you would have not have been in the right spiritual state, etc., etc.

These were real issues at the time, and now we look back and go, “What was that about?” So sometimes there are real ethical issues and we want to engage, and I want to engage with George on those, and sometimes maybe it’s just OK if polio goes away.

KHUSHF: I wasn’t meaning to suggest that curing cancer isn’t a good thing.

But the problem is, first, the timeframe, right? The ten years.

But also the focus, that technology is the key, that if we want to do that we just look at technology, without looking at, say, you know, again the Institute of Medicine Report, seventeen-year average lag for the integration of technology from, say, the first publication of the research into what goes on in practice at the bedside, right? To just focus on technology and not focus...on the kinds of deeper social transformation necessary to realize these goals is to work against that goal.

So it wasn’t that we shouldn’t pursue it. It’s just if we pursue it, we should see it in its full context and not just focus on the technological pill and the breakthrough research, but focus on the whole context—

KRASNY: The whole picture.

KHUSHF: —of the problem.

KRASNY: Let me ask those of you who are here with us to join in here with any comments or things that you would like to contribute, or certainly any questions you want to raise. We’ve come to that point, actually, now, on the clock where we want to get interaction from the audience. Yes, sir?

AUDIENCE MEMBER: I have several questions. One question would be why aren’t we discussing the public’s disregard for their own and others’ health as it is? It’s a huge percentage I heard. What about the way people risk their lives in all kinds of different ways—squandering—obesity and the other things we’ve discussed today. (Inaudible.)

PETERSON: Well, OK. The question is about how people don’t take care of themselves today and what about that?

I’ll just give one example. If you look at modern lifestyles, and let’s take a very common lifestyle, the working mother. Think about her day and the stresses that she is under, and all the things she is trying to do in her life for her family.

You know, her own health often is last on the list. Does she work out? She does not work out. Does she eat on the fly and not have time to really prepare healthy—she may prepare healthy foods for everybody else, but she may not do it for herself.

So to some extent, what we need to do is lower the barriers—make it easier—somehow make it easier for folks to take better care of themselves. It's very hard.

KRASNY: Isn't nanotechnology going to do it, because you have all these robots and sensors that will just take care of everything, right?

PETERSON: Now you are talking about the long term. Helping people in the near term, that's really tough. Maybe—George, maybe you have some thoughts.

KHUSHF: Well, the question highlights how health issues are a function of a large cluster of factors. Some of these are related to how we care for ourselves. Some of these are social public health issues. Some are—a very well known study showed that whether your—the kind of work you have has as big an impact on health outcomes as whether you have healthcare services or not. Or male versus female, or whatever else.

So when looking at health, we need to look at the whole, the large picture. That's what I take to be your, your concern that was raised, and would share it.

KRASNY: Thank you for raising that concern. By the way, I hear these billiard balls in the back and it sounds like atoms clicking, you know (inaudible)

[Laughter]

Do we have any other—yes, ma'am. Please. The lady in the yellow jacket. Yes.

AUDIENCE MEMBER: Two questions. Christine, you had mentioned under issues the word toxicity or toxic in the process. If you could explain that.

The second one, which is unrelated, is: what is going on in the rest of the world in terms of the debate, and are you speaking from a global context or an American one in the debate, as it exists?

PETERSON: Well, first on the toxicity question, these nanoparticles, it turns out that they have varying chemical reactivities and that's natural. The surfaces are very different on the different particles. Some of them can be toxic.

Now, that actually turns out in some cases to be a good thing because they are often doing a lot of work against cancer with these particles, and you need that toxicity to do that.

On the other hand, if it is something that is going to be let off in the environment or used in the consumer product, you've got a big issue. This is something that the EPA and the

FDA are grappling with right now. It turns out they don't have enough funding to do a really good job on it. That's something Foresight is certainly advocating—that they need to be beefed up.

KRASNY: There's real concern, as I think you have expressed, about nanoparticles getting—

PETERSON: There is real concern.

KRASNY: —past the immune system, into cells, right?

PETERSON: Well, I think there was one study that indicated that some of them might cross the blood-brain barrier. So there are issues here. They need a serious study. They are starting to get real attention, though, so it's not that they are getting no attention. They are.

Then you asked about the global views? Now, do you mean global views of nanotechnology or of longevity issues? Nanotechnology in general? Oh, it's—there is tremendous interest. The U.S. is only spending about a quarter of the world's spending. So Europe is spending heavily. Japan is spending heavily. Other countries, like China, are ramping up fast.

So it's—there is no reason to think the U.S. will be the—I'd say we are still a little bit ahead in nanotechnology, but that is not a given; and we could easily fall behind.

KRASNY: I made the mistake yesterday of saying that the U.S. leads in terms of expenditures, and the fellow who heads up the nanotechnology research at Hewlett-Packard corrected me and said, "This is something that has been misrepresented deliberately by this government to make it seem as if we are leading the pack, but we are not.

This gentleman over here—he had something.

AUDIENCE MEMBER: I'd like to ask you to perhaps extend the context of the discussion a little bit. I'm a lawyer who's been asked by the insurance industry to look in the medical/legal issues and to stretch the context of the discussion.

What would you, if you were in my shoes, talk to the insurance industry about in terms of how nanotechnology is going to impact it?

PETERSON: Well, the—since you've started looking into this you probably are aware, but I'll mention to the audience, that there was a major report that came out from Swiss Reinsurance, that you have already read, that looks at this issue and they are nervous, is my impression. They are quite nervous about the toxicity issues. I think they are probably right to be nervous. There needs to be so much more testing done to make sure these things are really safe.

So that's the major issue. I mean, most of these other things we are talking about are too far in the future for them, I think, to be concerned.

I would say that's—this whole nanoparticle toxicity issue is the one that they should be focusing on and looking for some kind of safe harbor rules. Industry is working right now with government to try to come up with some kind of procedure to follow to test these things, that—so that you can get an approval, and know that you at least followed the generally acceptable procedures. It's not established yet.

KRASNY: Christine (inaudible) safe harbors. I am sorry. We are running close to the end of the clock here and I want to give each of you an opportunity to make some closing remarks. But if you can fold those in, George. And Christine, could you just segue into yours?

PETERSON: I've really enjoyed this discussion, and what I would suggest is those of you who are interested in these general issues, any aspect of nanotechnology, that you are welcome to get involved.

Our organization, Foresight Institute, is a membership group. We are nonprofit, and we welcome participation from everyone. We will be tracking the near-term issues, such as toxicity, the mid-range issues that George is pointing out and the long-range issues.

We have a special interest in intellectual property, which we feel has tremendous impact on access by the general public.

We also look beyond medicine. We look at other applications, especially energy, water, agriculture, information technology, and space development. Those are our other focus areas for nanotechnology.

So I'd invite you to join as a member. You can come to our conference this fall here in San Francisco, in October. Just go to our website, Foresight.org and you will see it right there on the page. I'd love to continue the conversation.

KRASNY: And if anybody needs heavy lifting they seek your mother for that, right?

PETERSON: She's in the back. Yeah.

KRASNY: Strong upper muscle!

PETERSON: Right.

KRASNY: George?

KHUSHF: Yes. Well, maybe as transition, one piece of the legal question that I think is of interest.

There are the actual concerns, say, about toxicity or biocompatibility or whatever else. But there are also, you could say, questions of public debate and response, which are important in the larger legal context. That is, are people going to be afraid of nanotechnology, seeing it as a risk? What will that do to public response in terms of, say, regulatory context or the kinds of burdens that are placed on those involved in the developing of the technology?

Now, ideally to establish a context for what might be viewed as more informed reflection on the issues associated with nanotechnology, that's going to entail dissemination and informed discussion of nanotechnology. How do we bring that about? And, also, with "nano," I think there is an interesting challenge and problem.

We can take "nano" not just for the actual capacities, but as a kind of symbol for the technological capacities that are on the horizon that make possible new forms of intervention, and perhaps even sort of new kinds of capacities. How do we think through these technologies on the horizon in a responsible way to anticipate them. To not just look at where we are now; to look ahead, anticipate them, but perhaps not go so far ahead that we lose the connection with the actual technologies that are emerging right now. It seems to me that that's one of the central challenges in thinking through nanomedicine and aging.

KRASNY: Well, it's an exciting field, and there are many challenges ahead, as I think we've heard today. I'd just simply like to say that I thank you all for being here, and hope that you will, in the spirit of good citizenship, continue to keep informed on this subject because it is an important one that obviously affects us all as community, as society, and as global citizens.

So thank you again so much indeed, and thank you to the sponsors of the program, and thank you especially to Christine and George.

[Applause]

PERRY: On behalf of the Alliance for Aging Research and the American Association for the Advancement of Science, I also want to thank Christine Peterson, Dr. George Khushf, and our moderator, Dr. Michael Krasny.

SAGE Crossroads was created in large part to break down the language barriers that separate science and the public and policy makers, and what you've added today under the specific title of "Nanomedicine and Nanotechnology" adds to the growing library of discussions and debates as they will affect the certainty of a future in which our population will experience longevity and aging in ways that will be dramatically different from ever in the past. Thanks to all of you for participating in this. A final word of thanks to the sponsors of SAGE Crossroads, the Archstone Foundation of Southern California, the Atlantic Philanthropies, and the Retirement Research Foundation.

On behalf of the Alliance for Aging Research, I'm Dan Perry. Thank you all very much.

Nanotechnology: Past, Present and Future

[Applause]