Nanotechnology: The Promise of the Future or Pandora's Box?

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KONDRACKE: Welcome to our latest SAGECrossroads debate. I'm Morton Kondracke, your moderator. Today we are going to discuss the potentials and the possible dangers of nanotechnology, which is a major breakthrough, a new field funded by the federal government at almost a billion dollars a year, and growing. It is thought to have great potential in everything from strengthening materials to curing diseases, but also has ethical issues.

Our guests today, to discuss the pros and cons of nanotechnology, are: Robert Best, who is Associate Professor and Director of the Division of Genetics at the Department of Obstetrics and Gynecology at the University of South Carolina; and Mike Treder, who is the Executive Director of the Center for Responsible Nanotechnology, and is also a board member of the World Transhumanist Association, which we will get into the philosophical underpinnings of as we go on.

So by agreement, Dr. Best is going to start and talk about the benefits and some of the problems, and what's being done to regulate nanotechnology. Also, I hope he will explain what it is and how it works and some of the science behind it, for those of us who are challenged in those areas. Thanks.

BEST: OK. So nanotechnology has really caused a lot of excitement, Mort. It is the manipulation of things at the molecular and atomic level. So this is something that we've previously not been able to do—some very, very small manipulations. The instrumentation to do those kind of manipulations has only recently been developed.

KONDRACKE: What is it? What is the instrumentation? How do you get down to the atomic level?

BEST: Well, there are a number of instruments that are used. Atomic force microscopy is probably the most prominent of those technologies.

KONDRACKE: Which is how you would see it, in other words.

BEST: So you can pick up and move around individual items using this type of microscopy. So there's a lot of potential with nanotechnology, because—

KONDRACKE: Well, just let me stop you there.

BEST: Yes.

KONDRACKE: I mean, you obviously don't use tweezers, so what is the—after you see them, how do you manipulate atoms and molecules?

BEST: Well, you just physically move them around. So, unlike chemistry, which is a sort of a bulk molecular reaction of things bumping into each other, the idea with nanotechnology would be that you grasp individual atoms using the tip of the atomic force microscope. Then you physically move it to where you want it to be.

KONDRACKE: So it is like—

BEST: Like tweezers.

KONDRACKE: Microscopic tweezers. OK.

BEST: Very like tweezers. Yes.

KONDRACKE: Good.

BEST: So there's a lot of potential here, because this is a level of manipulation of matter has really been inaccessible in the past. The accuracy, the power to be able to make molecules do things at that level, could have striking and powerful applications in all kinds of things—in energy, in health, and in an environment manufacturing things without waste.

So the idea then would be that we could manipulate matter in very controlled ways to do powerful things. So those powerful things would have potential benefits, as I've mentioned, because they are powerful. If you apply anything powerful in the wrong way, then there's also the potential for harm and damage, so that would be the counter balancing claim for nanotechnology. How do we use these things safely and wisely to achieve practical ends?

KONDRACKE: How far are we along in nanotechnology? What's been done and what is on the horizon?

BEST: Well, I think we are right at the beginning, really, of an explosion in those technologies, because of the instrumentation and the science that has just recently been worked out with the creation of, say, carbon nanotubes, which maybe we'll talk a little bit, more about and the atomic force microscope. So these are sort of basic working tools that one would use in nanotechnology.

So we are near the beginning of that. The hope is that we would progress very quickly now to be able to use these things efficiently and effectively to achieve practical ends. So there are, as you mentioned, about a billion dollars in federal funds now directed toward nanotechnology research in the United States.

KONDRACKE: So what are the kinds of things that nanotechnology would allow us to do? What are the kind of changes that are implicit in the ability to do it?

BEST: Yeah. That's a great question.

Well, I'm perhaps most interested in nanomedicine. If you look at nanomedicine, the idea would be that if you look inside a cell, there are 30,000 or so genes, there are about 100,000 different proteins, there are many, many more macromolecules. As many as 10 million different forms of proteins are found in cells when you consider all chemical modifications.

We understand the molecules one-by-one right now. We have a sort of a linear approach to understanding how these molecules interact.

The idea with nanotechnology would be that you would look at the way these molecules interact in groups. How do cells make machines? If you look inside the living cell, you can see a number of examples of things that look very much like the machines that we use to achieve practical end points in society.

In the realm of nanomedicine, what we would hope to do is characterize the way these machines work, start to study not the molecules themselves, but the way that they aggregate into machines, to begin to imitate those machines. Or to think how, if one of those machines goes astray and doesn't do what it's supposed to do, how can you reverse that or fix that or put something in its place to do the work that it ought to be doing?

KONDRACKE: So this would be an artificial cell, then, to replace a cell that had died? Or what?

BEST: Well, that's not really what I'm talking about right now. There is some vision for the artificial cell, a completely synthetic sort of life form that self-replicates and can do various things.

If those things ever happen, they are—I would say they are a long way off.

KONDRACKE: So would it mainly be a diagnostic tool in the beginning?

BEST: They could be used as diagnostics. They could be used—there is some very interesting work on how to make little miniature pumps that actually can fit inside of cells that are made from biological materials that actually use the same energy source that the cell uses to power the pump up. So no need for batteries. You can get these things to do practical work in terms of physical work inside the cell.

KONDRACKE: What diseases are likely to be the first targets?

BEST: Well, there's a lot of discussion right now about cancer. I mean, it would be virtually every disease. But there's a lot of talk right now about cancer, and the National Cancer Institute has a fairly ambitious goal of curing cancer and alleviating suffering due to cancer by the year 2015.

I think that's a very ambitious goal, but as we look at the power of the tools that we will have in nanotechnology that may well be achievable.

KONDRACKE: OK. Mike Treder, tell us what the problems are.

TREDER: Actually, I would like to start by going back to the atomic force microscope—

KONDRACKE: Please do, please do.

TREDER: —that you asked about initially.

What I wanted to say about that is when we are talking the nanoscale, which is a billionth of a meter, that's actually smaller than the wavelength of light, visible light. So you can't actually see. The microscope doesn't look down and see the way we imagine a microscope in a biology class seeing something.

The way the microscope works is it has a tip that Bob referred to. That tip goes over a surface, and the movements of the tip on the surface are then translated, if you will, into a picture. So it's a representation.

KONDRACKE: By computer.

TREDER: Yeah. Of what is there. The tip of the atomic force microscope can, under certain circumstances, select, pick up individual atoms and move them. It's been shown to be able to do that.

One of the ways that's done is by changing the chemical structure at the tip of the microscope. What you are doing is—you're not actually using, somebody used the word pincers. You are not actually grabbing an atom, but you are using chemical reactions at the tip, just as it happens all the time, and moving that atom to another place.

Well, that's just really the beginning of what may be possible through nanotechnology. It's the most sort of crude or primitive way of doing things now. But we are watching at our organization, the Center for Responsible Nanotechnology, we are looking at the progress that's being made, the new tools that are being developed, the studies that are being done, and we are seeing that what we can do today is just the bare beginning of what could be done.

When moving those atoms, when designing and guiding those chemical reactions can be done on a greater scale, and can be automated, programmed, then there's almost no end to what we might be able to accomplish in anti-aging, in medicine in general, as well as in other areas of society for energy—cheap, clean energy production, for environmental remediation. But also, as you said, on the down side, it could be used for new weapons, new types of weapons, new surveillance devices.

There are a whole host of ramifications that really need to be studied.

KONDRACKE: Well, let's be as concrete as you can about what the potential would be for diseases of aging, because that's why we're here—but just more broadly. Then, what are the dangers?

TREDER: I guess one thing we should talk about is the time factor here. Because Bob mentioned, and some people will tell you that we're, you know, twenty, forty, a hundred years away from some of these things coming to pass.

But as we've seen the sort of acceleration of progress in technology, through advanced computerization and new tools being developed, our expectation is that the progress is going to happen more quickly than is presently anticipated. We haven't really studied what the impacts are going to be—what the effects on society will be.

So actually the reason that I'm here today is not so much because I'm an expert on medicine or aging, which I'm not, but because I'm concerned that the ability to do that research and to spread the beneficial effects throughout society could be impeded if some of the other things happen that cause controversy, that cause delays, that cause disruption in society.

KONDRACKE: Such as?

TREDER: Such as economic displacement—if the manufacturing revolution that we are anticipating takes place. If thousands, millions of jobs are lost when products are manufactured within essentially an automated desktop appliance, rather than in a block long factory. What happens to all those jobs?

KONDRACKE: Like what? What would not be made in a factory that could be made at a desktop?

TREDER: In the early stages anything that—essentially anything that can be made out of carbon, because carbon is the easiest element to work with.

So you could virtually—anything in the room here, computers, tables, glasses, medical instruments, bicycles, automobiles, airplanes, almost anything you could think of conceivably could be manufactured on a molecular level, building from the bottom up.

Instead of—today we sort of start at the top and we make things smaller and then put them together.

But when they are able to manufacture products atom-by-atom, and build them up, then not only will you get cheaper products, you'll get much more powerful, much longer lasting, stronger, more durable products. It's—

KONDRACKE: —effects. I could see making an airplane out of something more lasting than aluminum, and, therefore, you wouldn't need to replace them as often. Therefore you wouldn't need as many jobs in the airline industry.

TREDER: Um-hmm. Um-hmm.

KONDRACKE: That makes sense. But so you are worried that—what? That the politics of this would—that people losing jobs would militate against nanotechnology and try to slow it down?

TREDER: There are a lot of concerns. The first concern that's being expressed today, which is legitimate, are the environmental impacts, or the health impacts of people breathing, for example, nanoparticles. That's starting to be studied. We should study that.

But it will go beyond that. For example, if the economic impacts of job displacement—one of our biggest concerns, though, are the military implications. If new weapons can be created and tested and deployed much, much faster than what they are now, more powerful, more deadly weapons, then that could upset the current balance of power.

There will be groups, as there are already, who are vehemently opposed to these sort of developments, and who will, you know, fight to have moratoriums or bans placed on this type of development.

We think that's going too far. But without adequate proposals for how we should regulate the technology, then extreme measures would be called for and even ( ).

KONDRACKE: One could imagine, if you can, on the medical side, that if you can manipulate cells, that you have the capacity to create incredible bio-weapons.

TREDER: Um-hmm.

KONDRACKE: That would-that there would be no antidote for, because they would be manufactured on the spot by somebody and could be used to destroy civilization before-before you knew what hit you, I assume.

TREDER: That's correct. When molecular manufacturing, as it's called— building things from the bottom up, when that becomes a reality, it's a science or a technology that is, by its nature, very small and therefore easy to hide, easy to conceal, easy to transport or even smuggle.

So it's not like, say, with nuclear weaponry, where you can do, you know, satellite imagery and you can tell where people are working on those sorts of things. This is something you could conceivably walk through in your pocket and not have it detectable at all.

So there are a lot of concerns about it.

KONDRACKE: So, you have a grant from the National Nanotechnology Initiative to study the ethical and social issues. Where is the government now in terms of anticipating these threats to the technology?

Best: That's right. Well, it's actually the National Science Foundation (NSF) that -is currently funding our work at the University of South Carolina.

Well, the powerful technologies are potentially two-edged swords, right? So we could use them to do things for us, or they could be used against us.

So the development of the technologies does have these sort of issues associated with them, although I think in terms of my perspective as to where it goes, I think in the short term and in the medium term—say short term being the next five years, medium being, say, ten or fifteen years—I don't think that we know what the end use will be. I don't think that we know that we'll get to desktop manufacturing, or anything of that sort on a large scale.

I think one of the concerns would be to frame nanotechnology where we really are today. Today we are using fairly crude instruments compared to what we'll develop in the future. So the work we're doing at the University of South Carolina is to try to look at all of the ethical, legal and social implications of the development of nanotechnolgy. How is it communicated? Or is there—

it seems that there are very strong utopian views, very strong dystopian views where the world—there will be heaven on earth or we'll be destroyed by these technologies.

Those are pretty extreme views, and not within the foreseeable future as I would understand it.

Treder: Can I say something about that?

You made a really significant point there, that we really don't know what the expected timetable is for these things. That's one of our big concerns, that because enough study has not really been put in to determining what the roadmap is to get to the point where desktop manufacturing becomes a reality, we're not able to adequately prepare. It's really a shame that in the 2001 Nanotechnology Act that was passed by Congress and signed by President Bush, there was originally, in the House of Representatives' version of the bill, a section which was to study molecular manufacturing and to assess what the likelihood was if it's being developed, what the research agenda should be and what the timeline would be.

Unfortunately, after some lobbying from the existing nanotech industry, that was taken out, presumably because they though it might just create, you know, too much controversy.

As of now, the U.S. federal government is not expending any dollars to try to determine what the long-term impacts of nanotechnology will be.

KONDRACKE: So your study doesn't cover that? I thought it would.

BEST: No, I would have a little different take on it. You know, we spent a lot of time talking with people all around the world about what is developing and, I mean, I think that the reason it's not in the initiative now to study is that it seems far enough off that you might think in a sort of a theoretical way about those scenarios. I think that's a good thing to do.

But in terms of the advance warning we'd get, there are some things that will have to come first. To focus on those things in the short term seems just unproductive. It seems beyond what we would imagine with the tools that we have in hand with everything that we can foresee in the next ten years.

We wouldn't see, you know, self-replicating nanobots and the problem of some sort of synthetic life form that digests—

KONDRACKE: Self-replicating nanobots. I mean, I can parse that out so these are robots that can reproduce themselves.

BEST: Yes. A very powerful image, used in a lot of Hollywood—Agent Cody Banks, a Disney production, where these things just kind of digest the environment around them to get atoms to make new things.

It was a scenario that was imagined at one point. I think most people have accepted that, you know, that's far enough off that it probably will never happen. If it is potentially going to happen, then there are a number of key developments that will have to precede them that we would have some warning about.

TREDER: It's unfortunate, in fact, that they—if you put it "the self-replicating nanobot" it's an attention-grabber. It has gotten into science fiction novels and movies and television shows. It's stimulating. But the problem is it sort of diverts attention from the more serious and more likely implications of the technology.

Even though, as you said, the potential for self-replicating nanobots may be far in the future. It may not even be necessary. The person who essentially founded the interest in nanotechnology, Eric Drexler, who is the author of Engines of Creation back in 1986, and then a textbook on nanosystems in 1992, recently published a paper co-written with the director of research of my organization, Chris Phoenix, in which they examine that whole issue about self-replicating nanobots. They determined that there is really no reason for them, because everything that can be done or will want to be done with molecular manufacturing can be done without self replication of little tiny nanobots.

So there really isn't that risk that was originally imagined. But the attention paid to that takes away from the attention that needs to be paid to the other-the other economic implications and military applications of the technology.

KONDRACKE: Let's go back to our basic subject of interest on this, and that is aging, and aging research.

Where are we in the application of nanotechnology to aging diseases, diseases of aging? Or the aging process itself?

BEST: That's a great question. We're trying first of all to understand the biology of aging, so that's a prerequisite to straightening it out.

KONDRACKE: Right.

BEST: So a lot of the initiative in nanomedicine will be to characterize all the physical systems, the machines and the proteins that do the work inside of cells to examine carefully what they do, how they interact with each other. So NIH, in its roadmap for nanomedicine, articulates a vision where we develop a catalog of all those interactions between the macromolecules to try to understand what is actually the normal state of the cell and how is that perturbed in a disease state? how is that perturbed in aging, which is most often not a disease state?

When we understand that, and when we've characterized that, then we can address the questions as we discover how those changes are wrought in the living cell. Can we forestall those? Can we reverse those? So I am sure that aging will turn out to be a very complex process, where there's a number of end points that are all important.

So to start to select individual end points and say, "This is how we reverse that or prevent that from happening," that's, I think, where nanotechnology will come in.

KONDRACKE: When does the roadmap envision actually learning something? I mean, actually discover something?

BEST: Well, the roadmap was unfurled in spring of this year. Right now a number of centers around the country have submitted proposals for funding.

So funding will begin some time in spring of 2005. It will be initially three centers and then an additional three the next year. Those centers will begin to try to develop, in collaboration with each other, and with the rest of the nanomedicine community, what needs to be done. What are the funding priorities? What baseline work needs to be done first?

That's really in the planning stages right now.

KONDRACKE: Um-hmm. Are there specific targets for the funding? I mean, how-how is the funding targeted?

BEST: Well, the funding is—that's a great question. I think that NIH has some ideas about how that funding ought to work, the idea of using a systems biology approach of understanding—this is a term meaning the understanding of how all of the systems in the cell interact with each other.

KONDRACKE: Right.

BEST: Taking that approach, we'll build the basic science. Some of what we've argued for in our proposal is that one needs to consider, as I think Mike would agree, ethical issues and societal issues as you develop the very science. Even in nanomedicine, how will these things be used? How do the values and the ethics that prevail in society influence the direction that you'll take, how you set your priorities, you know, where you'll go first, what limits you'll set as to places that never should, maybe, be gone to?

KONDRACKE: Go ahead. What would you say are the issues involved here?

TREDER: I was just going to say—one issue, I think, that needs to be considered is, to whom will the benefits be made available?

The typical model of new technology is that it's very expensive at first, and it's offered to the elite, those who can afford to pay the bill. Then, over time, economies of scale come into play, and it becomes available to, say, an upper middle class and so on. Only eventually, if at all, does it become available to those in, say, the developing world.

Because of the sort of personal impact of anti-aging research and nanomedicine, the fact that if it is not developed in time or at a price that I can afford it, that means I die while you live.

There are going to be people who are going to object if it's not made available on a more equitable basis.

Now, what the mechanism is for doing that, nobody knows yet. But that's going to be a big issue, and one that needs to be planned for well in advance. Because otherwise, you can imagine the controversies that will erupt if one class is able to extend their health span and another class is not.

Best: Those are great issues, and in March we'll host an international conference on nanotechnology to address ethical, legal and social aspects. That would be a key issue of the—what is sometimes being called the nanodivide—the haves and have-nots. It seems like the powerful can get more powerful, and the weak more weak if you implement these the wrong way.

Kondracke: Well, it's the case with every new discovery as in—

Best: That's right.

Kondracke: —retrovirus. I mean, HIV treatments arrive last in the developing world, as you say, and were available first in the developed world for people who could afford the medicine first. That's an issue across medicine.

BEST: Except that these are enabling technologies for further development. So I mean, it's compounded in that sense, that—

KONDRACKE: What do you mean by that?

BEST: An enabling technology, meaning that the person who has it not only gets the benefit but can develop the next level and the next level and the next level.

So if you can't get in on it, then you can't develop much of anything.

KONDRACKE: Um-hmm.

BEST: Unlike, say, just the application of something like AIDS medicine which, you know, we can send AIDS medicine to other countries, but no, they don't need to create a research program on understanding AIDS to make use of that.

KONDRACKE: Well, one question that constantly comes up where NIH is concerned is, is this going to be primarily a research project that is going to try to discover how systems work? Or it is going to be specifically targeted on the cure of specific diseases to extend the life span of people who are presently alive?

That's always an issue. Now, which—

BEST: Which is it?

KONDRACKE: You said that NIH wanted to start out at the systemic level of all cells, as opposed to, you know, picking a target cell like cancer, to use as a model to see what could be discovered along the way. Is that an issue?

Best: Well, probably the centers will pick a disease state to study so that they would compare and contrast a disease state along with a healthy state.

So presumably both will be discovered. We've proposed a breast cancer model for looking at, you know, looking at the machines that are used, looking at diagnostic agents, and incorporating ethical and social issues and cultural issues in medicine then in society.

But we would focus that on breast cancer as a disease and then characterizing both people with breast cancer and not. So I think they'll grow together.

KONDRACKE: Are there any issues in nanomedicine that you think are not being adequately studied? You mentioned the economics of it. I mean, are you concerned that any of these other issues won't be covered?

TREDER: We are not really addressing the field in terms of what areas are being studied currently. As an aging baby boomer, I am hopeful that everything will be studied and fast! But it's certainly—the argument can easily be made that more money should be put into all of this research. But we're probably not here today to talk about, you know, how the federal government spends money.

KONDRACKE: Well, we can.

TREDER: Excuse me. We can.

KONDRACKE: But let me just ask one question along this line: Is there any danger that we will be outstripped by some other country?

BEST: Well, yes. I mean, these are powerful technologies. If we don't invest in—I think a lot of the countries around the world have that same sense. It's not just the U.S. Everybody seems to be—everybody that can afford to be—is interested in it. So, again, it is an example of an enabling technology—that is, as you reach one level you then can proceed to the next. And each discover—

KONDRACKE: Well, who is the leader in nanotechnology among the countries of the world?

Best: Well, we are up there. Japan and China have strong interests in it. All throughout Europe there's an interest. The European nations have banded together in some ways to address issues of nanotechnology.

KONDRACKE: Who is spending the most money?

BEST: I suspect it would be us. Do you know?

TREDER : Yes. The U.S. budget is probably the highest, although that's a little bit misleading because the effects of money spent in this country don't go nearly as far as they do in, say, China, where the same researcher—the same quality of researcher might work for one-tenth of the salary of the researcher in the United States.

So just putting it in terms of the gross dollars is not really telling the whole story. It's also difficult to know how much research is going on in certain countries where there is not as much openness as there is here.

The other point to be made is even though we talk about "up to a billion dollars" being spent by the U.S. government in research in nanotechnology, the field as a whole is just barely beginning to develop. To say who's making the most progress, it's really hard to say at this point because we are just at the beginning stages.

I want to mention, too, that the new president of India has really put a hard push on for his country to become more involved in developing nanotechnology. Considering the size of their country, and the wealth of well-trained and educated researchers they have there, if India devotes a significant portion of resources to it, then they could become a leader quickly, as well.

BEST: —reason.

KONDRACKE: By your scenario, a country now poor could make a dramatic leap if it produced a breakthrough—

TREDER: Yes. Yes.

KONDRACKE: —or a series of a breakthroughs in nanotechnology.

TREDER: One of our concerns is that the U.S. is currently the only super power, by far the most powerful country in the world, if the U.S. —

KONDRACKE: Wait a minute. Just a second. Just a second.

A listener has sent in a question that is actually very interesting. Is there going to be the kind of political/ethical objection to nanotechnology, such as there is with stem cells? I mean, sort of moral, religious. Can you envision anything of that sort?

TREDER: It could come out of the nanomedicine because—

KONDRACKE: It is not, well, maybe there is a pro-life aspect to this.

BEST: We don't see any underlying potential issue of that character. I think that there are a lot of issues; and you know, as you look at ethics and science are intertwined in the development of technologies like this, religious values are part of it-historical perspectives, cultural perspectives, all of those things would come into it.

But we don't really see that there's a dividing point that would be a natural point in our culture.

KONDRACKE: So, where do you see nanomedicine being ten years from now?

BEST: I believe where we'll be in ten years—well, NCI believes that they will be on the verge of curing cancer and eliminating suffering due to cancer by that time. Or on the verge. They say 2015. That's an ambitious goal. But very smart people have looked at those numbers, so yes, I think it is overly ambitious personally, but I have to say these technologies are hard to judge—in the same way it would have been hard to judge space exploration or the development of cell phones or wireless computing, even, you know, twenty years ago for computing and cell phones. It's hard, really, to say.

But I would expect that in ten years we will make substantial progress in understanding the basic nature of machines that are used in cells—naturally occurring machines that the body uses to do its work. I believe some things will be very easy to correct when we see the simple nature of the defects, and other things will be perplexing and extraordinarily difficult, and hard to get at, and will take another fifty or a hundred years.

But I expect that we'll see a revolution in medicine as we start to uncover the basic principles of how these machines work, and so on.

KONDRACKE: Now, what about environmental dangers? What environmental dangers are there from nanotechnology and what kind of a regulatory structure needs to be created to at least monitor what the dangers are, and then create warning for something to be done about it?

TREDER: We think that some sort of structure needs to be created, and it's impossible to say now exactly what that structure should be, because we haven't learned enough to know what all the effects will be.

The whole point of our organization existing, really, is to say, "There are plenty of questions that haven't been answered, so let's start talking about those questions." We put together a series of thirty studies that should be completed. We call it "Thirty Essential Studies" in nanotechnology that we believe are urgent to be answered that will go a long way toward determining what sort of regulatory structure might be recommended for environmental health, economic, social issues.

Another point to be made is that these effects, almost all will cross national borders. So even if one country does certain types of studies, it may not really deal with the effects that will take place in other countries. There's going to have to be international cooperation. You know, treaties will eventually come forward...

KONDRACKE: Well let's just run down them. There is a British study that has already called for a moratorium, I believe, on some cosmetics that contain nanotechnology ingredients that, in I believe it's in animals, produces disease.

Now, you could imagine, I guess, a nano-manipulated bug getting loose in the atmosphere and doing damage. I mean, is that a realistic fear? Is that what we are talking about?

TREDER: It probably is not a realistic fear, but it's the type of thing that catches public attention. It's the type of thing that will distract from other, more serious concerns. But it's that type of overreaction that we are concerned about could cause problems.

There is a group in Canada that was involved in the regulation of GMOs—genetically modified organisms—and that had an impact on most of Europe having essentially a moratorium on importing GMOs.

KONDRACKE: Absolutely.

TREDER: And so, if that same sort of thing was applied to nanotechnology, it could really slow down progress toward all sorts of benefits. We think it's really important that we talk about all of those issues now and not let the same sort of thing happen.

KONDRACKE: Are there groups that are militating against nanotechnology the way there were against genetically modified organisms?

TREDER: Yes, the same group from Canada, the ETC or Etcetera Group, the one that pushed for the GMO ban in Europe, has called for a complete moratorium on implementation of nanotechnology.

Now, that's gotten pretty much rejected by almost everyone because it doesn't make sense.

KONDRACKE: Well, I thought there were still bans on genetically modified foods—

TREDER: There are.

KONDRACKE: —in Europe.

TREDER: Yes. But as far as nanotechnology—

KONDRACKE: Oh, I see.

TREDER: As of now, nobody has taken them up on that. However, you may be familiar with the article written by Bill Joy, who is one of the-the-the chief scientists at Sun Microsystems. In 2001 he wrote an article also calling for relinquishment of development of nanotechnology.

So there is a minority out there who would call for rather extreme reactions.

KONDRACKE: Now, I mentioned—go ahead.

BEST: Well, the nature of nanotechnology and nanosciences, that it's the convergence of a number of disciplines, so there is no actual field of nanotechnology. It's a combination of chemistry, physics, biology, engineering, material science.

I think one of the problems with calling for a moratorium is you'd have to call for virtually a moratorium on all elements of science if you want to absolutely halt nanotechnology.

So it would be naïve to imagine you could stop it. It can't be stopped.

There might be some boundaries that you place on it, and probably there should be.

KONDRACKE: Such as?

BEST: Well, as we learn more about these agents—If there are particular kinds of agents which are shown to be destructive to the environment or to human health, then, one ought to forego using those until they can be designed in such a way that they can be made safe.

The idea of self-replicating things. If that were possible, and I don't think it is, but one should have a moratorium on those sort of issues, because they involve a whole set of risks that that would be avoidable.

So you could limit certain applications, particularly ones where a broad base of society informed people who would look at it in an unbiased way would say, "There's some reasonable risk there."

The toxicity of nanoparticles is a very hot issue right now. It's not this question of a synthetic bug getting out in the environment, but what do these particles do when you inhale them? Do they destroy tissue in the body? Do they cause disease states? So that the call on that one—to ban them from use in costmetics—L'oreal, the company as I understand, has the most number of patents on nanotechnologies that are almost ready or are being ready to be released for use.

So those questions I think are reasonable things.

KONDRACKE: Just to cover these points so people understand. I mean, what nanoproducts are there in cosmetics that create problems?

BEST: Well, the idea would be that you could make emollients that penetrate the skin deeper.

KONDRACE: I see.

BEST: They could be more effective in that way. There are some sunscreens that are using a much finer form of titanium dioxide. I'm not sure of the report you were referring to, but I bet that's the one—I think that one's in use, and there may be some concern about that.

KONDRACKE: I see. OK. Now, I mentioned that we were going to get into transhumanism. Tell us what it is. And Francis Fukuyama, who was previously a guest on this show—as a matter of fact, on the first program that we had—declares that transhumanism is one of the most dangerous ideas on the plant.

So if that's the case, I want to hear all about it.

TREDER: I am also involved with some people whose study was called Transhumanism, which is the idea that humans don't necessarily represent the final or end of evolution. That it might be possible, with all of the advances that are being made in science and technology to improve upon humans or at least to add additional features to us as humans, whether it is to expand our life span, to improve our health while we are living, to give us a longer life, but also to give us better eyesight, maybe have us see in different types of wave lengths, to have more direct connections, or improve memory by implanting, say, computer chips in our brains and so forth.

It's obviously very speculative. But there is a group of people known as transhumanists who think that this is worth talking about and exploring what the possibilities are and advocating for research to be done in those areas to see how humans can modify, augment, improve what we've been given so far by evolution.

KONDRACKE: What are the opportunities that you might foresee for nanotechnology to produce some of these, you know, Superman effects?

TREDER: Well, Bob mentioned earlier, and he's right, that nanotechnology is—well it's not a single field. It's sort of a conglomeration of numerous fields. It is also an enabling technology, as he put it. Or sometimes people refer to it as a general-purpose technology.

The advances that we can make starting at the atomic molecular level can affect a whole range of fields. In any case, it should be possible to really expand the length of the human life span.

There's really no reason, necessarily, why humans die at a certain age. You know, a thousand years ago most of us died at age thirty. Today, most of us are living to seventy or eighty. There seems to be no reason why human lives couldn't be extended.

KONDRACKE: That was largely a product of public health and curing childhood diseases and so on.

TREDER: Right.

KONDRACKE: That was not basically changing human nature. You are saying that we are actually going to change human—

TREDER: Sure.

KONDRACKE: —nature through science.

TREDER: Right. One could say that we already are. I mean, you are wearing eyeglasses. Nature didn't give you those.

KONDRACKE: Right.

TREDER: People have pacemakers installed and so forth.

But what we are doing today is relatively crude. It's possible to imagine, you know, devices, medical devices that would be much less intrusive but much more effective at curing cancers or repairing damage to the body, cleaning out arteries, and so forth, that could really extend our life span.

Then you get into genetic engineering. If the genes right now are set up in such a way that our life span is limited, and—you probably are familiar with research on the telomeres, the ends of DNA strands—if those could be artificially extended, then it may be that cells wouldn't die at the normal time when they die according to nature.

There lots of different ways that we might extend life spans.

BEST: Transhumanists—transhumanism is not necessarily wedded to nanotechnology, so I think a lot of people who are interested in seeing nanotechnologies advance don't really have leanings toward transhumanism, although you might be surprised that some exceptionally bright and powerful people have adopted transhumanist views pretty strongly so.
KONDRACKE: Inaudible.

BEST: Well, Mike...?

KONDRACKE: No, I thought you might—I thought maybe Arnold Schwarzenegger was secretly dead (inaudible)

BEST: But I think people who are, you know, Nobel laureate sort of scientists, maybe their names wouldn't be familiar to the general public, but—

TREDER: But people may not know it by that name, transhumanist. I didn't until just a few years ago. But throughout most of my life, I have been interested in science and technology and, you know, how we can improve the world we live in, how we can improve ourselves.

It's essentially a natural human yearning, I believe, to make our situation and ourselves better. This is simply applying what we are learning now to go beyond what nature has given us.

KONDRACKE: Right. Now, the opponents of transhumanism would say that we are getting into Brave New World territory here—that we are going to manufacture super humans who will be one class of people, and then the rest of us will be another. I mean, I can foresee all kinds of dangers.

You can foresee them, too, I take it, but you think it is worth the risk.

TREDER: Well, progress is always worth risk, as long as it's done wisely.

But those kinds of questions really should be discussed. It would be silly to say, "Well, we don't need to think about the down side because the up side is so high." In fact, that's what our group is doing with nanotechnology.

KONDRACKE: Right.

TREDER: We believe that nanotechnology has wonderful benefits and should be pursued, but at the same time, there are also potential dangers that should be studied so that the technology should be developed responsibly.

That can be applied, not only to the field of nanotechnology, but certainly to human enhancements of whatever type they might be.

KONDRACKE: So what are the potential human enhancements that you might see as problematical for mankind?

TREDER: As you said, if there—it may be that we will develop different types of humans, some augmented in certain ways. If that's not done fairly, that is, you know, opportunities presented to more than just an elite class, that can certainly cause problems.

There's been discussion—I'm not directly involved with it, but certainly there are people who are concerned about the evolution, the artificial evolution of super-intelligence, whether on a computer or through human augmentation of our own intelligence, to the extent where an intelligence that was as much smarter than we are, as we are, say, smarter than dogs, could eventually look down on us as pets, or, you know, as zoo animals.

That all sounds far-fetched, but then many of the things we take for granted today sounded far-fetched.

KONDRACKE: (Inaudible cross colloquy) movie.

TREDER: Yeah, right.

KONDRACKE: As a matter of fact, I think the movie's been done!

(Laughter)

BEST: When I talk about nanomedicine, often times to medical audiences and more often than not to people in genetics, and since that's my home field, people are surprised. There isn't a lot of broad-based support for transhumanism. They find it, I think, a little bit creepy that you might meddle with the nature of humans.

So I think that in terms of the nanotechnologies, what we see is that nanotechnology converges with other major technologies—genetic technology, with information technology with neuroscience. When you converge those technologies, you potentially can do very powerful things, and things that maybe a lot of people would say never should be done just because they change the character of people.

But enhancements can go everywhere from drinking coffee to keep you more stimulated, wearing eyeglasses, you know, plastic surgeries for various reasons.

So enhancements range from the, you know, nearly benign or completely benign to—

KONDRACKE: The philosophic objection to this, Leon Kass's objection, who is the chairman of the President's Council on Bioethics, and Francis Fukuyama's and Charles Krauthammer's and others', is that we are going to essentially change human nature in this process. I mean, Leon Kass argues, I think, sometimes he argues it and sometimes he doesn't, that extending human life to, say, 150, will essentially change the nature of the kind of life we live.

Now, is that a concern to either of you, that human nature, that we have the capacity through nanotechnology to actually change what human life consists of?

TREDER: You know, my answer to that is it's essentially more of the same. We've been changing ourselves as humans and changing our natures, for centuries, if not for eons.

You mentioned earlier, Bob, that to try to somehow relinquish or call a halt to all development or progress in nanotechnology is essentially impossible.

Well, you can imagine, let's say, a hundred thousand years ago, if somebody said, "No, we shouldn't use fire, because fire could burn down our houses."

BEST: Well, people said it about medicine.

TREDER: Sure. Of course. We shouldn't give vaccinations, we shouldn't do heart transplants. There's all sorts of times when people have said, "No. We are going too far." This is another one of those times.

But it's, as I said, it's in the nature of human to continue improving ourselves, and our environment.

BEST: Can I just say—

KONDRACKE: Yeah. Go ahead.

BEST: —that I think those of us who don't think transhumanism is a great idea or enterprise, I think would—

KONDRACKE: And why don't you?

BEST: Because I think the human nature and the interactions we have with each other are very, very complicated things. If one were to proceed along these lines, it would seem that one would have to go very carefully and slowly.

So if you adjust the age—the longevity top by five more years, it's probably not problematic. But if you double it overnight, you can't begin to predict, because of the complex nature of human interactions and the way things work in society. How we relate to our children—

KONDRACKE: How are we ever going to monitor such a thing? I mean, would NIH not give grants to things, to studies that were heading in that direction? Is that how it would happen? And furthermore, what's to prevent Chinese scientists from discovering such a thing, and all of a sudden, it, you know, appears on the front page of the New York Times and then everyone wants it, or lots of people want it. I mean—

BEST: Mike makes a great point on this, that these technologies—I mean, where are you going to see them. We are seeing right now you can do cochlear implants for people who are hearing impaired and they can hear again. So it's an example of an enhancement. But it's a therapeutic enhancement.

The retinal sensors—there are various designs for that, but you can overcome blindness to some extent—a very limited extent right now.

So you know, what I think will happen is that we will develop therapeutic applications. There's a big gray zone where you cross from therapy. Those of us in medicine would see a clear distinction between therapy and the amelioration of disease and the lessening of suffering, compared to, say, augmentation.

So to give a child with Down's Syndrome forty extra IQ points, would, I think, not be so controversial. To give that to myself or to Mike or you know, anyone that would be listening to a broadcast of this sort—

KONDRACKE: If you can give forty more IQ points to anybody—if you can enhance intelligence, I think there is going to be an incredible demand for it.

TREDER: It sounded like what I was hearing there—please correct me if I am wrong—is I am hearing an echo of those who say that aging and death are natural and essentially shouldn't be tampered with. We shouldn't try to change ourselves in that way—that there's a natural place for aging and death.

But I think that that's a pretty easy objection to answer. I mean, polio is natural and smallpox is natural.

KONDRACKE: Right.

TREDER: And tooth decay is natural. And we (inaudible)

BEST: You know, Mike, I think I agree with you more than you realize in the sense that I really think that people—the nature of people and the nature of society and culture changes. It does.

So my argument would come in terms of the pace. I think radical changes are dangerous.

KONDRACKE: Let us do a sum up here, each of you, and it will have to be reasonably short—less than a minute each. Just answer one question quickly. Is there a nanotechnology lobby? I mean, are there associations now that are going to form to advance nanotechnology? Then go on from there to sum up your position.

Best: Surely, there are. Yes. I think wherever there's an economic interest, and there are huge economic interests in the development of nanotechnologhy, you will see lobbying—I think that's just reality.

KONDRACKE: So your fundamental position is that we have to contemplate all of the downsides in order to deal with them so that there will not be an anti-nanotechnology lobby that stops everything from happening. Is that a fair summation of your position?

TREDER: That certainly is half of it. The other half of it is we need to contemplate the upsides, and see what's the best way to accomplish that, in the safest, wisest, more responsible way as soon as possible.

KONDRACKE: And are we doing that?

TREDER: Not nearly as well as we could.

KONDRACKE: And why not?

TREDER: Partly because the technology is so new. But also because there is a business lobby, as you talked about, that has actively sort of suppressed discussion of what the long-term potential is. Partly they don't want to raise expectations too high and be seen as disappointing when they are not achieve enough in the near term.

But also because they don't want the funding stream interrupted if people are concerned about what the long-term impacts could be.

KONDRACKE: And do you think it is growing as fast as it can grow?

BEST: Well, I think more funding will make it grow faster. I think it's growing at a good pace right now, and I think as there are successes we will want to fund those and accelerate that growth.

KONDRACKE: OK.

BEST: I would say that our chief concern would be that the public interests should be concern from from the bottom up, so from the bench laboratory to the application in the surgery suite, people should be concerned with the ethical implications of any powerful technology like that. And so we are advocating for a strong public awareness, trying to develop programs that engage the public, that allow fruitful discussion and honest and open debate, and really don't give a lot of play to vested interests.

KONDRACKE: I think we have done yeoman's service in contributing to this—to understanding, at least. And to the issues involved.

So Bob Best and Mike Treder, thank you so much. We are glad you joined us, and join us next time for the next SAGECrossroads debate.

END