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Professor of Chemistry Edward Samulski
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Nano-stuff: What Is It and Will There Be Policy Implications?

Guest: Edward Samulski

Date: 06 Feb - 10 Feb 2006
Time: 9 a.m. EST (1400 GMT)
February 6 – 5 p.m. (2200 GMT)
February 10

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Edward Samulski studies very small things. His time is devoted to nanotechnology -- technology on the scale of single atoms and small molecules -- but February 6-10 he will hold an extended webchat to explain the "bigger picture" and will spend part of each day discussing and answering questions submitted by the public about nanotechnology.

Guest Biography:

Edward Samulski is a tenured professor of chemistry at the University of North Carolina at Chapel Hill (UNC) and one of five Jefferson Science Fellows who offers science counsel to the U.S. Department of State. He also serves as co-director of an initiative – the Biologically Inspired Materials Institute (BIMat) – funded by the National Aeronautics and Space Administration. At the BIMat, Samulski and other researchers strive to make advances in materials used in aerospace vehicles. The scientists are studying the work of nature, looking for clues about how they can create synthetic materials with desired capabilities.

He started his academic career at the University of Connecticut in 1972, after postdoctoral studies in the Netherlands and Texas. Samulski holds a doctorate in chemistry (Princeton University, 1970) and bachelor of science in textile chemistry (Clemson University 1965). He joined UNC in 1988 and has held visiting posititons at the Cavendish Lab, the Weizmann Institute, and the University of Paris. Samulski was also a Guggenheim Fellow at Massey University, New Zealand. His research interests include magnetic resonance in oriented soft materials (liquid crystals and polymers) and high-yield routes to semiconductor oxide nano-rods.

[Transcript follows]

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Webchat Examines Nanotechnology Emerging Role in Health, Science

USINFO Webchat transcript, February 6-10

Following is a transcript of February 6-10 online discussion with Ed Samulski, a physical chemist from the University of North Carolina currently serving as Jefferson Science Fellow at the State Department, on nanotechnology's emerging role in health, science and government:

U.S. DEPARTMENT OF STATE
Bureau of International Information Programs
USINFO Webchat Transcript

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Nano-stuff: What Is It and Will There Be Policy Implications?

Welcome to the Webchat on Nano-stuff -- an online interactive forum wherein you can submit questions about this increasingly important advance in the biological, physical and medical sciences. I am a physical chemist from the University of North Carolina spending a year in the State Department as a Jefferson Science Fellow. I look forward to sharing what I know, and I will try to get answers to questions that are beyond the scope of my expertise.

WEBCHAT MODERATOR: As moderator, I'd like to welcome you to our webchat on nanotechnology. This asynchronous chat will begin at 9am on February 6 and will continue until 5 p.m. on February 10. We encourage you to submit questions and follow-ups any time throughout the week.

Nanotechnology -- science on the scale of single atoms and small molecules -- is an exciting new topic on the international scene.

President Bush mentioned the need for developing nanotechnology in his State of the Union speech; it will soon occupy center stage in international scientific research, along with other recent issues such as biotechnology and genome exploration. Please ask questions and find out more about this emerging issue. Don't forget to HIT REFRESH in order to see updated answers

QUESTION [Poonam]: Dear Mr. Samulski, I am highly interested in pursuing a degree in Nanotechnology. I am a Post Graduate in Microbiology (Research) from Bombay University,

India, and would like to know the feasibility of registering for an online program in Nanotechnology under your able guidance. Kindly let me know the possibility of the same. With best regards, Poonam

ANSWER: Poonam, Your instincts are good: advances in nanotech will undoubtedly impact the biological sciences. But getting up to speed in this rapidly moving field is a challenge, one that does not, in my opinion, lend itself to online instruction. I think you need to enroll in a more formal postdoctoral program at an either a research university or a national laboratory in order to acquire the tools you would need to make a contribution in nanotechnology

Q [Elvin]: Do you think many other nanoscientists share your commitment to public input in the development of nanotechnology? What means are available to nanoscientists who want more public input to their work, and what means are available to members of the public who want a greater say in nanotech's development?

George Elvin, PhD, nanotechbuzz.com

A: Dr. Elvin I do think that today, by and large, scientists are more cognizant of the broader impacts of their discoveries than they were in earlier generations. Perhaps Rachel Carson's book "Silent Spring" led the way to this increased awareness. And the public's reaction, especially in Europe, to genetically modified foods is another indicator that the public must be "in the loop" as we go forward with new technologies. Your own website www.nanotechbuzz.com is an example of a contemporary means of sensitizing folks to advances in nanotechnology. And, representatives of the public respond when questions arise -- there are ongoing hearings in the Congress about nanotech-related issues. But involving the public in a meaningful way can be challenging, especially when science illiteracy is so prevalent. It is incumbent on scientists like yourself to translate discoveries into accessible formats and to separate hype from fact so that technological advances are not retarded by misconceptions.

Q [Mark]: In his State of the Union address last week, President Bush mentioned that he would like to see a greater emphasis on math and science in U.S. schools. Do you think the U.S. is losing its edge in science? Are American students and scientists the ones who will spearhead advanced technologies such as nanotech?

A: Mark, thanks for your question. I absolutely think that science and math education in K-12 education needs to be strengthened because students start to formulate career options at an early age and many are prejudiced against entering the sciences. If this trend continues we will lose our edge in science. President Bush's statement about the country's competitiveness was apparently responding to the recently released study by the National Academies, "Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future," wherein proposals for strengthening K-12 math and science education in the US are delineated. (See http://fermat.nap.edu/catalog/11463.html). If the US's well-being in a global world is intimately connected to a preeminent "Knowledge Economy" as has been suggested, then we must initiate steps outlined in that study. It is gratifying to see that this has bipartisan support.

But your question goes beyond our borders: Science is inherently collaborative on an international scale. I think a substantial part of the "American edge" in science and technology has been a result of the influx of excellent students in the sciences from other parts of the world. I also think America will "keep its edge" only with a combination of US-born and foreign-national students working together to tackle global problems we all face in the areas of energy production, clean water resources, and environmental stewardship

Q [M. Rao]: Dear Professor, Thanks for your effort in creating global attention regarding the emerging Nanotechnology. I am a doctoral student of IIT, Kharagpur, India. Though I am new to this technology, I would like to know more about its application in Agriculture. As Agriculture plays a key role in India's GDP, increasing the agricultural production is urgently needed for growing population. I am very much interested to use this technology in my area of work (Soil and Water Conservation Engineering).

My questions are:

1) How can we adopt this technology for Agricultural production?

2) Is there any university offering PostDoc positions on Nanotechnology applications in Agriculture?

3) I am an Agricultural Engineer, How can I use this technology in my field?

I would be very happy to hear from you. Thank you sir. Sincerely, M.D.Rao

A: Mr. Rao, It appears that nano could apply to agriculture in a wide range of applications from impacting fish growth with iron nanoparticles to more efficacious release of fertilizers. As this is beyond my realm of expertise, I am merely going to direct you to a website that addresses this topic. http://www.azonano.com/Details.asp?ArticleID=1331

At this early stage of agricultural applications, I think you would have to explicitly inquire about each specific research program you are considering in order to ensure that you could specialize in the nano aspects of agricultural engineering as a postdoctoral researcher

Q [Cheryl]: Given that the general public isn't very well informed about nanotechnology, what are three important things you think the public should know at this point in the technology's development and commercial application? Thanks, Cheryl

A: Cheryl, thank you for your deceptively innocuous question. The scientist in me wants to pick three technical attributes that the public should know, like the scale of nano (one billionth of a meter), the intrinsic changes in properties that well-know substances undergo at the nano-scale (gold, for example doesn't glisten and becomes an insulator), or the myriad of possibilities in the health sciences (instead of systemic oral therapies, nano-scale objects may penetrate specific cells and dump a cargo of drugs at the site where it will do the most good).

On the other hand, perhaps it is more important that the public be aware that like information

technology, nanotechnology encompasses an extremely broad range of phenomena that will impact areas as diverse as microelectronics fabrication, solar energy conversion, and medical diagnostics. Or the fact that we have been living with nano-stuff for millennia: the Egyptians used powders and make-up that contained nano-particles, and soot and smoke are comprised of nano-scale particulates. Should the public know if in fact the emperor is wearing especially new clothes? Or is the emperor (like the public) merely mesmerized by the labels on new clothes, in this case, the label "nano"?

Q [Mustapha]: Greetings Mr. Samulski, I am not a scientist but I believe Nanotechnology will contribute a great deal to science and technology. Yet I have a question: What are the "side-effects", so to speak, of Nanotechnology, if any; and to what extent would it be more profitable, rather than harmful, to the Human race? Thank you very much in advance, Mustapha

A: Mustapha, some have worried that nano-particles could penetrate cells or the blood-brain barrier. If that is the case what damage might this cause. By the same token, one asks what therapies might nano-particles enable. So the risks are inherent and probably proportional to the benefits. I don't have to tell you that there are potential "side-effects" for every technology. Many of these can be anticipated. For example, a half-century ago the scientists exploring atomic structure understood the ramifications of nuclear physics, some of which we struggle with to this day. Do the benefits of, say, nuclear energy outweigh the risks? Your answer to that question may change with time; that is, it may be different after oil stocks are exhausted.

But apart from your answer to that specific question, I think human nature compels us explore our surroundings, including risk-laden subjects such as genetic modification, nuclear fusion, stem-cells and the topic we're addressing, nano-stuff. We now have tools to manipulate atoms and build nano-scale structures. Human nature propels us to explore the consequences. Simultaneously, we are getting better at predicting risks and we must improve our ability to manage the "side-effects" of all newly discovered phenomena ultimately for the betterment of the Human race.

Q [A. Cunningham]: If one is to consider a career in facilitating nanotechnology with health care being a primary motivation, can one do so from an administrative point of view? What, in your opinion, is the best combination for an undergrad, grad, and doctoral degree? What in your estimation would make me most attractive to a research health care-oriented program?

Thank you so much for your time and consideration. Respectfully, A. Cunningham, TTU undergrad

A: Ah, advice to undergraduates, my specialty! (Actually I'm rather prejudiced on this point so, be sure to ask advice from other faculty members at TTU.) I think you will have the most credibility with an advanced degree. There are two paths to choose here: 1) a Ph.D. in one of the so-called hard sciences: Math, Physics, Chemistry or a challenging biological science. That is, I think that mastering a classical discipline is the best preparation for successfully entering an interdisciplinary field like Nano-medicine. This is especially true if you want a

top line administrative position. 2) In the health care field, some of the most sought-after people are those with the combination M.D-Ph.D. These programs are increasingly available at medical schools

Q [Joanna]: Dear Mr. Samulski, Greetings from Poland.

What are the most important directions for the future of nanotechnology research, in your opinion? Joanna

A: Joanna, thanks for participating, especially from one of my favorite countries! There is a lot of hype out there, so it's hard to decide where nano will make its most important contributions. There is good evidence that the health sciences will be one area - tailoring nano-particles for precision drug delivery. I also see exciting possibilities for exploiting the intrinsic changes in the properties of metals and alloys when their dimensions are on the nano-scale: New light-emitting-diodes (Quantum Dots), sensors and detectors exploiting the peculiarities associated with the very high surface areas of nano-clusters, etc. But I also think it is risky to make such predictions. Often the most important application comes "out of nowhere," a serendipitous discovery, an accident in the laboratory. That's what makes science so exciting in my opinion.

Q [Cheryl]: The Environmental Protection Agency held a meeting in October about the best way to regulate the very diverse field of nanotechnology. Apparently not all nanotechnology materials and products are currently regulated. What is the status of nanotechnology safety regulation? Do you think nano materials and products should have the same safety rules as, for example, foods and drugs?

A: Cheryl, I am not really conversant in the current status of regulations of things nano. I do know that there have been several reports where this aspect of nano is included (e.g., reports by the Royal Society and the Woodrow Wilson International Center). But consider the following: The FDA already regulates things smaller than nano -- drug molecules! So it seems to me as a non-expert in this domain, that extant regulations could be augmented and/or modified in order to handle nano-stuff as well. I suspect that the EPA and the FDA are actively evaluating regulation strategies with input from scientists, manufacturers and the public.

Q [Clara]: Professor Samulski, Why has interest in this industry increased so rapidly over the past few years? Have there been any breakthroughs to note over the past few years? Thanks

A: Clara, I think that a lot of the interest derives from "spin" - and I'm not talking about quantum mechanics! There is an inflated expectation that nanotechnology will solve all of our problems, and everyone wants a piece of the action. There have been fundamental breakthroughs in the laboratory. But for the most part, these remain in basic research labs and have not yet been translated into products. There are some exceptions, e.g., fluorescent nano-particles for biological imaging, nano-structures for solar conversion, and "new and improved" sun screens. The high quality basic research that is ongoing in the field is certainly stunning and you can see the results in journals like SCIENCE, NATURE and CELL.

It is certainly the case that early in the twentieth century the scientific breakthroughs were in theory -- quantum mechanics and general relativity. By contrast, now clearly the breakthroughs are in the experimental sciences because we have instrumentation that allows us to see and manipulate individual atoms. I'm not sure how one should characterize the advances in the microelectronics industry: there is the constant push for smaller devices. Some of today's devices are now nano-scale devices, but I view this more as a routine miniaturization effort by that industry as it continues to conform to Moore's Law - the apparent historical record showing that the microelectronics industry roughly doubles the number of devices on a chip every eighteen months. Some predict a bright future for nano-stuff. Mihail Roco, of the U.S. National Science and Technology Council's subcommittee on Nanoscale Science, Engineering and Technology, says "By 2015, half of the new products will be made with nano-scale science and engineering."

Q [Elvin]: Have you had a chance to look at the President's proposed 2007 budget and its allocations for nanotech research? If so, do you see any trends or areas of concern?

A: Elvin, I have not looked in any detail at the 2007 budget. I was encouraged, though, by President Bush's remarks about actively promoting and advancing new technologies, including nanotechnology. I for one certainly think we need larger investments in the basic sciences in order to protect our "intellectual security."

Q [Cheryl]: What sort of policy implications -- domestic and international -- might nanotechnology generate?

A: Cheryl, The inherently collaborative nature of science can go far in building positive international relations. Nanotechnology could be a platform for enhancing global cooperation. That said, I only have a superficial understanding of the extant policy efforts already underway on aspects of nanotechnology. Some see the glass half full and others see it half empty. You need only look at the title -- "Toxic Potential of Materials at the Nanolevel" -- of a review article in the recent issue of SCIENCE (February 3) to get a sense that warranted or not, the US in conjunction with other countries will have to deal with this class of materials. (Note: The authors of the review have used conditional modifiers -- may, might, could, possibly, etc. -- throughout in the absence of hard data on toxicity.)

Q [Ahmed]: Are there any health concerns with nanotech? How may workers potentially be exposed to nanoparticles?

A: Ahmed, certainly there are health concerns associated with nano-stuff. Meaning, we should be reasonably concerned about POTENTIAL, but as of yet unconfirmed, deleterious health consequences associated with deliberate or accidental handling or ingesting nanomaterials. Manufacturers have a lot to loose if hazards are not anticipated and minimized. See also my reply to Cheryl drawing attention to a recent review article in SCIENCE and the risk-benefits I pointed out to Mustapha.

Q [Gary]: I am a beginning science fiction writer. I enjoy speculating on upcoming technologies, and using these possible developments in my writing. What myths do you

think need to be corrected about nanotechnology in popular science fiction, and which nanotechnologies do you feel would be interesting to speculate about in future science fiction that may still be quite a few years beyond our current capabilities?

A: In order to answer your question I've turned to a physicist and an avid sci-fi reader and he tells me: "The biggest 'nanotechnology' myth I know is the 'smart virus.' I've read many stories with blood and tissue-borne ultra-micro-computer-robots that aren't anywhere near reality."

Some ideas that are close to reality and may inspire sci-fi are: (1) Nano-machine telemetry -- implantable chips to monitor temperature, pulse, blood pressure and sugar. (2) Unalterable identification chips for animals, children, demented professors! (3) Nano-meter scale sensors that detect and amplify neuronal activity and could allow an amputee to control a bionic limb or restore function. (4) Smart materials that repair themselves or adjust to their environment. A nice site to go look at for stuff like this is http://www.physorg.com/

Ed Samulski: I'm signing off now. Many thanks to all of you who submitted questions. Ed

WEBCHAT MODERATOR:

Our successful week-long chat has come to an end. We'd like to thank all of our participants for asking insightful questions. We are very grateful to Dr. Samulski as well; hopefully his answers have shed some light on the fresh, fascinating topic of nanotechnology.

For more information about upcoming webchats and to review the transcript for this chat, please see our Webchat Station. (http://usinfo.state.gov/usinfo/Products/Webchats.html).

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