Interview with Dr. Andrew Maynard

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Dr. Andrew Maynard, a world expert in nanotechnology served as the chief scientific advisor for the Project on Emerging Nanotechnologies at the Woodrow Wilson International Center for scholars. He recently moved to Michigan and is currently the director of the University of Michigan Risk Science Center. He has served on various international committees which help oversee nanotechnology and is internationally recognized as a research leader and lecturer in the fields of aerosol characterization and the implications of nanotechnology to health and the environment. He received his Ph.D. at the University of Cambridge. Follow him on his blog http://2020science.org/.

MO (Muna Oli): Hello, we're here with Dr. Andrew Maynard to discuss nanotechnology for the YSJ.

AM (Dr. Andrew Maynard): Thank you, Muna.

MO: Let's start at the basics. How would you define nanotechnology (NT) in simple terms that everyone understands?

AM: This is an impossible task. I have to say that up front. Defining NT, one of the problems we have is there is no one definition, so I always joke that if you get 10 nanotechnologists (NTists) in the same room you will get at least 20 different definitions of NT. The one that I find most helpful though is probably one from the chemist Rick Smalley, famous for his work on carbon nanotubes and fullerenes, and he used to describe NT as the art and science of making stuff that does stuff at the nanometer scale. I like it because it's vague. And one thing you begin to realize with NT is that there's very little preciseness here; it's somewhat avague and grey area. But it also captures this idea of art as well as science. So you've got the science there; things behaving in an unusual way at the nanometer scale. But then you have the art of actually using it in very creative ways. So that's the definition I usually use. But it still doesn't really help people understand what all the fuss is about, so in addition to that I try and explain what is unusual and exciting about NT using thee terms: smallness, strangeness and sophistication.

Really briefly: smallness - we all know you can do things with small objects you can't do with larger ones. Think of a car trying to get into a small space. A small car can get in; a large car cannot. You can extend that idea to the nanoscale – a scale just a little larger than atoms. You can do stuff with it you can't do at a larger scale. You can get to places you can't get to with larger materials, which might be important for treating diseases for instance.

Then think about strangeness - this is where things get weird. With some materials their properties change very radically if you start creating them with structures at the nanometer scale. The best example is perhaps gold. So you take gold. We know that gold is gold in color and doesn't corrode, which is why we use it in jewelry. But when you take that same gold and make it into particles at about 5nm in diameter, all of a sudden it changes color - it becomes red. And it becomes chemically highly reactive - very strange. That's an aspect about working at the nanoscale level that excites a lot of people. Because a lot of times they discover that they can do things they never thought they could do before. So that's a real driver and important aspect of NT: working at this level, objects behave very differently.

The third term is sophistitication. And the analogy I usually use here is that people are programmed to build things. Little kids pick up blocks from an early age. The older they get, the more sophisticated they get, and the smaller the building blocks they use. What we have now are the ultimate building blocks of nanotechnology - we can now work at the scale of atoms and molecules. So we have a high level of sophistication and that enables us to take existing technologies and make them better. Most things around us work pretty well, but don't work as well as they could because of defects at the atom level. So this new sophistication helps us to fix those imperfections. But then we can also start to create brand new technologies with this NT.

MO: How small exactly is a nanometer (nm)?

AM: The obvious answer is that a nm is just a little bit larger than a typical atom. It's hard to get a clear intuitive understanding about how small we're talking about. Even scientists find it hard. One analogy is comparing the size of an atom to something on the human scale such as a tennis ball. And it gives you an idea of what we're talking about. So you look at the difference between one nm and a tennis ball. The difference in size between those is equivalent to the difference in size between the tennis ball compared to the size of the moon. So that's the scale we're spanning. It's a huge difference in size.

MO: Why do people care about nanotechnology, where can consumers find it?

AM: If you're talking about consumers (people buying stuff), we can find it in all sorts of products. Five years ago, the organization I worked with, the Woodrow Wilson Center Project on Emerging NT, asked this question, because it was hard to find information on where people were coming in contact with NT. So we started looking at consumer products. We developed this online database of consumer products (http://www.nanotechproject.org/consumer) which now contains well over a 1000 entries and it contains everything from things like sunscreens and cosmetics to sporting goods like tennis rackets and golf clubs and even electronics, items associated with foods, etc. In almost any class of consumer products it seems, people have found out you can improve the products by using NT. To give you a sense of how broad it is, if you go out and buy sunscreen, there's a good chance that there are nanoparticles of titanium oxide in it to make it work more effectively. Or if you use an MP3 player – an iPod for instance - it does what it does because it is engineered at the nanoscale.

MO: Since it's becoming more and more common in our everyday lives, do you think that people need to be wary of it?

AM: I don't think people need to be wary of it, but it would be helpful if people were aware of it for a number of reasons. One is so people can make informed decisions, and there you have two aspects. On the one hand you have technology that very clearly can make products better, so that's something someone might want to take advantage of when buying a product. On the other hand, you have a very powerful new technology which could potentially cause harm if not used appropriately or wisely. People need to know what they're buying, what's in it, what the uncertainty surrounding the technology is and how that might be the cause of harm or benefit for the user. So yes I think that people need to be aware that NT is used in a large spectrum of consumer products but not necessarily wary.

MO: With all this talk on NT, being aware of it evokes the question is NT good or bad?

AM: NT is both good and bad. You can see there's huge potential for good applications. Think of it in terms of having a greater ability to manipulate matter and materials. Think about the big challenges faced by society at the moment. Things like access to renewable energy for instance or clean technology where you're not polluting the world. In each of these areas we could do a lot, but in every single case we run into problems where we cannot solve the challenges we face with conventional technologies. We need new ideas and innovation. We can now see where we can innovate and extend our current abilities by engineering matters at the nanometer scale. That's where NT is very exciting - helping solve important challenges. On the down side, we have to learn how to use it wisely and responsibly. Just like any other technology, it can cause harm - you have to learn how to use it so it doesn't cause harm. So back to the original question - is NT good or bad? NT has tremendous potential to be good as long as we get it right.

MO: You've been on a lot of international committees looking at regulating NT and how NT is used. Could you explain how the government and international organizations are regulating NT?

AM: One of the things we are trying to do is to work out what the challenges are ahead of time. Industry, regulators and other organizations are trying to work out how to get nanotechnology right from the get-go. This has led to interesting conversations, initiatives, etc. but there are a lot of questions that are trying to be answered. There are a lot of international initiatives going on to work out some of the problems. Representatives from many different organizations are trying to grapple with these issues. Big international standards organizations for instance, that develop consensus standards, have been looking at how they can develop standards for NT for responsible use. Similarly, the Organization for Economic Cooperation and Development (OECD) which is an organization of first world governments, is enabling governments to work together to try to understand potential barriers to developing NT responsibly, how to overcome these barriers, how nanomaterials might cause harm, and how to test and ensure their safe use. There is close collaboration with both scientists developing NT and regulators to see how you can organize and develop it safely.

MO: There's a lot of science fiction about NT taking over the world. A great example is Michael Crichton's book 'Prey'. How logical is the story? Is it possible? Will NT take over the world?

AM: NT will not take over the world in terms of science fiction like 'Prey' where nanobots self-organize and take over. It makes for a great story but it is science fiction - not science fact.

MO: What is your opinion on NT, the future of it, and where do you think it is going to take us?

AM: This is a difficult question to answer. It is going in a hundred and one directions at once. The ability to manipulate matter at that fine, fine scale will lead us to some great advances. That is without question. The more effectively we can manipulate materials at the scale of molecules and atoms, the more effectively we craft and manipulate the world around us to do things the way we would like them to be done. We're going to be seeing tremendous advances in that respect in terms of stronger and lighter materials, in terms of electronics and photonics. Then we are also getting into the world of biology - this is where it gets really interesting. People describe biology as nanotechnology that works - think of DNA and how the whole biological process works. But what we are finding now as people are getting more adept at working with materials at the nanoscale, they are beginning to interface that with biology. And that's where you have an explosive combination; people are beginning to integrate nanoscale materials with biological systems and are coming up with completely new and innovative technologies. That's definitely something to watch in the future.

MO: How can NT make people's life better?

AM: There are a number of things you can do with NT that we haven't been able to do before. One is being able to use energy more wisely and to find better ways of utilizing energy. Think about the energy crisis. We would love to be able to harness the sun's energy more effectively. We haven't been able to do it well in the past. But what we're seeing with NT is a whole suite of new technologies that allow us to do that better. One of the particularly exciting ones is printable electronics, where you can effectively create ink that contains NP and you can use something that looks similar to an inkjet printer and print electronics – including solar cells - on a variety of different surfaces. So you potentially go from a fabrication plant that costs millions of dollars to a printer that costs only 100,000's of dollars to make solar cells. And you can effectively use this technology to print solar cells onto a variety of surfaces, leading to cheap and versatile solar cells.

Another area is water purification. There are immense challenges in getting clean water to people who need it when they need it. There aren't too many solutions for providing people with clean water. So we are trying to work at the molecular scale to get rid of the stuff we don't want in the water such as dissolved salts or contaminants, and to do that with minimal energy input. This is an area where nanotechnology can have a tremendous impact.

A third area is disease treatment, especially treatment of cancer. Cancer has always been high on the radar, but we really haven't made that much progress toward treating many cancers. What we have now, is a crude set of tools. When you look at something like chemotherapy, you may treat a tumor, which is a localized cluster of cancerous cells in the body, by flooding the whole organism with toxins, and just hope that the cancerous cells die before the rest of the body does. That's very crude medicine. With NT, we can begin to target the cancer cells specifically. We can create very small "machines" that can be programmed to do multiple things. So you can take these particles and program them to seek out and attach to cancerous cells once they're in the body, let physicians know when they are in place and use them to say something about local environment. And then you can program them to respond to an external signal - in most cases to destroy cancer cells on demand. Targeting cancer cells is a significant step for getting rid of the cancer cells without harming the rest of the body.

MO: What is the role of young people in NT?

AM: One of the obvious roles is having the imagination to use this NT in novel ways. One thing we are seeing is where NT works best is where it breaks down boundaries between conventional ways of thinking. We have a problem in science where people are locked in their disciplines. But in reality the exciting innovation happens at the interface between multiple fields. Not only between scientists, but when scientists start talking to social scientists, who start talking to economists, and others in different disciplines. In NT, we're seeing the sparks where people cross those boundaries. The next generations of young people aren't necessarily constrained by those specific discipline boundaries. So as long as they are not bound, and develop or maintain an interdisciplinary outlook, I think that will be very exciting. There is only so much you can do with older generations, but if the younger generation can do stuff differently, there we can establish a foothold for combining science and NT in a totally different way.

MO: To wrap up our conversation, do you have any last thoughts and opinions to share with our readers?

AM: NT is an area which such potential yet such complexity. It's a rich area to get involved in and get excited about and can have a significant impact. It's an area I would certainly encourage everyone to be aware of and to understand what the possibilities are, but also to approach NT with an open mind. To see where the flaws are in people's thinking and more importantly to be able to transcend the idea of NT, and to start thinking about how the world and things can be different if we engineer and manipulate things at the nanoscale level, working with atoms and molecules; that's the number one thing I would say. I'd like to inspire people to think about how they can make the world a different and better place by working with this new finesse and technology.

But the other aspect of this is, don't just get wrapped up in the science and technology, but also think about what the long term consequences are to society; to people; to themselves and to their families. Consider the good consequences as well as the bad consequences. The reason I say this is that I think we're seeing a change in society where we just can't assume that, if we get science right, everything else will be right. We have to think about things in more of a holistic way. And this is just such a wonderful opportunity and a wonderful time for young people to begin to think in this alternative way, to think about how science can interface with society and how everything meshes together.

MO: Thank you Dr. Maynard for your insightful discussion and recommendations about the broad subject of NT.

About the Author

Muna Oli is a senior at Eastside High School in Florida. Aside from research, she enjoys photography, traveling, running and reading. She hopes to pursue a combined MD-PhD degree in the future.