

The Incestuous Technology Circle.

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NBIC (the coming together of the previously disparate fields of **N**anotechnology, **B**iology & medicine, **I**nformation sciences, and **C**ognitive sciences) is already bringing fascinating new things to light. As we further illuminate the nanoworld we may find that it is NBIC's effects on biology and medicine that will yield the most extraordinary insights and capabilities of all.

Consider these examples:

- **Nanowires -- biologically!**

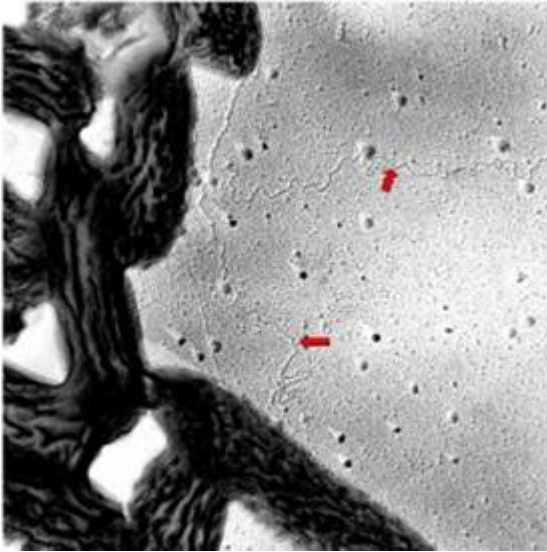
It's certainly improbable -- molecular wires that are six-times stronger than steel and superconduct current with little loss. Yet recent advances in nanotechnology have made the term Carbon Nanotube so familiar that my spell checker doesn't hiccup when I type it, and carbon nanotubes are a topic for discussion in many high schools. Some scientists are even speculating that when we learn how to make long cables out of these beasts, they should be strong enough to tether orbital "[space elevators](#)" popularized by Arthur C. Clarke.

The production of these "nanowires" is an engineering marvel. Unsurprisingly, Nature has also been experimenting towards the optimal way of doing things at the nanoscale for eons. Now that we too can work at Nature's atomic and molecular level, scientists at the University of Massachusetts led by microbiologist Derek Lovley have found a living microorganism that that builds its own three-to-five nanometers in diameter wires! And they are (relatively) long -- 1,000-times their diameter in length.

According to Dr. Lovley in the June 23, 2005 [Tom's Hard News](#),

"...microbial nanowires could be useful materials for the development of extremely small electronic devices."

The chemistry is a bit complex for many of us, but you can find an overview in the article noted above. Additional details are in the June 23, 2005 Nature and the [Geobacter Project](#) page at. But the concept is pretty simple. A particular microorganism, *Geobacter sulfurreducens*, found itself needing a better way to transport electrons out of its cell to fulfill its environmental niche. So it developed a protein that grows its nanowires (called "pilin") on demand! (See the red arrows in the picture below).



We've only recently learned to construct nanowires, but Nature has been doing this for quite some time. So it's hardly a surprise that she has much to teach us.

In a similar light, consider:

- **Viral Cameras!**

Indiana University's Bogdan Dragnea has created a "[VirusCam](#)." [I coined the phrase -- remember that if it catches on :-)].

This "VirusCam" isn't going to show up in your cell phone but it is a good demonstration of how scientists are beginning to harness tiny viruses to do our bidding.

The scientists infuse the virus with gold particles and send it off to do what a virus is so good at -- breaking into a cell. Once it's inside the living cell, a green laser shined into the cell reflects light with properties that can be analyzed to,

"...give an unprecedented picture of the chemical and physical activity in cells.

Researchers currently study living cells using a technique called Raman spectroscopy... But Raman spectra are very weak. Introducing gold nanoparticles into cells enhances the Raman signal more than fivefold, because electrons on the surface of the nanoparticle interact with and reinforce the scattered light."

Commenting on this work, Princeton virologist Lynn Enquist explores the value of such techniques:

"...Imaging individual viruses in living cells is powerful technology."

The process sounds cumbersome, and it is, but that's almost always the case for initial laboratory breakthroughs. If it proves practical and valuable, more refined techniques, and many uses, are sure to arise.

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Think about what we've just been discussing here -- scientists "taming" individual viruses to allow us to better image the workings of living cells. And our recognizing that Nature has far predated our newfound abilities to create wires at the nano-scale, which offers to teach us new ways to get "life" to build things for us at this scale.

The only reason that we've been able to pursue these directions is because the "computing" industry has had sufficient need, and resources, to dramatically improve how we can look, and work, at the nanoscale. In an incestuous circle,

- it's these very advances in nano-imaging and manipulation that enable the creation of more powerful computer chips;
- which in-turn allows us to control the tools and analyze the data that we extract from the nanosphere;
- which we then put to use in the biosphere;
- which yield new nanoscale imaging and manipulation capabilities that feed the improvement process anew!

This is why I'm so convinced that the most interesting and useful advances to be made in the foreseeable future will not come from a single field of endeavor (as has often been the case in the past), but will come from the knowledge we gain from the Convergence of many fields such as **N**anotechnology, **B**iology, **I**nformation sciences, and **C**ognitive sciences (NBIC).



What We Need.

This type of progress will certainly continue to require the innovative experts who have historically focused in narrowly defined areas. But of significantly more importance than in the past, I believe that a growing number of our new insights will come not from these "narrow experts," but from a new class of "renaissance people" whose knowledge extends beyond multiple historic boundaries (as in medicine, engineering, biology, psychology, and more).



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Our future lies with these "renaissance people" -- individuals who are adept at taking in, synergizing, and using the "many colored learnings" that are now coming to light through discoveries and insights across many different "stovepipes" of study. Encouraging this cross-field knowledge and insight in individuals poses quite a challenge for an educational system that is historically focused on depth at the expense of breadth.

How To Get There.

I suspect that it will be the educational institutions that begin to focus on producing these cross-discipline "renaissance people" that may become the "Ivy League" of tomorrow, and our national educational policies would benefit from encouraging and offering incentives for such change.

Our future national intellectual and technological and economic standing may well be at stake.

Don't Blink!

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