Scaling up: The future of nanoscience

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In the late 1950s, Richard Feynman famously imagined a science where researchers and engineers could achieve remarkable feats by manipulating matter and creating structures all the way down to the level of individual atoms.

Now, over fifty years after "There's Plenty of Room at the Bottom," four prominent researchers -- David Awschalom, Angela Belcher, Donald Eigler, and Michael Roukes -- are sharing their thoughts about the future of nanoscience and nanotechnology. In a special dialogue ahead of a Kavli Futures Symposium on the same topic, the scientists focused on how Feyman's vision may evolve in the next fifty years, beginning with taking nanoscience in an upward direction.

"We've gained some important beachheads in the science, but we've also made very little progress towards translating this toward what we all often speak of as the "full potential" of nanotechnology," said Michael Roukes, professor of physics, applied physics and bioengineering at Caltech and co-director of the Kavli Institute of Nanoscience. "Going forward, I think the challenge is to breach this chasm and... actually translate this into stuff that affects our everyday lives. …[It will be about] using the building blocks of individual atoms, molecules, individual nanostructures, and assembling them into larger-scale systems with emergent functionality that will be of great use to humankind."

Roukes explained there are many things that are very exciting about being able to control things at the atomic scale and then –- from the bottom –- "build back to the middle to creating complex systems with

just incredibly exquisite control about what these complex systems do. ...[O]ne area that's absolutely ripe for incredible advances is the life sciences and medicine, where aggregations of individual nanodevices to create nanosystems will allow us to embrace, rather than run away from, the complexity of biological systems."

These advances, stated Roukes, could "give us the tools, I believe, to understand and engineer biological circuitry… and ultimately, I think, will give a technological foundation for personalized medicine."

Donald Eigler is renowned for his breakthrough work in the precise manipulation of matter at the atomic level. Agreeing with Roukes, Eigler stated the impact of nanoscience in medicine "is going to grow dramatically over the next 10 to 20 years, especially in the field of regenerative medicine." Loosening his imagination, he could also conceive of other innovations, such as one day "hijacking the brilliant mechanisms of biology" to create functional non-biological nanosystems. "In my dreams I can imagine some environmentally safe virus, which, by design, manufactures and spits out a 64-bit adder. We then just flow the virus's effluent over our chips and have the adders attach in just the right places.

"That's pretty far-fetched stuff, but I think it less far-fetched than Feynman in '59."

Angela Belcher is widely known for her work on evolving new materials for energy, electronics and the environment. W. M. Keck Professor of Energy, Materials Science & Engineering and Biological Engineering at the Massachusetts Institute of Technology, Belcher believes the big impact of nanotechnology and nanoscience will be in manufacturing -– specifically clean manufacturing of materials with new routes to synthesis of materials, less waste and self-assembling materials. "It's happening right now, if you look at manufacturing of certain materials

for, say, batteries for vehicles, which is based on nanostructuring of materials and getting the right combination of materials together at the nanoscale. Imagine what a big impact that could have in the environment in terms of reducing fossil fuels. So clean manufacturing is one area where I think we will definitely see advances in the next 10 years or so."

David Awschalom is a professor of physics, electrical, and computer engineering at the University of California, Santa Barbara. A pioneer in the field of semiconductor spintronics, in the next decade or two Awchalom would like to see the emergence of a genuine quantum technology. "I'm thinking about possible multifunctional systems that combine logic, storage, communication as powerful quantum objects based on single particles in nature. And whether this is rooted in a biological system, or a chemical system, or a solid state system may not matter and may lead to revolutionary applications in technology, medicine, energy, or other areas." Awschalom also discussed how he expects nanoscience to transform other fields. "I believe that the broad umbrella of nanoscience is rapidly dissolving the traditional barriers [between scientific disciplines]."

More information: The complete dialogue is available at: www.kavlifoundation.org/scienc … res-symp-nanoscience

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