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Welcome at NSF

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First, I'm sure you are all interested to hear about NSF's budget. We are currently operating on a continuing resolution, at the same level of funding we had last year, or $8.1B (which was the highest budget ever for the agency). Both the House and the Senate have marked up budget bills that would give NSF even more than that, either $8.3 or $8.6B, and we are hopeful that they will come together to pass a budget to fund the government and we will be able to realize those gains. The current CR ends on Dec. 20, right before Christmas, and we are hopeful that we will have a budget by then. If not, at least another continuing resolution, instead of a shutdown.

I'm sure you've heard about NSF's 10 Big Ideas. A few years ago, these were rolled out as areas that are ripe for rapid advancement that can have significant societal impact. We have prioritized these Big Ideas in the budgets.

All the Big Ideas require collaboration across multiple disciplines, bringing together diverse expertise to address these grand challenges. Nanotechnology is present in many of the Big Ideas, such as brain-like computing for enhancing the future of work, developing faster computers for harnessing the data revolution, and developing improved sensors to help us better understand the universe. It is an important area of investment for the federal government, not only within NSF but across multiple agencies. The advances in improved materials, new sensors, and faster computers lead to significant societal benefits.

Although materials based on nanotechnology have been around forever, Nanotechnology as we now know it began more than 30 years ago, when tools to image and measure at the nanoscale became available. Around the turn of the century, government research managers in the United States and other countries observed that physicists, biologists, chemists, electrical engineers, optical engineers, and materials scientists were working on interconnected, multidisciplinary issues emerging at the nanoscale. In 2000, the U.S. National

Nanotechnology Initiative (NNI) was created to help these researchers benefit from each other's insights, accelerate technology development, and foster commercialization across disciplines. This Nano grantees conference has been going on since 2001, to allow researchers in nano to continue to share their best practices across different disciplines and learn from each other.

The foundational Big Idea is Convergence Research. When the practice of science is siloed in disciplines, it limits the potential for discovery. Nanotechnology was one of the early areas where the benefits of convergence were appreciated. In fact, Mike Roco here co-edited a book on Converging Technologies for Improving Human Performance:
Nanotechnology, Biotechnology, Information Technology and Cognitive Science

When you stop to think about it, it's not too surprising that originally, **discipline** referred to training of scholars to proper conduct and action through instruction, resulting in a set of rules. Thus, when an interdisciplinary group starts to form, some rules will be broken. This can be exciting for people who like to try new things but challenging for others.

NSF identifies convergence as having two primary characteristics: The first is deep integration across disciplines. And the second is research that is driven by a specific and compelling challenge.

It's not just taking a biologist, a geologist, and an engineer and putting them in a room together to see what they come up with — even though they may come up with some very interesting research ideas! We'd like to see teams that are addressing current national changes such as clean water, sustainable energy, or personalized medicine, that require convergent research.

We realize that brining people from different disciplines together to work on a common project requires that most precious commodity, time. Time to get to know each other, to learn to speak each other's languages, and to learn to work together. In many situations, we have been offering planning grants to give teams of researchers that valuable time that they need to work well together at the highest level. We believe that these will be effective, and of course we will evaluate the impact, as we do with so many of our activities.

As experts from different disciplines pursue common research challenges, their knowledge, theories, methods, data, research communities and languages become increasingly intermingled or integrated. New frameworks, paradigms or disciplines can form from sustained interactions across multiple communities.

Although nano is exploring at the very smallest scales, that doesn't mean that the equipment fits in a shoebox. In fact, trying to understand very small things can sometimes require very big infrastructure. Another of NSF's 10 Big Ideas is Mid-scale research infrastructure. Traditionally, NSF has funded "major research infrastructure", or MRI, up to about $6M. And we had an established process for MREFC, or Major research equipment and facility construction, or projects of $100M or more (big ships and telescopes). The gap in the middle is what we called "mid-scale", and there were projects getting funded, there just was no established process.

In 2019, we put out 2 calls for mid-scale, the first for projects between $6-20M, and the second for $20-$70M. Awards have been made for the first group, and many of them relate to nanotechnology. For example, there was the Zettawatt-Equivalent Ultrashort Pulse Laser System, National Extreme Ultrafast Science facility for producing extreme ultraviolet and soft x-ray photon energies, and the ultrahigh field 1.2 GHz nuclear magnetic resonance (NMR) spectrometer. The larger proposals are still under review. We plan to run this competition again, so if you have good ideas for shared research infrastructure that can help support convergent research in nanotechnology, be sure to write a proposal.

As nanotechnology expands to new applications, new methods will need to be developed in multiple domains of science and engineering. Convergence of nanotechnology with biotechnology, information technology, cognitive science, and artificial intelligence has the potential for unlimited progress.