

Overview of the National Nanotechnology Initiative's Education Efforts

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Director, National Nanotechnology Coordination Office

Sunday, September 13, 2020

NNCI Education Symposium

*Integration of Nanotechnology Contents with Current State-Wide
K-12 Science Curricula: Challenges and Strategies*

Virtual Event hosted by SDNI



Nanotechnology research & development spans many applications areas



Credit: NASA Jet Propulsion Laboratory



Credit: NIAID/NIH

Credit: Temple University, Lewis Katz School of Medicine



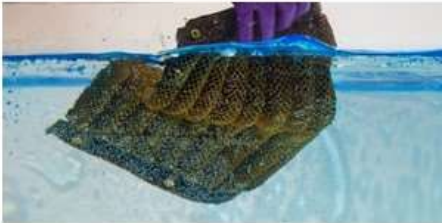
Credit: Lisa E. Friedersdorf



Credit: Randy Montoya, Sandia National



Credit: Pexels.com



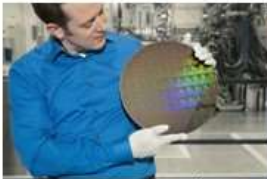
Credit: Mark Lopez, Argonne National Laboratory



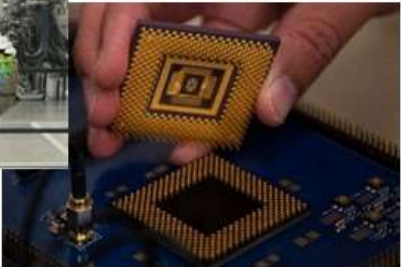
Credit: Jennifer M. McCann/Penn State



Credit: Johns Hopkins University Applied Physics Laboratory



Credit: IBM



Credit: Robert Coelius, Michigan Engineering



Credit: Joseph Xu, University of Michigan



Credit: Liang Dong, Iowa State University



Credit: Jason White, Connecticut Agricultural Research Station

Education and Workforce Efforts of the NNI



- Research Capacity
- Courses and Curriculum
- Technician Training and Targeted Workforce Development
- K-12 Students and Teachers
- Public Engagement

L. E. Friedersdorf, "Developing the Workforce of the Future: How the National Nanotechnology Initiative Has Supported Nanoscale Science and Engineering Education in the United States," in *IEEE Nanotechnology Magazine*, vol. 14, no. 4, pp. 13-20, Aug. 2020, doi: 10.1109/MNANO.2020.2994799

Research Capacity



Credit: Stony Brook University



Credit: George Mason University



Credit: UC Davis College of Engineering



Credit: UPenn (Singh Center for Nanotechnology);



Credit: NIST (SURF student with researcher)

Courses and Curriculum

Nano.gov
National Nanotechnology Initiative

Nano 101 ▾ About the NNI ▾ Networks and Communities ▾ Publications ▾ Commercialization ▾ R&D Infrastructure ▾ Educational Resources ▾ Communications ▾ Events ▾

Educational Resources / Educational Resources

Educational Resources

A highly skilled and motivated workforce with increasingly more knowledge of science, technology, engineering, and mathematics (STEM) will be required to ensure America's global competitiveness. Over the past 15 years, the Federal government has invested over \$22 billion in R&D under the auspices of the [National Nanotechnology Initiative](#) (NNI) to understand and control matter at the nanoscale and develop applications that benefit society. As these nanotechnology-enabled applications become a part of everyday life, it is important for students to have a basic understanding of material behavior at the nanoscale, and some states have even incorporated nanotechnology concepts into their K-12 science standards. Furthermore, application of the novel properties that exist at the nanoscale, from gecko-inspired climbing gloves and invisibility cloaks, to water repellent coatings on clothes or cellphones, can spark students' excitement about STEM fields.

The educational efforts of the NNI span from pre-K to gray with information ranging from that for the general public to formal lesson plans and degree programs. This section of Nano.gov provides resources for students and teachers; information about nanotechnology programs from community colleges to PhD's, a description of the growing Nano and Emerging Technologies Student Network, and links to multimedia contests, videos, and animations.

Additionally, a searchable database of nanotechnology education resources can be found at [nanoHUB.org](#).

Educational Resources

For K-12 Students

For K-12 Teachers

Associate Degrees, Certificates and Job Opportunities

College and Postdoctoral Opportunities

Resources for Nanotechnology Laboratory Safety

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Nano 101 | About the NNI | Network and Communities | Publications | Commercialization | R&D Infrastructure | Educational Resources | Communications | Events

Official website of the United States National Nanotechnology Initiative

Technician Training and Targeted Workforce Development



Credit: Penn State (Center for Nanotechnology Education and Utilization)



Credit: NACK Network/Bob Ehrmann



Credit: Montana Technological University

K-12 Students and Teachers



Workshop at NSTA NNCI/NNCO



Math Science Innovation Center



Math Science Innovation Center

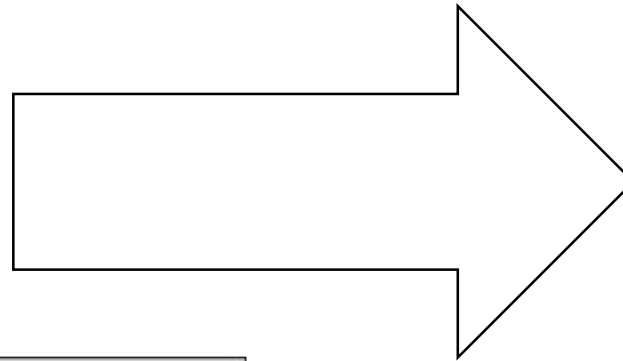
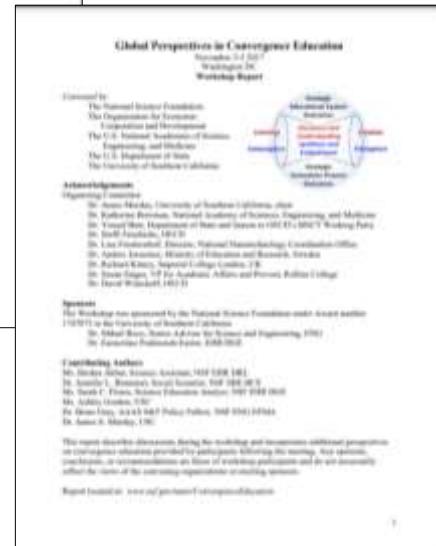
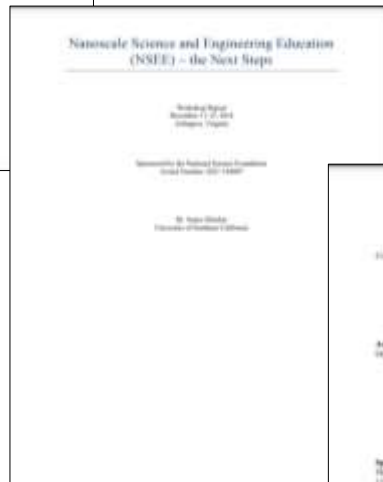


NExT, University of Virginia



Credit: International Institute for Nanotechnology/Northwestern University

Nanoscale Science and Engineering Education (NSEE)



Activity	Source	Source ID	Contributor	Year	Grade	Subject	Resource Type	Resource ID	Resource Title	Resource Description	Resource URL
1. Nanoelectrical Engineering	Source 1	Source ID 1	Contributor 1	2010	High School	Physics	Video	Resource ID 1	Nanoelectrical Engineering	Video showing the structure and function of nanoelectrical devices.	http://www.nsee.org/resources/1
2. Nanoelectrical Engineering	Source 2	Source ID 2	Contributor 2	2011	High School	Physics	Video	Resource ID 2	Nanoelectrical Engineering	Video showing the structure and function of nanoelectrical devices.	http://www.nsee.org/resources/2
3. Nanoelectrical Engineering	Source 3	Source ID 3	Contributor 3	2012	High School	Physics	Video	Resource ID 3	Nanoelectrical Engineering	Video showing the structure and function of nanoelectrical devices.	http://www.nsee.org/resources/3
4. Nanoelectrical Engineering	Source 4	Source ID 4	Contributor 4	2013	High School	Physics	Video	Resource ID 4	Nanoelectrical Engineering	Video showing the structure and function of nanoelectrical devices.	http://www.nsee.org/resources/4
5. Nanoelectrical Engineering	Source 5	Source ID 5	Contributor 5	2014	High School	Physics	Video	Resource ID 5	Nanoelectrical Engineering	Video showing the structure and function of nanoelectrical devices.	http://www.nsee.org/resources/5



Nanoeducational Resources Database

Hundreds of resources in database with columns to sort or search

- Activity (Name of the resource)
- Source
- Source URL
- Core discipline (Bio, Chem, Math, Physics, etc.)
- Grade (K- 16)
- STEM focus
- Inquiry learning
- Resource type (Teaching Aid, Interactive, Video, Lab, etc.)
- Mapped to Framework (Disciplinary Core Idea from the NRC report: A Framework for K-12 Science Education)
- NS1 (Big Idea in Nanoscience #1: Size and Scale.)
- NS2 (Big Idea in Nano #2: Structure of Matter.)
- NS3 (Big Idea in Nano #3: Forces and Interactions.)
- NS4 (Big Idea in Nano #4: Quantum Effects.)
- NS5 (Big Idea in Nano #5: Size-Dependent Properties.)
- NS6 (Big Idea in Nano #6: Self-Assembly.)
- NS7 (Big Idea in Nano #7: Tools and Instrumentation.)
- NS8 (Big Idea in Nano #8: Models and Simulations.)
- NS9 (Big Idea in Nano #9: Science, Technology and Society.)

[Educational Resources](#) / Educational Resources for K-12 Teachers

Educational Resources for K-12 Teachers

Nanotechnology is a part of various scientific disciplines, such as physics, biology, chemistry, materials science, engineering, and more. As such, it can be taught at various levels and woven into various types of STEM learning.

Based on feedback from the nanoscale science and engineering education community, the NNCO is working with nanoHUB.org to create a teacher-friendly nano education resource portal. All of the below resources (and more!) will be included in the [searchable database](#) in order to help teachers who are making nanotechnology a part of their lesson plans.



Contact us for up to 400 copies of our educational brochures for students and anyone eager to learn.

NanoLeap is specifically geared towards teaching nanoscience and technology.

Molecularium: The Molecularium® Project is the flagship outreach and education effort of Rensselaer Polytechnic Institute's Nanotechnology Center, bringing audiences worldwide into the amazing nanoscale world of atoms and molecules.

Materials World Modules: This Northwestern University project offers for purchase a series of interdisciplinary teaching modules assembled by Northwestern University on nanoscience and materials topics—including composites, ceramics, concrete, biosensors, biodegradable materials, smart sensors, polymers, food packaging, and sports materials—and supports a virtual community of module users. The modules are designed for use in middle and high school science, technology, and math classes; they have been used by more than 9,000 students in schools nationwide.

Nanolink: Nanolink, an NSF-funded project, is a collaboration between 11 educational institutions. Its goal is to promote nanotechnology education at multiple grade levels by providing comprehensive resources for students and educators. These resources are supported by hands-on educator workshops and online content and activity kits.

Nano4me: Nano4me is supported by the Nanotechnology Applications and Career Knowledge (NACK) Network at Pennsylvania State University. Through resource sharing, providing course materials, and stressing broad student preparation, they are creating and sustaining economically viable nanotechnology education across the U.S.

NanoSense: The goal of the NanoSense project is to promote the learning of science concepts that account for nanoscale phenomena. Though these concepts of nanotechnology do not represent new scientific understanding, *per se*, the characteristics and properties of substances exhibited at the nanoscale level is a relatively new focus. NanoSense is working closely with chemists, educators, and nanoscientists to generate a set of nanoscience activities to help students visualize physical, chemical, and biological principles that govern the behavior of particles on the nanoscopic scale. These materials also build on previous efforts in our NSF-funded ChemSense project.

NanoZone: NanoZone is an interactive, multimedia website run by the Lawrence Hall of Science at the University of California, Berkeley to help students from grades 2 through 7 learn about the nanoscale.

Related Resources

You can find additional, useful resources for teachers on the [K-12 Students page](#).

[Click here](#) for info on the Teaching Nano and Emerging Technologies Network.

Educational Resources

[For K-12 Students](#)

[For K-12 Teachers](#)

[Associate Degrees, Certificates and Job Opportunities](#)

[College and Postdoctoral Opportunities](#)

[Resources for Nanotechnology Laboratory Safety](#)

Collaborative Efforts: Nano Videos



Webcast: November 24, 2015
For Students in Grades 6-8

• Watch On Demand
• Watch Video Segments
• Watch on Partner Network YouTube Channel
• Order a DVD

How small is small? How can nanoscale matter improve our lives? **Innovation Workshop: Nanotechnology** explores the cutting-edge science and engineering of nanoscale matter. Nanotechnology involves manipulating and controlling matter from one nanometer to 100 nanometers. From airplanes to baseball bats, nanomaterials offer a variety of desirable properties such as strength and conductivity. Graphene and carbon nanotubes are wonder materials made entirely from carbon atoms. **Innovation Workshop** explores their structure of matter and how engineers can build with these new materials.



Students will learn about moving atoms, electron clouds, and how temperature affects matter from Joseph Strohsc at the **National Institute for Standards and Technology**. **Innovation Workshop** student reporter takes students into the National Institute for Standards and Technology's **NIST-Fall** where scientists work in a clean room to build highly structured nanoelectronic circuits. Nanoelectronics is a field of study where researchers are still creating new methods to build.

Nanotechnology is an innovation with big potential even though it's small in size. So small, it can't be seen with the human eye or even your school's microscope. In 1981, the scanning tunneling microscope (STM) launched the age of nanotechnology. It can see individual atoms and even move them to create advanced nanostructures.

Scientists use physical and chemical properties to describe and classify matter. Things like color, shape or texture can tell us about the matter and how that matter behaves. Well, nanotechnology isn't just exciting because it's small but also because of the new properties that emerge.

Nanotechnology is more than just one innovation. It's a movement that's revolutionizing the materials we build with and showcase how humans push for new ways of thinking and doing.

Standards of Learning

The content for **Innovation Workshop: Nanotechnology** was guided by National Institute of Standards and Technology staff, National Nanotechnology Coordination Office staff, FCPB curriculum specialists, and FCPB Information Technology staff.

SUGGESTED RESOURCES:

Small is Big: Discovering Nanotechnology and Its Applications Teacher's Guide and Student Workbook
A classroom resource from Fairfax County Public Schools Department of Instructional Services

Generation Next: Small Science, Superheroes
National Science Foundation & the National Nanotechnology Initiative competition to create a nanotechnology-inspired superhero.

Nanoscope
Online magazine from project of the Cornell Nanoscale Facility, and the National Nanotechnology Infrastructure Network.

Nanotechnology Resources
Rebustas from Virginia's CTE Resource Center

National Nanotechnology Initiative Classroom Resources
Teacher resources from the United States National Nanotechnology Initiative

AMSE Network



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Nanotechnology: Super Small Science

When Nature Strikes: Science of Natural Hazards

Mysteries of the Brain

Make It Memorable

Science of the NFL

Chemistry Now

Writers Speak to Kids

Science of Golf

Science of Innovation

Finishing the Dream

Parent Toolkit

Parent Toolkit en Español

Science of NHL Hockey

Science of the Summer Olympics

Science and Engineering of the 2014 Olympic Winter Games

Nanotechnology: Super Small Science

NBC Learn, in partnership with the National Science Foundation, explores the hidden world of nanotechnology, where objects are measured in the billionths of meters. If you are having trouble viewing the videos [click here](#).

Nanotechnology: Super Small Science

Showing 1-6 of 6





Nanotechnology: Nanotechnology at the Surface

Nanotechnology: Nanoelectronics

Nanotechnology: Nanoarchitecture





Nanotechnology: Nano-Enabled Sensors and Nanoparticles

Nanotechnology: A Powerful Solution

Nanotechnology: Harnessing the Nanoscale

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NanoTube - The National Nanotechnology Initiative

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Stories from the NNI

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Nano Matters

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Nano Entrepreneurship Network Podcast

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Webinars

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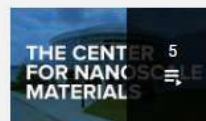
Learn about Nanotechnology!

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Student Webinars and Videos

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DOE Nanoscale Science Research Centers

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The National Nanotechnology Coordinated Infrastructure

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Perspectives on Nanotechnology

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Ideastations Animations

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Generation Nano

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NextTech

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Nano Nuggets

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Nanometer Dash!

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ACS Reactions

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2017 Nanosensor Manufacturing Workshop

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Training & Educational Videos

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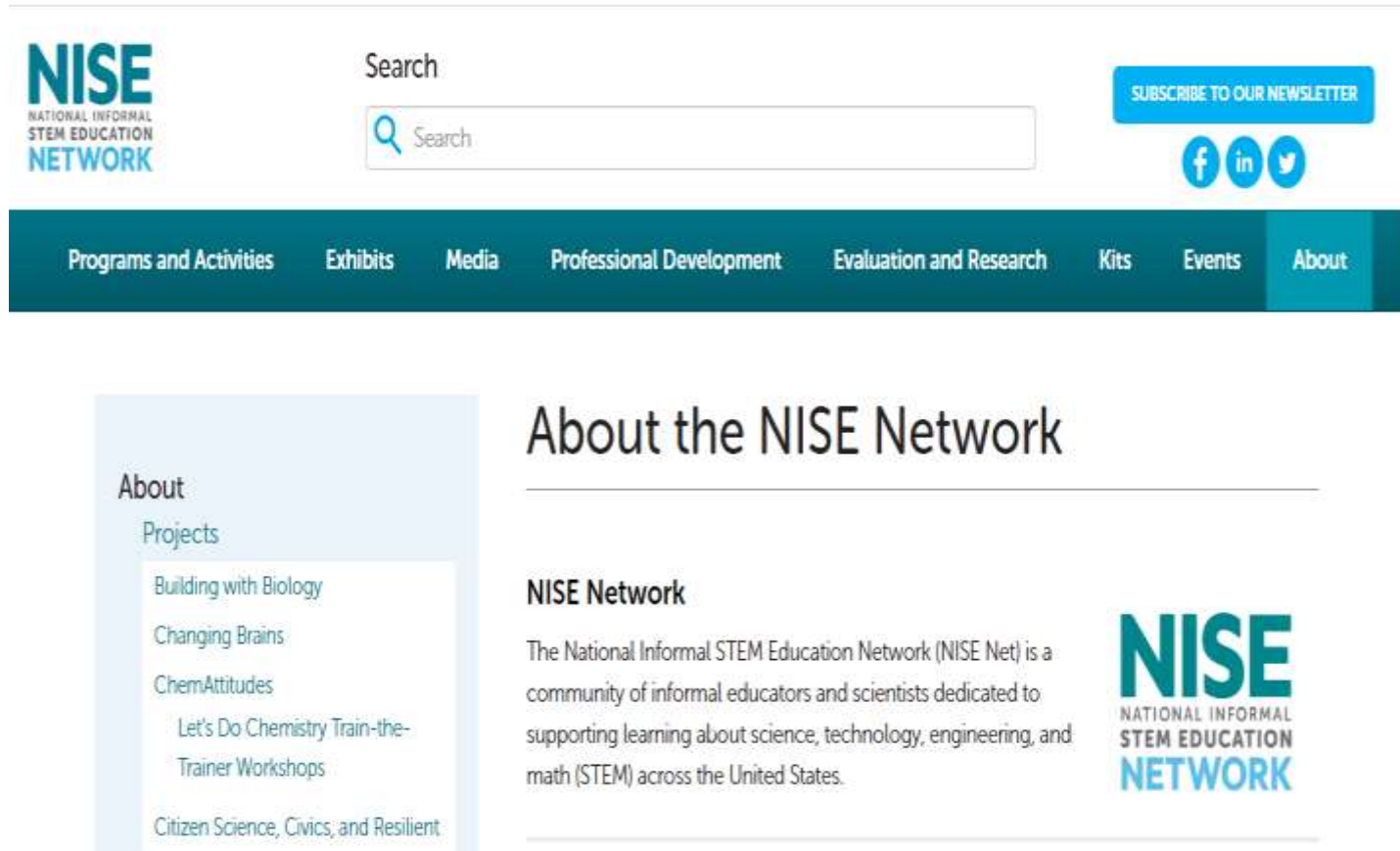
Nano Film

VIEW FULL PLAYLIST



Innovation Workshop

Public Engagement/ Informal Education



The screenshot shows the NISE Network website. At the top left is the NISE logo (National Informal STEM Education Network). To its right is a search bar with a magnifying glass icon and the word "Search". Further right is a blue button that says "SUBSCRIBE TO OUR NEWSLETTER" and three social media icons for Facebook, LinkedIn, and Twitter. Below this is a dark teal navigation bar with white text links: "Programs and Activities", "Exhibits", "Media", "Professional Development", "Evaluation and Research", "Kits", "Events", and "About". The "About" link is highlighted. The main content area has a light blue sidebar on the left with the heading "About" and a list of projects: "Projects", "Building with Biology", "Changing Brains", "ChemAttitudes", "Let's Do Chemistry Train-the-Trainer Workshops", and "Citizen Science, Civics, and Resilient". The main heading is "About the NISE Network". Below it is the "NISE Network" section, which describes the network as a community of informal educators and scientists dedicated to supporting learning about science, technology, engineering, and math (STEM) across the United States. To the right of this text is the NISE logo again.

NISE
NATIONAL INFORMAL
STEM EDUCATION
NETWORK

Search

Search

SUBSCRIBE TO OUR NEWSLETTER

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Programs and Activities Exhibits Media Professional Development Evaluation and Research Kits Events About

About the NISE Network

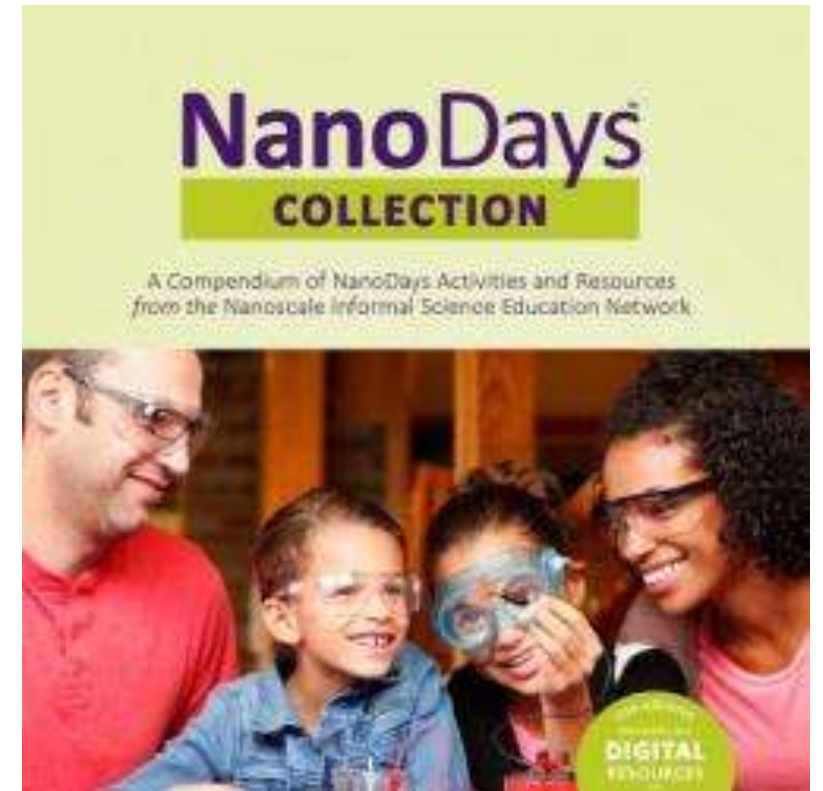
About

- Projects
- Building with Biology
- Changing Brains
- ChemAttitudes
- Let's Do Chemistry Train-the-Trainer Workshops
- Citizen Science, Civics, and Resilient

NISE Network

The National Informal STEM Education Network (NISE Net) is a community of informal educators and scientists dedicated to supporting learning about science, technology, engineering, and math (STEM) across the United States.

NISE
NATIONAL INFORMAL
STEM EDUCATION
NETWORK





Student Leaders Conference

Student Posters



Entrepreneurship & Career Panels



National Network of Student Clubs



Monthly Webinars & Phone Calls



NextTech Student Network

Nano and Emerging Technologies Student Network



New! Network-wide Webinar Series



Student Leaders Conference



National Nanotechnology Day

October 9th ($10^{-9} \rightarrow 10/9$)

How will you celebrate? Let us know!

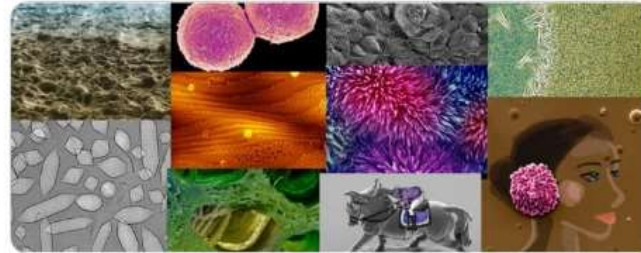
Happy Nano Day! ($10/9 = 10^{-9}$) Today we celebrate research at the nanoscale. How big is a nanometer? MIT.nano has a Nanoscale Estimator you can download; mitnano.mit.edu/news/nano-day #Nanoday



NanoTech at GA Tech @IEN_GATech · Oct 9

.@NSF_ENG Happy National Nano Day! See the amazing nano-art #photos and #vote for your favorite at the #NNCI #contest website nnci.net/plenty-beauty...

#NationalNanoDay #sciart #engineering
#WednesdayWisdom #BeautyAtTheBottom



Office of Energy Efficiency and Renewable Energy
@DOE

Happy National Nanotechnology Day! Big things are happening in small technology innovation. Learn more about our new, cutting edge, atomically precise manufacturing research projects. go.usa.gov/xVMHd
#NationalNanoDay #Nanotechnology
#NanoManufacturing



IIN at Northwestern @IINanoNU · Oct 9

In celebration of #NationalNanoDay, we're re-sharing our now famous 10 billion nanometer race video featuring IIN Director Chad Mirkin and @NorthwesternU researchers. Just how far is 10 billion nanometers? Will the runners endure?



Follow NNI on Social Media!



Twitter: @NNInanoneews

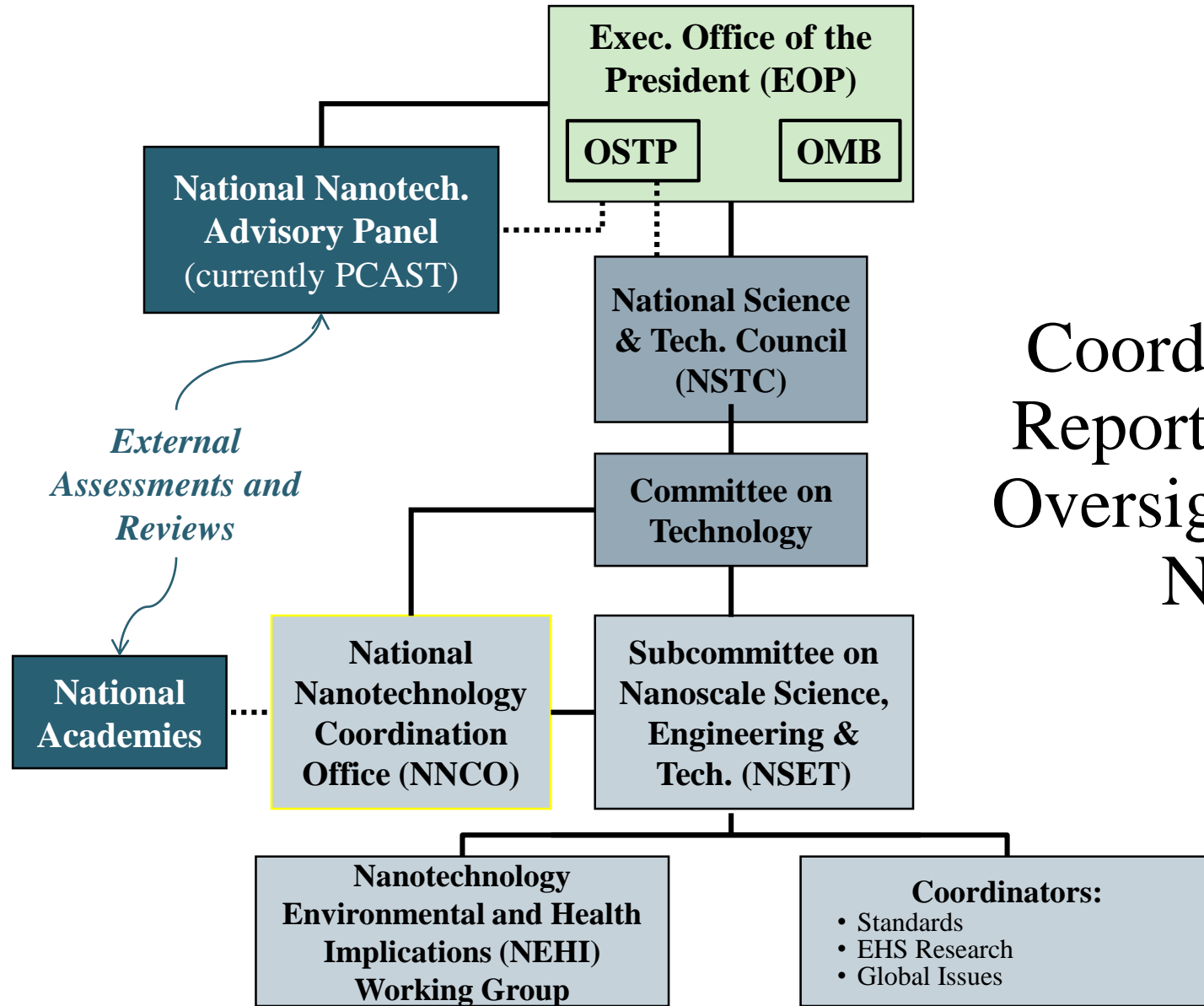


LinkedIn: National Nanotechnology Initiative

THANK YOU.

Lisa E. Friedersdorf, PhD
Director, National Nanotechnology
Coordination Office

<http://www.nano.gov/>
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Coordination,
Reporting, and
Oversight of the
NNI



NNI Webinars

NNI Public Webinar
Characterization and Quantification of Engineered Nanomaterials: Drivers of NanoEHS Research
April 9, 2019
Webinar will begin at 12 PM EDT

SPEAKER
Dr. Robert Kondilas
National Institute of Environmental Health Sciences

MODERATOR
Dr. Robert Kondilas
National Institute of Environmental Health Sciences

2019 NanoEHS Webinar Series
Evaluating Worker and Consumer Exposure to Engineered Nanomaterials
October 4, 2019
Webinar will begin at 12 PM EDT
Audio will be broadcast through your computer's speakers

SPEAKERS
Dr. Robert Kondilas
National Institute of Environmental Health Sciences
Dr. Robert Kondilas
National Institute of Environmental Health Sciences

MODERATOR
Dr. Robert Kondilas
National Institute of Environmental Health Sciences

2019 NanoEHS Webinar Series
Global Harmonization of Nanoinformatics: A Case Study in Convergence and Team Science
November 12, 2019
Webinar will begin at 12 PM EDT
Audio will be broadcast through your computer's speakers

SPEAKERS
Dr. Robert Kondilas
National Institute of Environmental Health Sciences
Dr. Robert Kondilas
National Institute of Environmental Health Sciences

MODERATOR
Dr. Robert Kondilas
National Institute of Environmental Health Sciences

STEM Resume Review
With Dr. Matthew Hull and Robert Kondilas

Nanotechnology for a new generation of gas sensors:
An industrial perspective on fundamental, applied, and commercialization aspects
National Science Foundation Engineering Center
Dr. Basilian A. Patyralis, USA Research, USA

Professional Development WEBINAR Series
Attend a FREE webinar
Wednesday, Sept. 18, 2019
4 pm EDT
Building Better Presentations
Speaker: Matthew Hull, Ph.D.

2019 NanoEHS Webinar Series
Potential Respiratory Effects of Engineered Nanomaterials in Relation to Physicochemical Properties
September 11, 2019
Webinar will begin at 12 PM EDT
Audio will be broadcast through your computer's speakers

SPEAKER
Dr. Robert Kondilas
National Institute of Environmental Health Sciences

MODERATOR
Dr. Robert Kondilas
National Institute of Environmental Health Sciences

2019 NanoEHS Webinar Series
Nanotechnology-Related Standards: Availability and Applications
July 9, 2019
Webinar will begin at 12 PM EDT
Audio will be broadcast through your computer's speakers

SPEAKERS
Dr. Robert Kondilas
National Institute of Environmental Health Sciences
Dr. Robert Kondilas
National Institute of Environmental Health Sciences
Dr. Robert Kondilas
National Institute of Environmental Health Sciences

MODERATOR
Dr. Robert Kondilas
National Institute of Environmental Health Sciences

NNI Public Webinar
Practical Applications of 15 Years of NanoEHS Research: Measurements of Potential Ecotoxicological Risk
June 11, 2019
Webinar will begin at 12 PM EDT
Audio will be broadcast through your computer's speakers

SPEAKER
Dr. Robert Kondilas
National Institute of Environmental Health Sciences

MODERATOR
Dr. Robert Kondilas
National Institute of Environmental Health Sciences