Ways of Introducing Nanotechnology Into Your Program

The NACK Center was established at the Pennsylvania State College of Engineering, and is funded in part by a grant from the National Science Foundation.

Hosted by MATEC NetWorks ***www.matecnetworks.org***

Welcome to NACK's Webinar

Today's Presenters

Center for Nanotechnology Applications and Career Knowledge (NACK)

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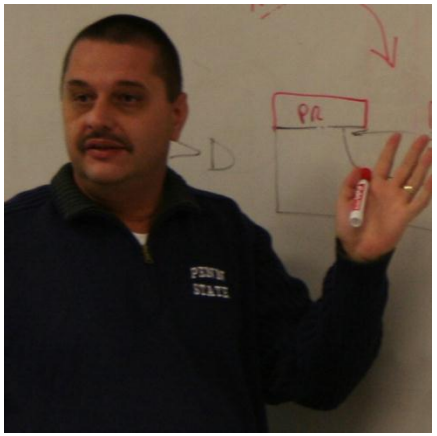

Webinar Desired Outcomes

Participant Understanding of:

- Some projections for nanotechnology workforce needs
- Some key points for nanotechnology outreach and outreach resources
- Resources and training opportunities available to educators through NACK
- Other examples of resources that are available for the integration of nanotechnology (websites, experiments, learning modules, etc.)

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FAQ 1 – The "Why" Teach Nano Question

- Please give me some data on why I should adjust (upset??) my curriculum to include nanotechnology.
  - Is nanotechnology a real trend or just a fad?
  - Will their be jobs in industry for people who get training in nanotechnology

Why Teach Nano?

"It has been estimated that the worldwide market value of **products incorporating nanotechnology** will:

- increase by 100X over the two decades

Why Teach Nano?

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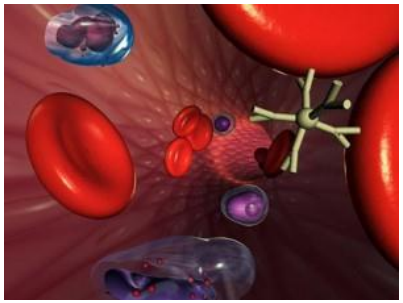
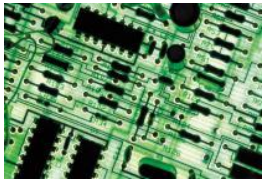
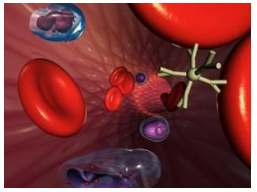
- increase by 100X over the two decades
- from about $30 billion in 2000 to about $3 Trillion in 2020





Why Teach Nano?



"It has been estimated that the worldwide market value of **products incorporating nanotechnology** will:

- increase by 100X over the two decades
- from about $30 billion in 2000 to about $3 Trillion in 2020
- .....from 0.8% of GDP to 5% of GDP…"

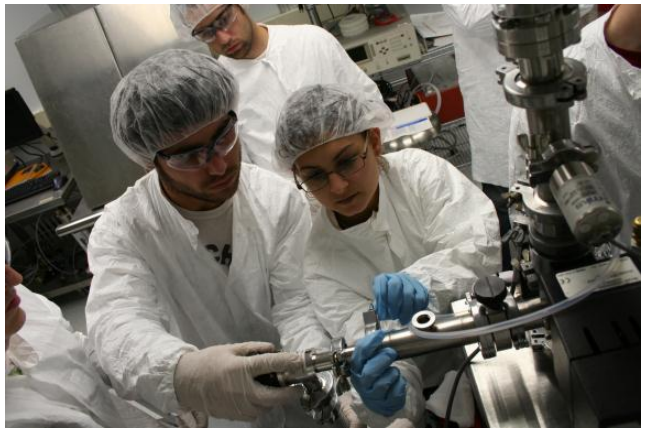
Mihail Roco, May 2011
Chemical Engineering Progress

Demand for Nanotechnology Workers

"…. promise of broad societal benefit from pursuing nanotechnology R&D…… where nanotechnology plays a key role, which would require:

- **2 million workers** with nanotechnology-related skills by 2020.

Mihail Roco
September 30, 2010



Demand for Nanotechnology Workers

"…. promise of broad societal benefit from pursuing nanotechnology R&D…… where nanotechnology plays a key role, which would require:

- **2 million workers** with nanotechnology-related skills by 2020.
- .....the rate of market increase is expected .... at a **25% increase per year**
- .... The nanotechnology markets and related **jobs** are expected to **double each three years**…."

Mihail Roco
September 30, 2010

Industries that Drive Demand

- Electronic/Semiconductor
- Biotechnology and Medical
- Pharmaceutical
- Optics/Optoelectronics
- MEMS
- Materials Design and Testing
- Food Industry/Water Purification
- Forensics
- Sales/Marketing
- University Research & Teaching
- Many More!

Job Titles for Nanotechnology Graduates

Nano in the Title … Maybe Not??

Biological Laboratory Tech.	Laboratory Tech.	Production Scientist
Biofuels Tech.	Lithography Tech.	Quality Control Tech.
Chemical Laboratory Tech.	Materials Science Lab Tech.	Research Assistant
Cleanroom Tech.	Medical Devices Tech.	SEM Operator
Deposition Tech.	Microfabrication Tech.	SPM Operator
Device Tech.	Nanobiotech Researcher	Scientist Specialist
Equipment Maintenance Tech.	Nanoelectronics Expert	Solid State Tech.
Engineering Tech.	Nanofabrication Tech.	Test Tech.
Etch Tech.	Nanotechnologist	Thin Films Tech.
Failure Analysis Tech.	Process Tech.	Vacuum Tech.

Source - NACK Alumni Committee

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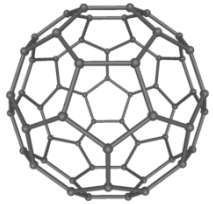
FAQ 2 – The Outreach Question

- I want to do some outreach in nanotechnology to make people aware of the impact it is having and stress some key points.
  - Where do I start?
  - What are some of the key points I should make?
  - What resources are available to me?

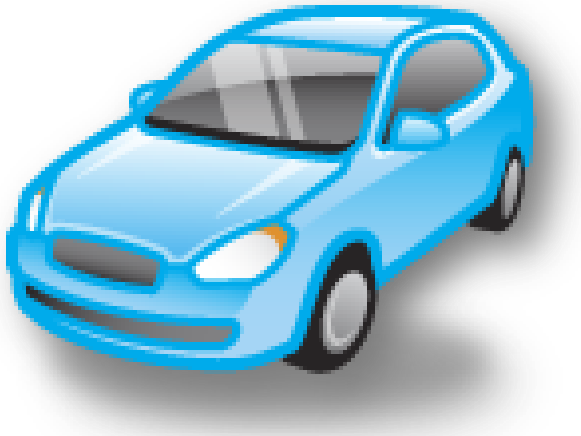
Nanotechnology is:

the creation of functional materials, devices, and systems through control of matter at the scale of *1 to 100 nanometers*, and the exploitation of novel properties and phenomena at the same scale.



A Nanometer is Very Small – so teaching scale is **important**

- Here is a you tube video that we use in our outreach to *drive* this point home



Museum of Science, Boston

A Mini Lesson:
How Small Is A Nanometer?

Museum of Science, Boston

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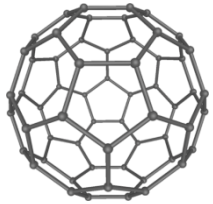
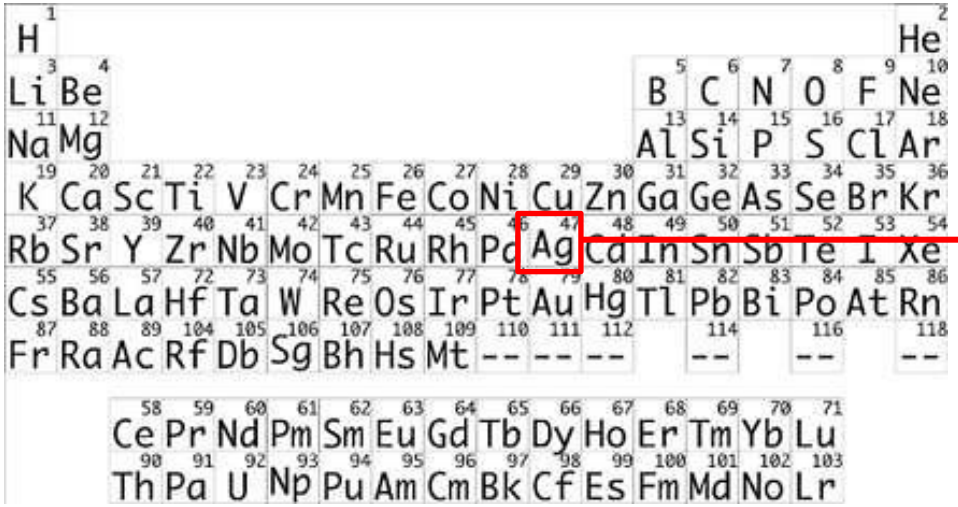


Why is Nanotechnology Different?

- Because of their size, nano-products have unique properties not found at the everyday, macro scale
  - Ex:
    - Large surface to volume ratios = high chemical reactivity
    - Same scale as light's wavelength = manipulate light
    - Same scale as cells = interaction with biological systems
- Unique properties can be tailored by adjusting the size and shape of nanoscopic components

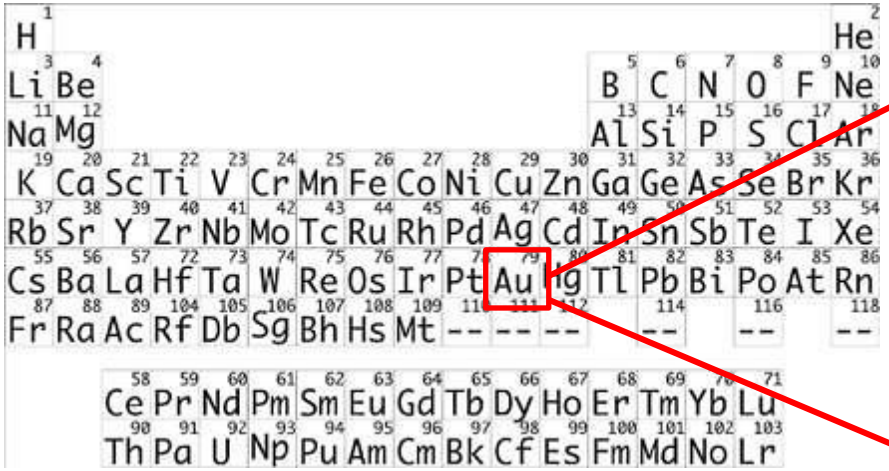
The Gold We Know:

- Material properties don't change with size.



The Gold We Are Discovering:

- Material properties (e.g. optical) change with the size of the gold nanoparticle.



Nano Gold Behaves Differently

- Each element on the Periodic Table can give us new capabilities at the nanoscale
- The periodic table is now multidimensional!

Need Helpful Web Resources?

- The Project on Emerging Nanotechnologies has kept track of the impact nanotechnology has in the economy and public and environmental health
- Searchable inventory of over 1,000 consumer products
- Funded by *Woodrow Wilson International Center for Scholars* and *The Pew Heritage Trust*

http://www.nanotechproject.org/inventories/consumer/

(included in handout)

Some Videos on Nano-Applications:

- NOVA Making Stuff Series (2011):
  - Making Stuff: Stronger
  - Making Stuff: Smaller
  - Making Stuff: Cleaner
  - Making Stuff: Smarter
- Each is one hour long

http://www.pbs.org/wgbh/nova/tech/making-stuff.html

(included in handout)

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FAQ 3 – The Integrating Nanotechnology into the Classroom Question

- I want to utilize nanotechnology to teach science or integrate modular intro to micro-nanotechnology units into my classroom or curriculum.
  - How can I personally learn more about it?
  - Where can I find some good resources to utilize in my classroom?

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NACK CENTER
Nanotechnology Applications & Career Knowledge

And Others…Can Help!!

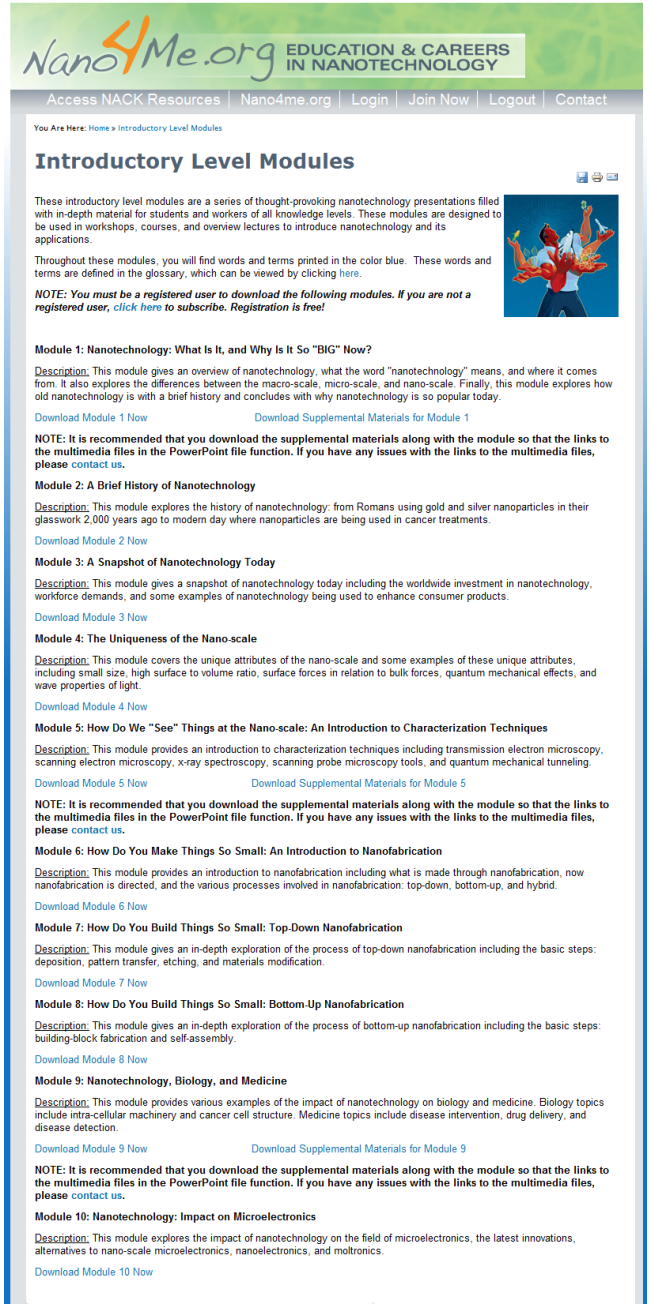
The Portal to NACK Resources

Visit:

www.nano4me.org

Introductory Level Modules

- Series of **thought-provoking** nanotechnology presentations
- In-depth material for **students** and **workers** of **all knowledge levels**.
- Designed to be used in **workshops**, **courses**, and **overview** lectures
- **Introduce nanotechnology** and its **applications**.
- Can be integrated into **secondary** and **post-secondary** curriculum as well as for **nanotechnology outreach**



Want Some More Nano Overview Information?

Try

Teacher Resources

One of the great strengths of nanoscience can also pose tough choices for teachers. Nanotechnology does not fall under one just discipline such as physics, biology, chemistry, materials science, or engineering, but all these and others. In science, technology, engineering, and math (STEM) education circles, there is an ongoing debate about nanotechnology education: Should it have its own individual curriculum? Or should nanotechnology be woven into the many scientific—and social—disciplines comprising its many elements?

Related Resources

You can find additional, useful resources for teachers on the K-12 page.

Education

- For Students K-12
- **Teacher Resources**
- Higher Education Programs
- Workforce and Training

This section won't settle that argument, but it does provide a wide variety of resources to help teachers who are making nanotechnology a part of their lesson plans.

Classroom Resources

- National Center for Learning and Teaching (NCLT) is dedicated to developing and offering nanostechnology-specific instructional modules, professional development, and a network of educator communities related to learning and teaching about the nanoscale. The website offers multiple resources across educational levels.
- NanoEd Resource Portal at Northwestern University is a rich resource for nanotechnology curriculum development and lesson plans, as well as video simulations and links for games, research, events, and news related to nanotechnology education.
- Materials World Modules 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.

Want a Nano Intro Course or Nano - Modules?

- Visit Nano-Link
- Primary mission: Provide **topical, nanoscience content** in an **easy to integrate modularized format** for high school, college educators, and industry.
- Modules:
  - Require 3 to 5 hours of class time
  - **Inclusive package of activities, experiments, background information slides, questions** and other related material.
- Tailor the modules to meet needs of your classroom.

Nano-Link
Midwest Regional Center for Nanotechnology Education

Want to Integrate into Nano Into Your Science Curriculum?

Try →

McREL — Mid-continent Research for Education and Learning
Delivering research and practical guidance to educators

Physical Science

Investigating Static Forces in Nature: The Mystery of the Gecko

Lesson 1 | Lesson 5
Lesson 2 | Lesson 6
Lesson 3 | Lesson 7
Lesson 4 | Lesson 8

NanoLeap

Entire Compilation—Lessons 1-8
+ **Physical Science Student Journals** (PDF 1.5 Mb)
+ **Physical Science Teacher Guides** (PDF, 2 Mb)

Preface
The *NanoLeap* project represents an approach for teachers to introduce the exciting world of nanoscale science and technology to their classes by integrating interdisciplinary research with traditional science concepts.
+ **Preface, Learning Objectives, Standards, & Big Ideas** (PDF 150 Kb)
+ **Materials Sheet** (PDF, 109 Kb)

Lesson 1: How Can a Gecko Walk on the Ceiling?
Students will:
- Make observations and interpretations of how the gecko's foot interacts with surfaces
- Formulate possible adhesive methods that might be considered for further investigations

+ **Teacher Guide** (PDF, 68 Kb)
+ **PowerPoint** (PPT, 373 Kb)
+ **Student Journal** (Word, 3 Mb)
+ **Tricky Feet** (WMV, 5.8 Mb)
+ **NanoSize Me** (QT, 4.7 Mb)

Lesson 2: What Do We Mean When We Speak About Surfaces in Contact?
Students will:
- Compare the amount of surface contact (real contact) to total unit area (apparent contact) at the macro level
- Understand that different textures of surfaces have different contact ratios

+ **Teacher Guide** (PDF, 55 Kb)
+ **PowerPoint** (PPT, 1.2 Mb)
+ **Student Journal** (Word, 4.6 Mb)

Chemistry

Nanoscale Materials and Their Properties

Unit 1 | Poster Assessment
Unit 2 | Unit 3

NanoLeap

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The *NanoLeap* project represents an approach for teachers to introduce the exciting world of nanoscale science and technology to their classes by integrating interdisciplinary research with traditional science concepts.
+ **Preface** (PDF 31 Kb)
+ **Teacher Resource Guide** (PDF 414 Kb)
+ **Student Handbook Student Version** (Word Doc 4 Mb)
+ **Student Handbook Teacher Version** (PDF 818 Kb)
+ **National Science Education Standards Addressed** (PDF 31 Kb)
+ **Materials Sheet** (Popup)

Unit 1: What is it?
Students will:
- Define nanoscience as the study of the fundamental principles of structures having at least one dimension lying roughly between 1 and 100 nanometers.
- Explain the importance of nanoscience research and technology.
- Evaluate the ethical considerations associated with nanoscience research and nanotechnology.
- Recognize the interdisciplinary nature of nanoscience.
- Identify the requirements of nanoscience and nanotechnology.

Lesson 1.1: What is Nanoscience?
+ **Teacher Guide** (PDF, 37 Kb)
+ **PowerPoint** (PPT, 463 Kb)

Lesson 1.2: What Makes Nanoscience So Different?
+ **Teacher Guide** (PDF, 90 Kb)
+ **PowerPoint** (PPT, 678 Kb)

Lesson 1.3: What Makes Nanoscience So Important?
+ **Teacher Guide** (PDF, 114 Kb)
+ **PowerPoint** (PPT, 535 Kb)

Want More Curriculum Integration?

Try

Want to integrate MEMS Technology? Kits?

Try →

Some Helpful Web Resources

- National Nanotechnology Institute (NNI): www.nano.gov
- Nano-Link: http://www.nano-link.org/
- NNIN.org education portal – RET lessons and more: http://www.nnin.org/nnin_k12teachers.html
- Mid-continent Research for Education and Learning McREL: http://www.mcrel.org/NanoLeap/
- SCME: http://scme-nm.net/scme_2009/index.php?option=com_docman&Itemid=53
- NCLT - Materials World Modules: http://www.materialsworldmodules.org/
- University of Wisconsin – Madison – MRSEC: http://mrsec.wisc.edu/Edetc/modules/index.html
- NanoHUB: http://nanohub.org/education/nanocurriculum/
- Molecular Workbench – http://mw.concord.org/modeler/
- NanoProfessor: www.**nanoprofessor**.net

- *Others ???* → Refer to your handout!

Faculty Development: Educator Workshops

Professional Development Opportunities

- NISE Net / Nano Days
- UCLA
- SCME Workshops & Webinars
- Nano-Link / U Minn Workshop
- SHINE – N.Seattle CC
- Ohio State (NSEC)
- Exploratorium
- NACK

NACK Introductory Educator Workshops:

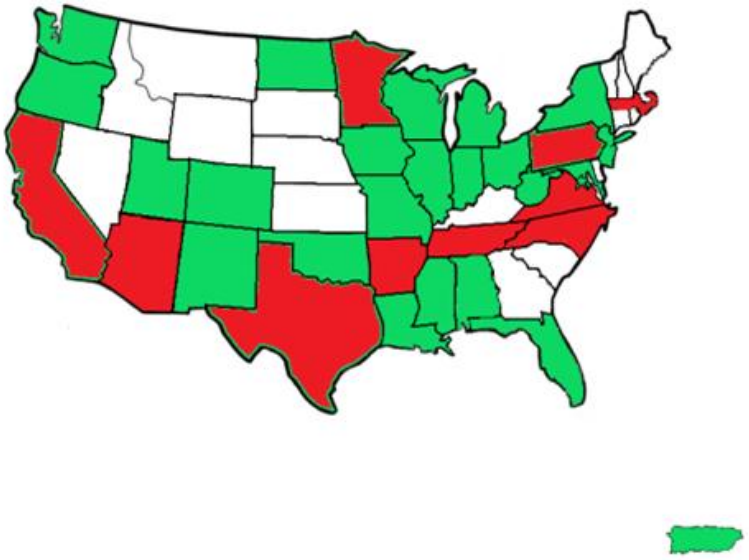
Workshop Desired Outcomes – Participant Understanding of:

- The Uniqueness of Nano-scale Materials
- How Nanotechnology is Impacting us Today
- Why Teaching Nanotechnology is Important
- Basic Nanofabrication Processing Techniques
- Nano-scale Characterization Techniques
- Basics of Clean Room Protocol
- Exposure to Some Nanotechnology Research Applications
- Educational and Career Opportunities in Nanotechnology

Educator Workshops

Attendees to Date:

- 983 Educators
- 34 States, DC, and Puerto Rico



2012 NACK Introductory Educator Workshop Schedule

- May 1-3
- Nov 13-15

Want to Learn More……
but can't get of Dodge???

Try Webinars!

NACK Webinar Series

NACK CENTER
Nanotechnology Applications & Career Knowledge

- Live monthly webinars
- Hosted by MATEC NetWorks
- Engage **and** Educate
- FREE to attend
- Recordings and slides available

Micro Nano Tech (MNT) 2012 Conference

- Produced by 5 NSF Advanced Technology Education (ATE) Centers:
  - MATEC – Arizona
  - NACK – Pennsylvania
  - Nano-Link – Minnesota
  - NEATEC – New York
  - SCME – New Mexico
- Build and foster nanotechnology communities across the country

MNT 2012 Conference – Who Attends?

Educators/Administrators who **have, will,** or **plan to** implement nano programs and/or coursework into their curriculum.

Join us!

MNT 2012 - May 7-9, 2012 @ NACK

FAQ 4: The Starting a Nano Program Question

- I’m ready to jump in with both feet and begin integrating a full program in nanotechnology
  - Where do I start?
  - What resources are available to me?

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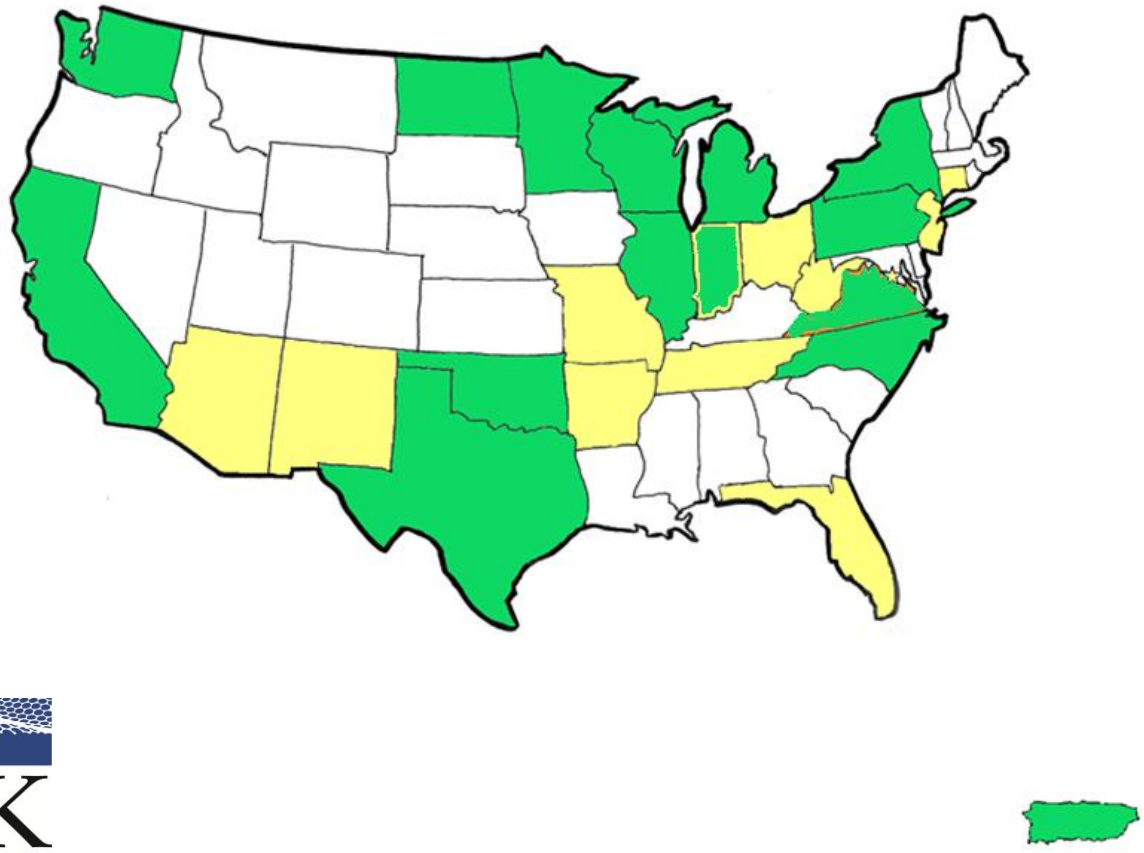
NACK CENTER
Nanotechnology Applications & Career Knowledge

Can Help!!

The Mission of NACK is to enable Nanotechnology Education at:

- 2-year Community & Technical Colleges
- 4-year Universities and Colleges in Partnership with Community & Technical Colleges

Nanotechnology Associate Degree Programs 2011 *PLUS* Works In Progress



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Nanotechnology Applications & Career Knowledge

Summary of Skill Sets Taught in the 6 Nanotechnology Courses

Basic Nanotechnology EHS Awareness

- Basics of Chemical and Material Properties—Role of Scale
- Chemical and Materials Handling, Storage, and Disposal
- Nanotechnology Health, Safety, and Environmental issues

Nanotechnology Equipment and Processing Foundation Skills

- Chemical Hoods and Glove Boxes: Use and Maintenance
- Cleanrooms: Use and Maintenance
- Pumps, Flow Control Systems, Scrubbers, Sensors: Use and Maintenance
- Vacuum Systems: Use and Maintenance
- Plasma Generating Systems: Use and Maintenance
- Furnaces, Ovens, and Rapid Thermal Annealing Equipment: Use and Maintenance
- Chemical Facilities and Maintenance
- Contamination Control
- Process Integration
- Introduction to Statistical Process Control

Nanotechnology Patterning

- Optical, e-beam, and Ion Beam Lithography
- Stamping and Imprinting Lithography
- Chemical techniques; e.g., Block co-polymer and SAMs

Nanotechnology Fabrication

- Top-down Fabrication
  - Reactive Ion, Sputter, and Wet Etching
  - Chemical Vapor and Physical Vapor Deposition Systems
  - Ion Beam, Plasma, and Chemical Materials Modification
  - Nanoparticles: Etching and Grinding Approaches
- Bottom-up Fabrication
  - Chemical, Physical, and Biological Self-Assembly
  - Nanoparticles: Colloidal Chemistry
  - Nanoparticles: Plasma Approaches
  - Nanoparticles: Chemical Vapor Deposition Approaches

Nanotechnology Characterization

- Optical Microscopy
- Scanning Probe Microscopy
  - Atomic Force Microscopy
- Electron Microscopy
  - Scanning Electron Microscopy (SEM and FE-SEM)
  - Transmission Electron Microscopy (TEM and FE-TEM)
- Chemical Characterization
  - X-ray (EDS)
  - Secondary Ion Mass Spectroscopy
  - Auger Electron Spectroscopy
  - Fourier Transform Infrared Spectroscopy
- Electrical Characterization
  - Current-Voltage Measurements
  - Capacitance Measurements
  - Opto-electronic Device Measurements
- Physical Characterization
  - Spectrophotometer
  - Profilometer
  - X-ray Diffraction

Nanotechnology Professional Skills

- Team Building
- Problem Solving
- Project Organization and Planning
- Research Skills
- Assessing Cost of Ownership
- Presentation Skills
- Technical Reporting and Documentation
- Handling and Generating Intellectual Property

NACK CENTER
WWW.NANO4ME.ORG

The Portal to NACK Resources

Visit:

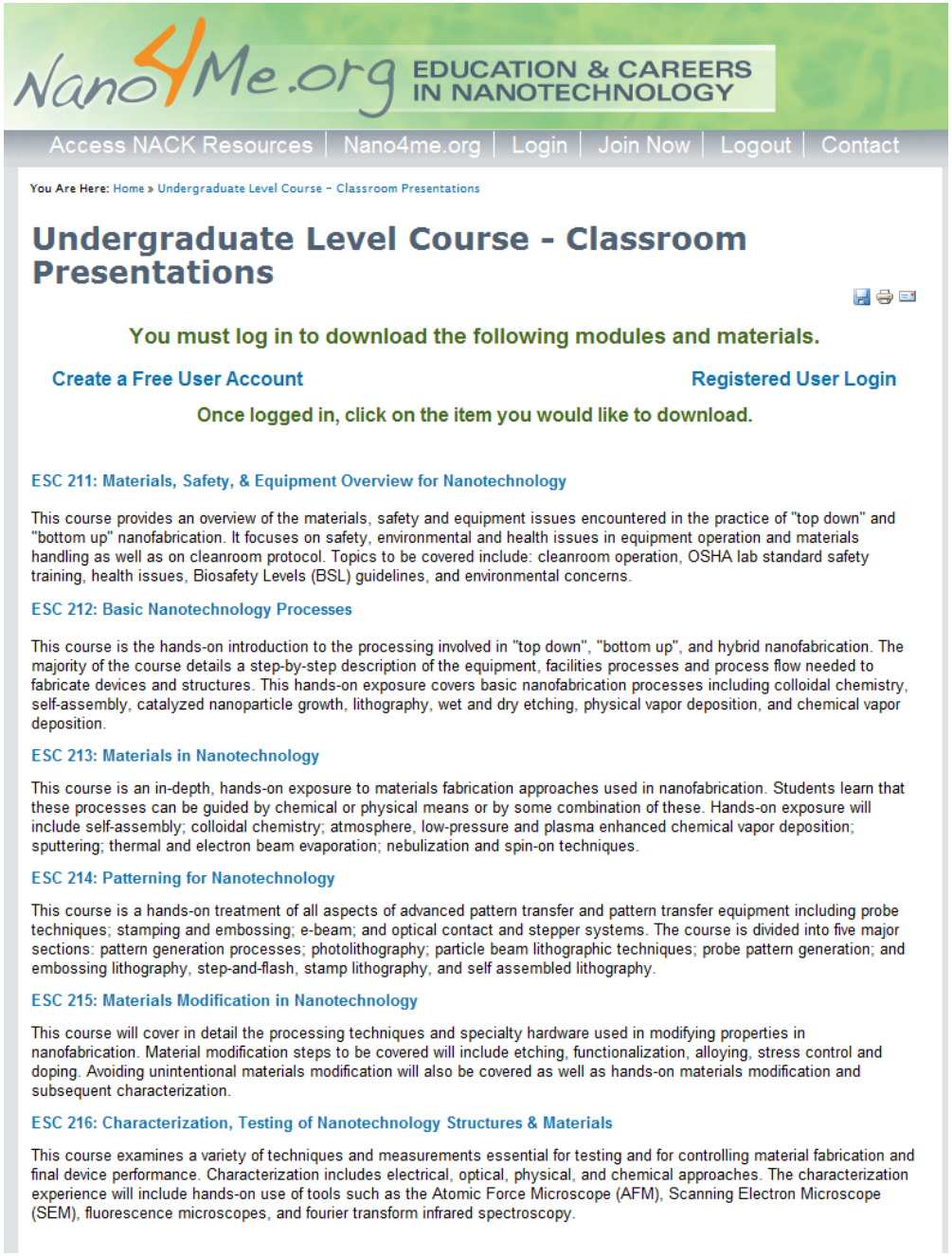
www.nano4me.org

NACK Educator Resources

- Post Secondary Resources
- Educator Workshops
- Webinars
- Remote Access to Tools
- K-12 Resources
- Interactive Multimedia

Undergraduate Level Course Material for 6 NACK Courses

- Classroom presentation material
  - Arranged in modular units
  - Videotaped lectures are now available
- Hands-on labs for the courses



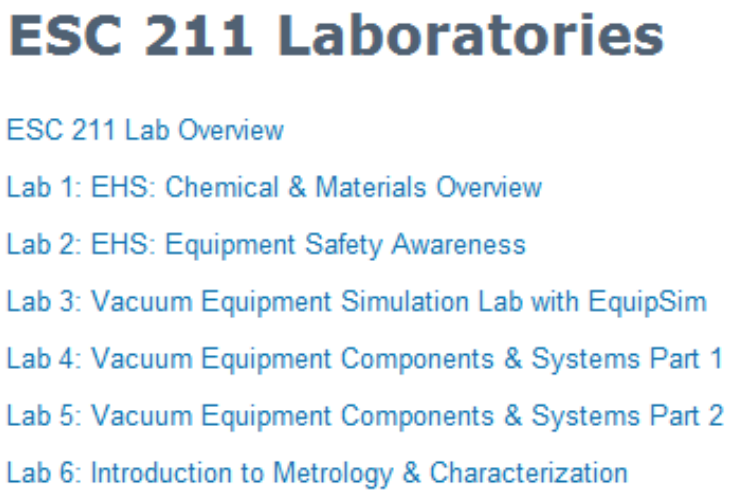
Undergraduate Level Resources: Presentations

Undergraduate Level Classroom Presentation Materials

ESC 211: Materials, Safety, and Equipment Overview for Nanotechnology

Unit Title	PDF File	PowerPoint File	Videotaped Lectures		
1. Safety and Environmental Concerns	Download	Download	Lecture 1	Lecture 2	
2. Vacuum Function, Operation and Systems	Download	Download	Lecture 1	Lecture 2	
3. Materials Overview	Download	Download	Lecture 1	Lecture 2	Lecture 3
			Lecture 4	Lecture 5	Lecture 6
4. General Processing Concerns, Contamination, and Damange	Download	Download	Lecture		
5. Basic Characterization Tools	Download	Download	Lecture 1	Lecture 2	

Laboratory Activities Available for Download:



ESC 211 Laboratories

ESC 211 Lab Overview

Lab 1: EHS: Chemical & Materials Overview

Lab 2: EHS: Equipment Safety Awareness

Lab 3: Vacuum Equipment Simulation Lab with EquipSim

Lab 4: Vacuum Equipment Components & Systems Part 1

Lab 5: Vacuum Equipment Components & Systems Part 2

Lab 6: Introduction to Metrology & Characterization

- All labs have an overview to introduce you to the core objectives
- Include sample questions to quiz students

Faculty Development: Educator Workshops

Nanotechnology Course Resources I & II Workshops (Series of 2):

Workshop Desired Outcomes – Participant Understanding of:

- Background information on NACK course and laboratory material development.
- Strategies for delivery of NACK course material
- Strategies for delivery of NACK laboratory material
- Understanding of equipment needs and costs needed for first class hands-on nanotechnology education
- Understanding of various modes available for teaching nanotechnology hands-on courses (on-site, remote, hybrid)
- Next steps plans for back home course/program development and continuous improvement of existing nanotechnology education offerings

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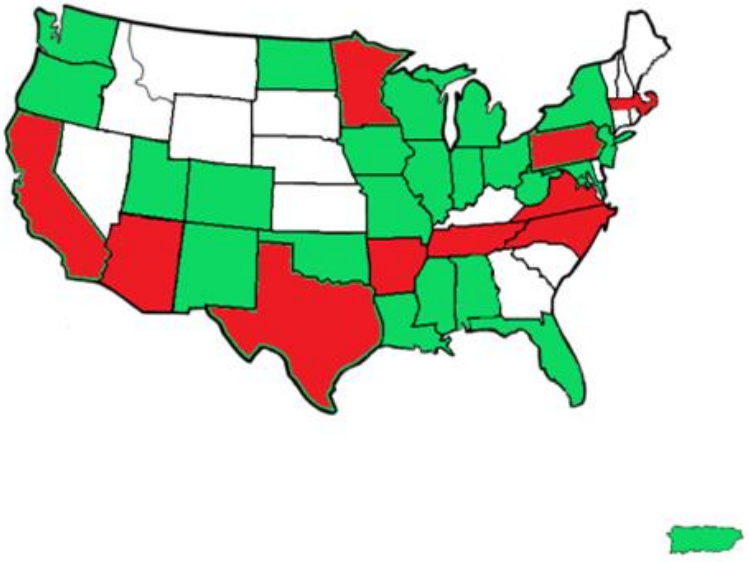

2012 NACK Course Resource Workshop Schedule

- **Apr 16-19 & Sep 17-20**
  Nanotechnology Course Resources I (***S***afety, ***P***rocessing, & ***M***aterials)
- **Aug 13-16 & Oct 1-4**
  Nanotechnology Course Resources II (***P***atterning, ***C***haracterization, & ***A***pplications)

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Nanotechnology Applications & Career Knowledge

Webinar Desired Outcomes

Participant Understanding of:

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How Can We Better Serve You?

Whether you are joining us live or watching the recorded version of this webinar, please take 1 minute to provide your feedback and suggestions.

http://questionpro.com/t/ABkVkZLohu

Webinar Recordings

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Ways of Introducing Nanotechnology Into Your Program