Resources for Learning and Teaching Nano

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This presentation will be available for viewing on:
http://nano4me.org/educator-resources
What is the PA NMT Partnership

PA Associate & Baccalaureate Students → “Hands-On” Capstone Semester @ PSU → Grads to PA Industry / Academia

Capstone Semester = 18 credit hands-on immersion experience offered at Penn State for all PA partner schools
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
With the support of the NSF ATE program, Penn State has developed a nation-wide partnership of research universities and community colleges that is bringing meaningful core-skills nanotechnology workforce education to technical and community colleges across the United States. This partnership, the NSF National Nanotechnology Applications and Career Knowledge (NACK) Network, fosters (1) resource sharing among community colleges and research universities for nanotechnology workforce development, (2) the availability of course materials, for web or in-class use, covering a core-set of industry-recommended nanotechnology skills and (3) broad student preparation for careers in the wide spectrum of industries utilizing micro- or nanotechnology. NACK has created and offers continually updated, free-of-charge core-skills course lecture and lab materials, web-accessible equipment capability, and faculty development workshop curricula. Since the inception of the nationwide effort in 2008, NACK research university-community college partnership hubs have been set-up and are functioning in Puerto Rico, New York, Indiana, Minnesota, Texas, and Washington State. Others are underway and these are in addition to the hub comprised of 30 Pennsylvania schools and funded by the State of Pennsylvania since 1998. To-date, there have been over 800 graduates from the nanotechnology core-skill classes offered by the NACK hubs, 20,881 web downloads of NACK educational materials, and 957 educators who have completed professional development workshops. The Penn State nanotechnology workforce development programs began as a Pennsylvania-focused activity with the founding of Pennsylvania Nanofabrication Manufacturing Technology (NMT) Partnership funded by the State in 1998. In 2003 the additional component of an NSF ATE regional center for nanotechnology workforce education was added. In 2008 this NSF ATE activity evolved into the NACK Network nation-wide workforce development partnership. By creating education pathways from high school to skilled manufacturing careers across the country, the NACK Network is working to train the U.S. nanotechnology manufacturing workforce.
NACK Network
Nanotechnology Education Hub Areas

A working, productive nanotechnology workforce development network involving research universities and community and technical colleges across the U.S.

- **AZ**: Central Arizona Community College, Maricopa Community Colleges, Arizona State University, MATEC - ATE Center in AZ
- **IN**: Ivy Tech Community College, University of Notre Dame
- **MN**: Dakota County Technical College, University of Minnesota
- **NY**: NEATEC - ATE Center in NY, University at Albany (SUNY)
- **PA**: NACK - ATE Center in PA, PA Community Colleges, Penn State University
- **TX**: Northwest Vista College, University of Texas
- **WA**: North Seattle Community College, University of Washington

[www.nano4me.org](http://www.nano4me.org)
Resources Developed by NACK
Integrating Nano Into the Classroom

**NEED:**
I want to utilize nanotechnology to teach science or integrate modular intro to micro- nanotechnology units into my classroom or curriculum.

**CHALLENGE:**
- How can I personally learn more about it?
- Where can I find some good resources to utilize in my classroom?
The Portal to NACK Resources

Visit: www.nano4me.org
NACK Educator Resources

Visit: www.nano4me.org/educator-resources
Undergraduate Level Course Material for 6 NACK Courses

Undergraduate Materials: Course Lectures, Videos, and Associated Labs

Packaged as six courses, each contains multiple modules and corresponding lab packages. All modules and labs can be rearranged to create new courses. Suitable for two-year degree programs, for certificate programs, and for freshman-sophomore use in four-year degree programs.

E SC 211 | E SC 212 | E SC 213 | E SC 214 | E SC 215 | E SC 216 |
Undergraduate Level Course Material for 6 NACK Courses

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

E SC 211 - Undergraduate Level Course - Classroom Presentations

Lab Mode Availability:
- "Download Template Laboratory" gives you an example of the lab as taught at Penn State;
- "Download Turnkey Laboratory" gives you a lab experience complete with video.

E SC 211: Materials, Safety, and Equipment Overview for Nanotechnology

<table>
<thead>
<tr>
<th>Unit</th>
<th>Lecture Video and PowerPoint Availability</th>
<th>Associated Laboratory Availability</th>
<th>Topics Covered</th>
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</thead>
</table>
| Unit 1 - Safety and Environmental Concerns
  Lecture 1: General Safety Awareness, Safety and Environmental Concerns | PPT | Template Laboratory | General Safety Awareness, and Wet Chemistry Safety |
  Lecture 2: Gas Safety, Biological Safety, and Nanomaterial Safety | PPT | Template Laboratory | Gas Safety, Biological Safety, and Nanomaterial Safety |
  Lecture 3: Energy, Safety, and Environmental Concerns | PPT | Template Laboratory | Energy, Safety, and Environmental Concerns |
Laboratory Activities Available for Download:

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

- Introduce nanotechnology and its applications.
- In-depth material for students and workers of all knowledge levels.
- Can be integrated into secondary and post-secondary curriculum as well as for nanotechnology outreach.

### Module 1: Nanotechnology: What Is It, and Why Is It So "BIG" Now?
**Description:** This module gives an overview of nanotechnology, what the word "nanotechnology" means, and where it comes from. It also explores the differences between the macro-scale, micro-scale, and nanoscale. Finally, this module explores how old nanotechnology is with a brief history and concludes with why nanotechnology is so popular today.

### Module 2: A Brief History of Nanotechnology
**Description:** This module explores the history of nanotechnology: from Romans using gold and silver nanoparticles in their glassware 2,000 years ago to modern day where nanoparticles are being used in cancer treatments.

### Module 3: A Snapshot of Nanotechnology Today
**Description:** This module gives a snapshot of nanotechnology today including the worldwide investment in nanotechnology, workforce demands, and some examples of nanotechnology being used to enhance consumer products.

### Module 4: The Uniqueness of the Nano-scale
**Description:** This module covers the unique attributes of the nano-scale and some examples of these unique attributes, including small size, high surface to volume ratio, surface forces in relation to bulk forces, quantum mechanical effects, and wave properties of light.

### Module 5: How Do We "See" Things at the Nano-scale: An Introduction to Characterization Techniques
**Description:** This module provides an introduction to characterization techniques including transmission electron microscopy, scanning electron microscopy, x-ray spectroscopy, scanning probe microscopy, and quantum mechanical tunneling.

### Module 6: How Do You Make Things So Small: An Introduction to Nanofabrication
**Description:** This module provides an introduction to nanofabrication including what is made through nanofabrication, how nanofabrication is directed, and the various processes involved in nanofabrication: top-down, bottom-up, and hybrid.

### Module 7: How Do You Build Things So Small: Top-Down Nanofabrication
**Description:** This module gives an in-depth exploration of the process of top-down nanofabrication including the basic steps: deposition, pattern transfer, etching, and materials modification.

### Module 8: How Do You Build Things So Small: Bottom-Up Nanofabrication
**Description:** This module gives an in-depth exploration of the process of bottom-up nanofabrication including the basic steps: building-block fabrication and self-assembly.

### Module 9: Nanotechnology, Biology, and Medicine
**Description:** This module provides various examples of the impact of nanotechnology on biology and medicine. Biology topics include intra-cellular machinery and cancer cell structure. Medicine topics include disease intervention, drug delivery, and disease detection.

### Module 10: Nanotechnology: Impact on Microelectronics
**Description:** This module explores the impact of nanotechnology on the field of microelectronics, the latest innovations, alternatives to nano-scale microelectronics, nanoelectronics, and molecular electronics.
NACK Webinar Series

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

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<tr>
<td>Friday, September 27, 2013</td>
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<tr>
<td>Presenter: Diane Hickey-Davis, Ph.D</td>
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<tr>
<td>Nanoscience Instruments</td>
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<td><strong>Nanotechnology: Needs, Risks, and Opportunities</strong></td>
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<td>Friday, November 1, 2013</td>
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<td>Presenter: Dr. Daniel J. C. Herr</td>
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<td>Professor and Nanoscience Department Chair</td>
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<td><strong>K-12 Resources in Nanotechnology</strong></td>
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<td>Presenter: Joyce Palmer</td>
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<td>Presenter: Dr. Nicholas Pinto</td>
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<td>University of Puerto Rico</td>
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Resources Developed by Others
For K-12 Teachers

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?

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

- Mid-Continent Research for Education and Learning (McREL) NanoTeach project is an NSF-funded program that combines an instructional design framework with nanoscale science content using multiple delivery methods for high school science teachers. McREL NanoLeap is specifically geared towards teaching nanoscience and technology.

- The National Nanotechnology Infrastructure Network Education Portal has useful guidelines for approaching how to integrate nanotechnology into your curriculum. The portal has a searchable database of approximately 60 K-12 lessons primarily written by teachers for teachers.

- Nanozoo is an online and print science magazine created by Cornell University as part of the education programs of the NNIN. Nanozoo has special topic print editions which teachers may download or order from NNIN.

Contact us for up to 400 copies of our educational brochures for students and anyone eager to learn.
• Resources in Technology and Engineering include:
  – NanoExperiences
  – NanoTeach
  – NanoLeap
NanoExperiences

Explore All the Awesome Possibilities: Nanoscience & Technology

FOR STUDENTS
Student website & more

FOR PARENTS
Information for parents

FOR MENTORS
Tools & resources

Want to... Learn cool stuff with friends in new and different ways? Be on your way in a well-paying career by 21? Make a difference in your community? NanoEx is for YOU!
NanoTeach

Integrating Nanoscience and Technology into the High School Curriculum

The NanoTeach project is breaking new ground by developing and testing professional development that combines an instructional design framework with nanoscale science content using multiple delivery methods for high school science teachers.
NanoLeap

Physical Science

Investigating Static Forces in Nature: The Mystery of the Gecko

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

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, 58 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
Unit 2
Unit 3
Poster Assessment

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 (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, 578 Kb)

Lesson 1.3: What Makes Nanoscience So Important?
+ Teacher Guide (PDF, 114 Kb)
+ PowerPoint (PPT, 535 Kb)
National Nanotechnology Infrastructure Network (NNIN)
## Nano Curriculum Materials (K-12)

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<tr>
<th>MODULE</th>
<th>LEVEL</th>
<th>SUBJECT AREA</th>
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<td>Small Scale Sculpting</td>
<td>Middle School</td>
<td></td>
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<tr>
<td>Small Scale Stenciling</td>
<td>High School</td>
<td></td>
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<tr>
<td>Making a Liquid Crystal Thermometer</td>
<td>Adult</td>
<td></td>
</tr>
<tr>
<td>Is measuring an art or a science?</td>
<td></td>
<td>Environmental Science</td>
</tr>
<tr>
<td>Powers of Ten with the Blue Morpho Butterfly</td>
<td></td>
<td>General Science</td>
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<tr>
<td>Lines on Paper</td>
<td></td>
<td>Physics</td>
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<tr>
<td>Nanotechnology Invention and Design: Phase Changes, Energy, and Crystals</td>
<td></td>
<td>Biology</td>
</tr>
<tr>
<td>Synthesis and Characterization of CdSe Quantum Dots</td>
<td></td>
<td>Chemistry</td>
</tr>
<tr>
<td>Taking a Closer Look at Objects</td>
<td></td>
<td>Tools and Technology</td>
</tr>
<tr>
<td>Wet Etching in Nanofabrication</td>
<td></td>
<td>Science and Society</td>
</tr>
</tbody>
</table>
NCLT – Materials World Modules

• Nanotechnology Center for Learning and Teaching (NCLT)
• MWM – products designed by NCLT partners to integrate into classroom curricula
whatisnano.org
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)
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 Charitable Trusts

http://www.nanotechproject.org/inventories/consumer/
(included in handout)
Want to integrate MEMS Technology?

www.scme-nm.org
SHINE – Based in Seattle, WA
SHINE Materials Include:

- Learning objectives
- Applications
- Material list
- Student Lab

And more!

To receive login information for the site, please email shine@northseattle.edu
Nano-Link – Based in Rosemount, MN

Educator Training
The Nano-Link consortium has trained instructors ready to come to your school district or area to help instructors learn how to integrate nanotechnology concepts and experiments into their curriculum. Learn more about our Educator Workshops, and see if we can help you bring a workshop to your area!
Nano-Link Materials Include:

• 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.
NEATEC – based in Albany, NY
Some Additional Web Resources

- Nano-Link: [http://www.nano-link.org/](http://www.nano-link.org/)
- NNIN.org education portal – RET lessons and more: [http://www.nnin.org/nnin_k12teachers.html](http://www.nnin.org/nnin_k12teachers.html)
- NanoHUB: [http://nanohub.org/education/nanocurriculum/](http://nanohub.org/education/nanocurriculum/)
Resources for Educators
To engage today’s learners we need to:

• Present content and information in different ways

• Provide multiple means of engagement

• Universal Design for Learning: http://www.cast.org/udl/
Universal Design for Learning

**Recognition Networks**
The "what" of learning

- How we gather facts and categorize what we see, hear, and read. Identifying letters, words, or an author's style are recognition tasks.

**Strategic Networks**
The "how" of learning

- Planning and performing tasks. How we organize and express our ideas. Writing an essay or solving a math problem are strategic tasks.

**Affective Networks**
The "why" of learning

- How learners get engaged and stay motivated. How they are challenged, excited, or interested. These are affective dimensions.
Objectives

• Help students grasp concepts in nanotechnology through multimedia:
  – Animations
  – Interactives
  – Video
  – Simulations/emulations

• And, how do we blend these in?
Rationale for Use

• **Complexity**
  – Hard to visualize, analyze or explain

• **Variable**
  – If a system is variable with respect to time or process

• **Interdependency**
  – Multiple inter-dependent variables
And sometimes...

You just want to show something in a different way
Multimedia Possibilities

• Show:
  – Animations
  – Interactives
  – Video

• Do:
  – Simple simulations
  – Complex simulations and emulations
Nanotechnology Animation Gallery

nanoHUB - https://nanohub.org/resources/8882
Nanomaterials for Energy Efficiency

http://www.youtube.com/watch?feature=player_embedded&v=-WQ28DJWhZk#!
Spanish Language Videos on Nanotechnology

http://www.nanodyf.org/multimedia.php
nanoHub – Purdue University
Powers of 10

http://www.youtube.com/watch?feature=player_embedded&v=0fKBhvDjuy0#!
NACK Network Multimedia

Multimedia

A collection of interactive multimedia in nanotechnology. These resources are suitable for a variety of levels and subject areas.

NACK Animations

Other Resource Center Nanotechnology Animations

MATEC NetWorks

The Deposition Process
This animation shows the chemical vapor deposition process.

The Diffusion Process
This animation shows the diffusion process.

Dressing for Work in the Cleanroom-Video
A video is presented in which a technician at a semiconductor fab explains the gowning procedure she uses at work. (70mb file)

The Etch Process
This animation shows the plasma etching of silicon dioxide. In this type of plasma etching, Chlorine gas and Argon gas mixture is used.

How a Plasma Etcher Works
This animation shows how a plasma etcher works.

Ion Implant
This animation shows an overview of the ion implant process.

Bourdon Tube Gauge
This animation shows the workings of a Bourdon tube gauge.

Five Stages of Flow
This animations shows the stages that molecules go through as they move from the turbulent stage of viscous flow, transition into laminar flow, and then transition again into molecular flow.

http://nano4me.live.subhub.com/categories/multimedia
## Animations

### PROCESS & EQUIPMENT I

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<tr>
<th>Title</th>
<th>Description</th>
<th>Objective</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>How a CMOS Device Works</td>
<td>An animation of how a CMOS device Works.</td>
<td>Identify the required electrical variables that allow a CMOS device to operate.</td>
<td>Launch iPod / iPhone video</td>
</tr>
<tr>
<td>n-Channel Enhancement MOSFET Characteristic Curves</td>
<td>This is an animation of a n-Channel Enhancement MOSFET Characteristic Curves.</td>
<td>Determine the active non-active operation regions of an n-Channel MOSFET gate.</td>
<td>Launch</td>
</tr>
<tr>
<td>The Making of the CMOS Microchip</td>
<td>How a CMOS Microchip is made.</td>
<td>Determine the process steps needed to complete a CMOS device.</td>
<td>Launch</td>
</tr>
<tr>
<td>The Deposition Process</td>
<td>An animation of the chemical vapor deposition process.</td>
<td>Identify the process of chemical vapor deposition.</td>
<td>Launch</td>
</tr>
<tr>
<td>Workflow in the CVD Tool</td>
<td>Animation of Workflow in the CVD Tool.</td>
<td>The steps in the CVD process cycle will be a unique step in the recipe. There may be more steps, or minor variations, but most CVD process recipes will look very similar.</td>
<td>Launch</td>
</tr>
</tbody>
</table>

[www.matec.org/animations](www.matec.org/animations)
Thank You!

Want to know more? Contact:

michael.lesiecki@domail.maricopa.edu
xaxiri.yamane@domail.maricopa.edu

This presentation will be available for viewing on:

http://nano4me.org/educator-resources