Resources for Learning and Teaching Nano

Presenters:

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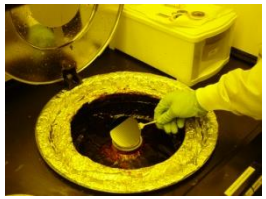
Maricopa Community College District – Phoenix, AZ

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

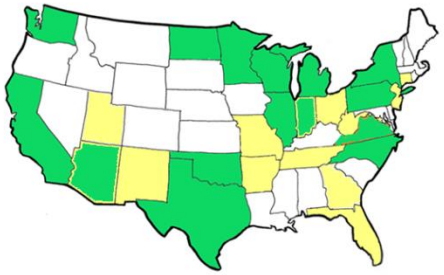
Grads to PA Industry / Academia

Capstone Semester = 18 credit hands-on immersion experience offered at Penn State for all PA partner schools

What is NACK?

NACK NETWORK
Building College-University Partnerships for Nanotechnology Workforce Development

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

PCAST Report (April, 2012, page 12)

REPORT TO THE PRESIDENT AND CONGRESS ON THE FOURTH ASSESSMENT OF THE NATIONAL NANOTECHNOLOGY INITIATIVE

Workforce Development


Courtesy NACK Center

With the support of the NSF's Advanced Technology Education (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 nationwide 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.

"With the support of the NSF ATE program, Penn State has developed a nation-wide partnership of research universities and community colleges that is bring meaningful core-skills nanotechnology workforce education to technical and community colleges across the United States……"

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.

Dakota County Technical College
University of Minnesota

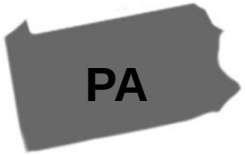
University of Puerto Rico, Humacao

Central Arizona Community College
Maricopa Community Colleges
Arizona State University
MATEC - ATE Center in AZ

NEATEC - ATE Center in NY
University at Albany (SUNY)

Northwest Vista College
University of Texas

Ivy Tech Community College
University of Notre Dame



NACK - ATE Center in PA
PA Community Colleges
Penn State University

North Seattle Community College
University of Washington

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?

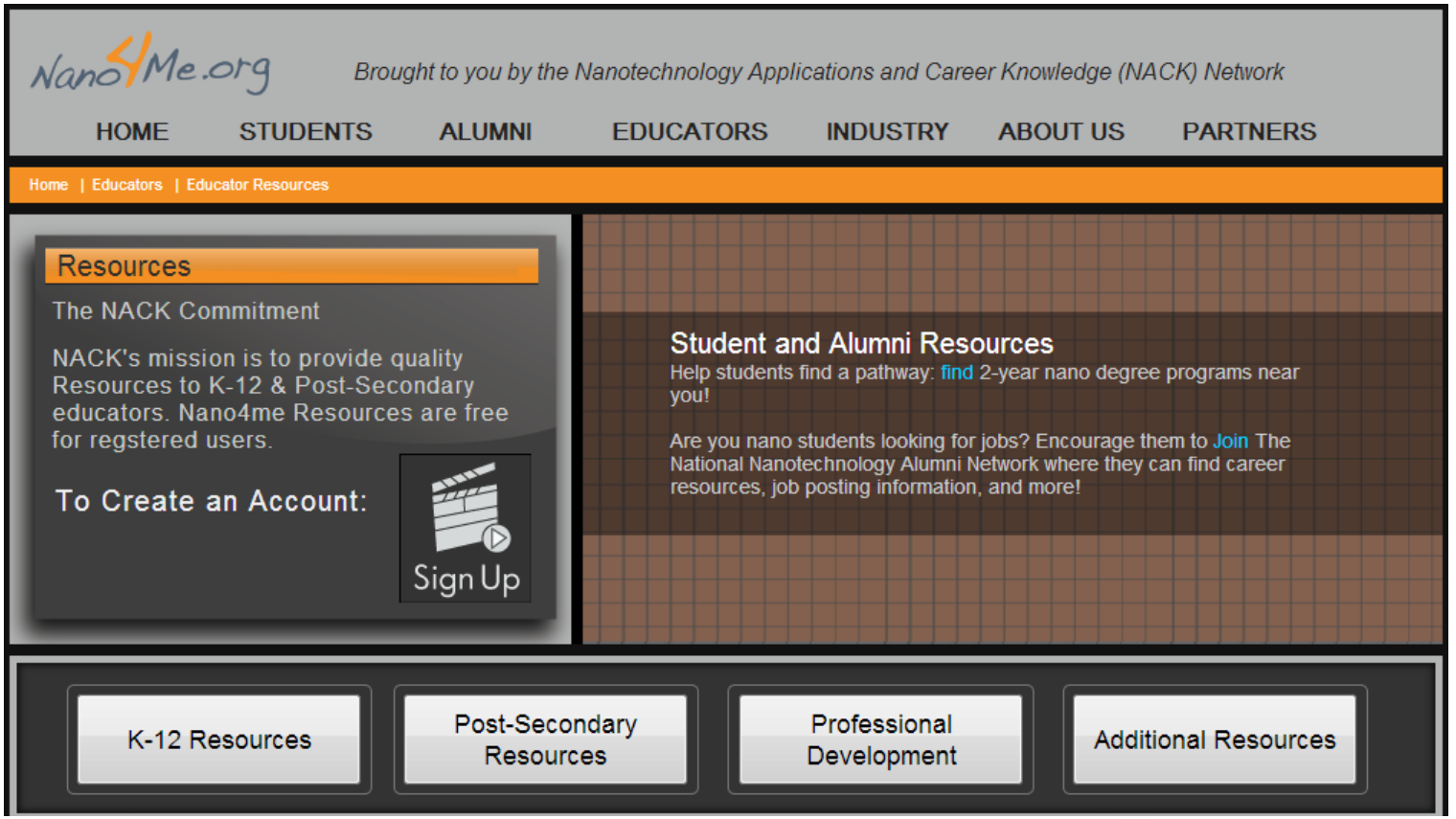
The Portal to NACK Resources

Visit:

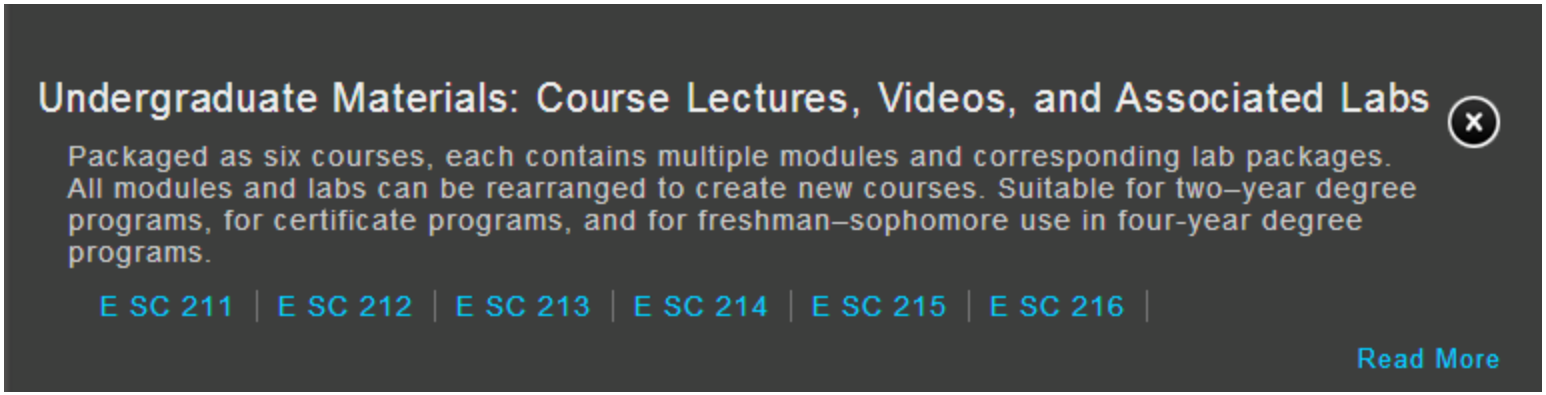
www.nano4me.org

NACK Educator Resources

Visit: www.nano4me.org/educator-resources



Undergraduate Level Course Material for 6 NACK Courses



Undergraduate 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 / 212 / 213 / 214 / 215 / 216

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

Unit	Lecture Video and PowerPoint Availability	Associated Laboratory Availability	Topics Covered
Unit 1 - Safety and Environmental Concerns			
Lecture 1: General Safety Awareness, Safety and Environmental Concerns	PPT PDF Video	Template Laboratory	General Safety Awareness, and Wet Chemistry Safety
Lecture 2: Gas Safety, Biological Safety, and Nanomaterial Safety	PPT PDF Video	Template Laboratory	Gas Safety, Biological Safety, and Nanomaterial Safety
Lecture 3: Energy, Safety, and Environmental Concerns	PPT PDF Video		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

E SC 211 Associated Laboratory Availability

ESC 211 Labs

Unit	Template Laboratory	Turnkey Laboratory	Supplemental Laboratory
Unit 1 - Safety and Environmental Concerns			
Lecture 1: General Safety Awareness, Safety and Environmental Concerns	Lab 1: EHS: Chemical & Materials Overview		
Lecture 2: Gas Safety, Biological Safety, and Nanomaterial Safety	Lab 2: EHS: Equipment Safety Awareness		
Lecture 3: Energy, Safety, and Environmental Concerns			
Unit 2 - Processing/Manufacturing Infrastructure			
Lecture 1: What is Infrastructure and Why Do We Need It?			
Lecture 2: Facilities			
Lecture 3: Overview of Vacuum Based Systems	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 3: Vacuum EquipSim Labs PDF Lab 4: Intro to PVD Final PDF	
Lecture 4: More on Vacuum Systems, Part I			
Lecture 5: More on Vacuum Systems, Part II			
Lecture 6: More on Vacuum Systems, Part III			
Lecture 7: Overview of Non-Vacuum Based Systems			

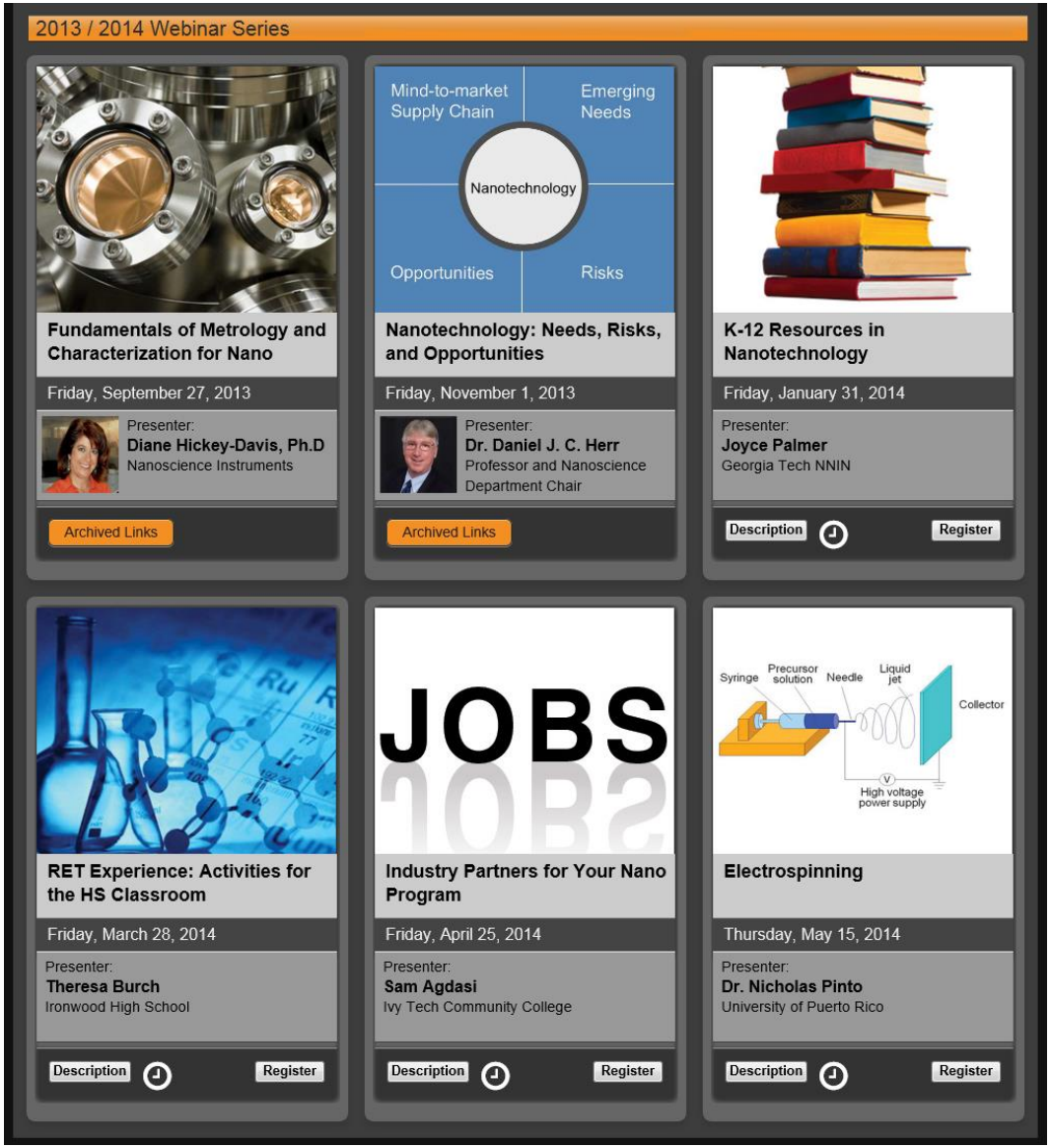
Introductory Level Modules

- **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**

Unit	Download Modules
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 nano-scale. Finally, this module explores how old nanotechnology is with a brief history and concludes with why nanotechnology is so popular today.	Module 1 Supplemental Materials
NOTE: It is recommended that you download the supplemental materials along with the module so that the links to the multimedia files in the PowerPoint file function. If you have any issues with the links to the multimedia files, please contact us.	
Module 2: A Brief History of Nanotechnology	
Description: This module explores the history of nanotechnology: from Romans using gold and silver nanoparticles in their glasswork 2,000 years ago to modern day where nanoparticles are being used in cancer treatments.	Module 2
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 3
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 4
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 tools, and quantum mechanical tunneling.	Module 5 Supplemental Materials
NOTE: It is recommended that you download the supplemental materials along with the module so that the links to the multimedia files in the PowerPoint file function. If you have any issues with the links to the multimedia files, please contact us.	
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 6
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 7
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 8
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 9 Supplemental Materials
NOTE: It is recommended that you download the supplemental materials along with the module so that the links to the multimedia files in the PowerPoint file function. If you have any issues with the links to the multimedia files, please contact us.	
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 moltronics.	Module 10

NACK Webinar Series

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



Resources Developed by Others

National Nanotechnology Initiative

Home | Sitemap | NSET Agencies | Contact Us Search Nano.gov

Nano.gov
National Nanotechnology Initiative

Nanotechnology 101 | Nanotechnology & You | About the NNI | Collaboration & Funding | Publications & Resources | Education | Newsroom | Events

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?

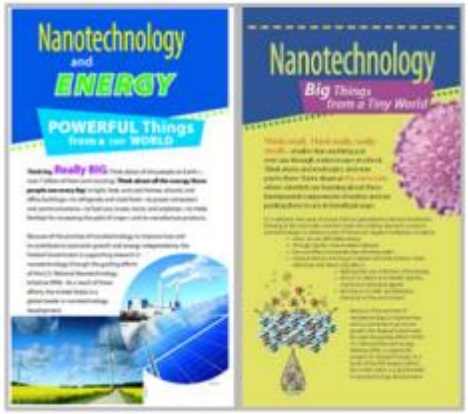
Related Resources

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

Education

- For K-12 Students
- **For K-12 Teachers**
- College and Graduate Programs
- Associate Degrees, Certificates, & Job Info

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.



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

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

STEM Education at McREL

- Resources in Technology and Engineering include:
  - NanoExperiences
  - NanoTeach
  - NanoLeap

NanoExperiences

NanoTeach

McREL

Mid-continent Research for Education and Learning

Delivering research and practical guidance to educators

NanoTeach

- Home
- Project Goals
- Nanoscience & Technology
  - Remote Access
- Designing Effective Science Instruction
  - Peer Review Team
- Virtual Classroom
- Project Team

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.

NanoTeach Photo Gallery

NanoLeap

Physical Science

Investigating Static Forces in Nature: The Mystery of the Gecko

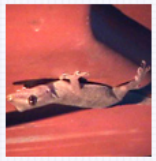
Lesson 1 Lesson 5
Lesson 2 Lesson 6
Lesson 3 Lesson 7
Lesson 4 Lesson 8

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

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.

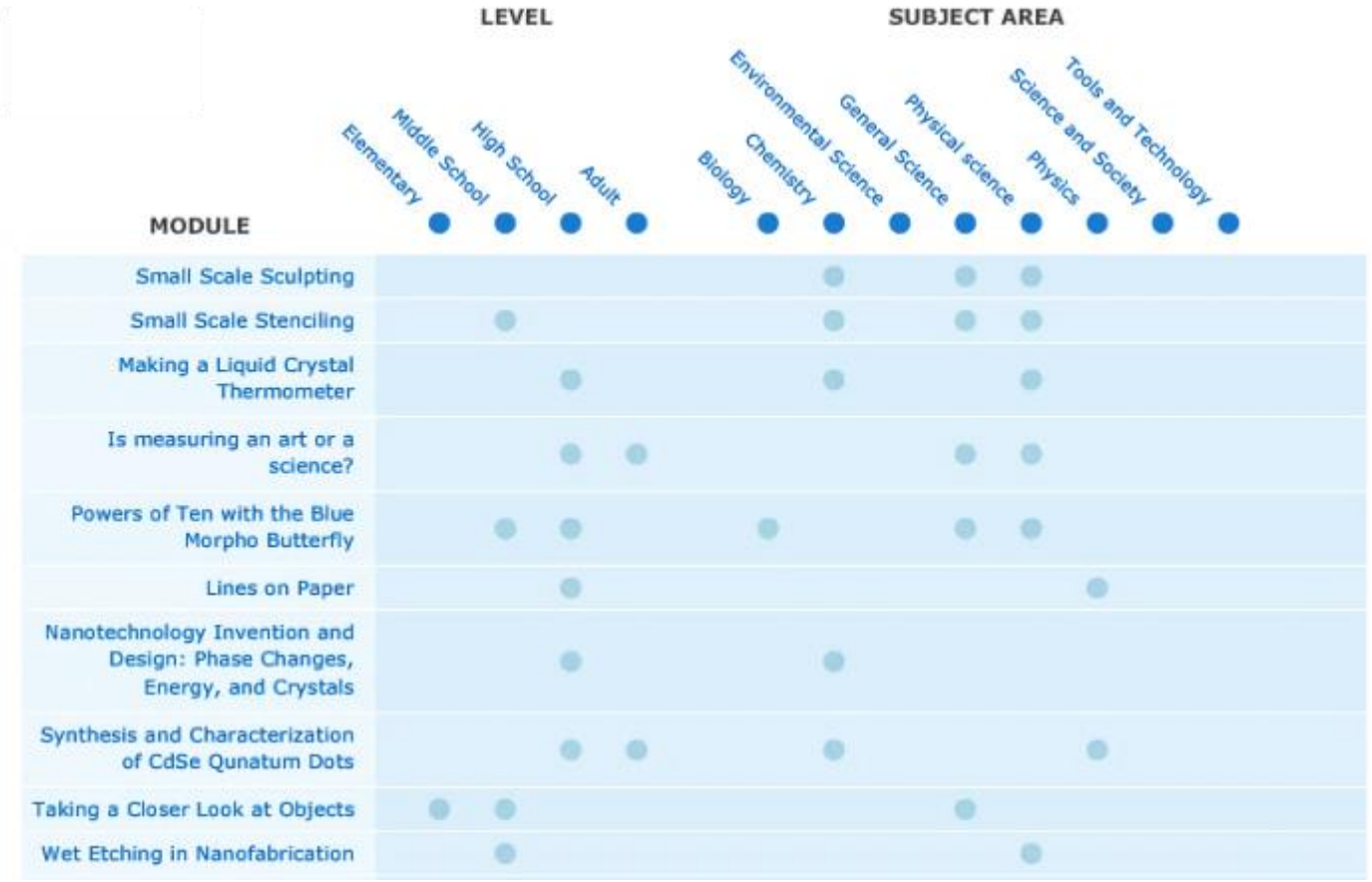
Lesson 1.1: What is Nanoscience?
+ **Teacher Guide** (PDF, 37 Kb)
+ **PowerPoint** (PPT, 463 Kb)

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

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

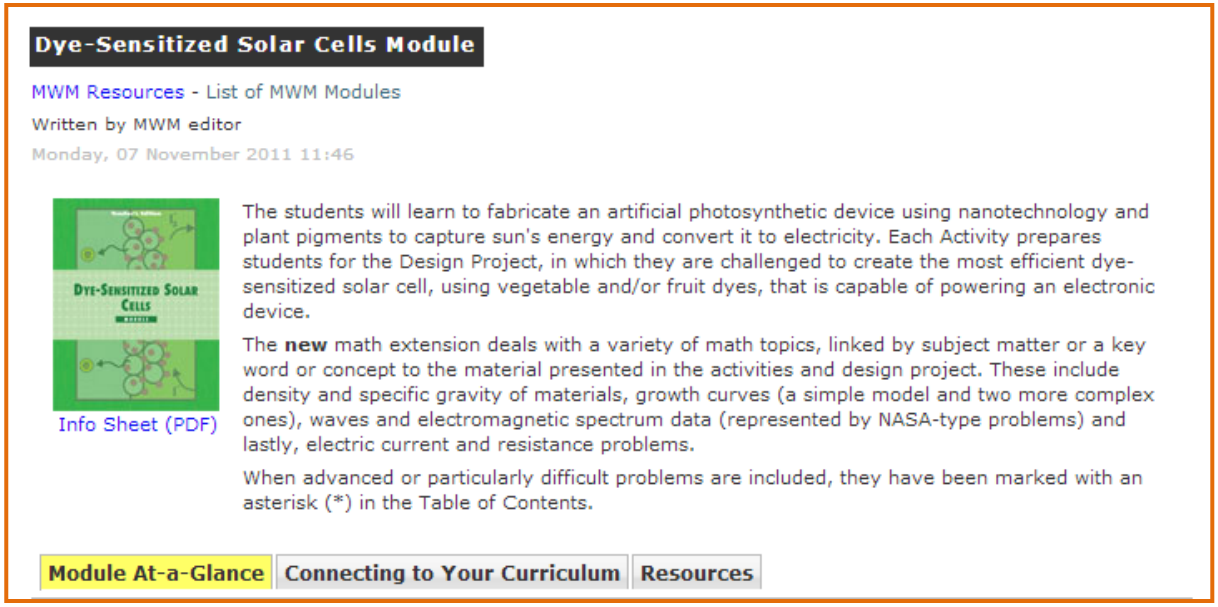
National Nanotechnology Infrastructure Network (NNIN)

Nano Curriculum Materials (K-12)



NCLT – Materials World Modules

- Nanotechnology Center for Learning and Teaching (NCLT)
- MWM – products designed by NCLT partners to integrate into classroom curricula



Dye-Sensitized Solar Cells Module

MWM Resources - List of MWM Modules

Written by MWM editor

Monday, 07 November 2011 11:46

Info Sheet (PDF)

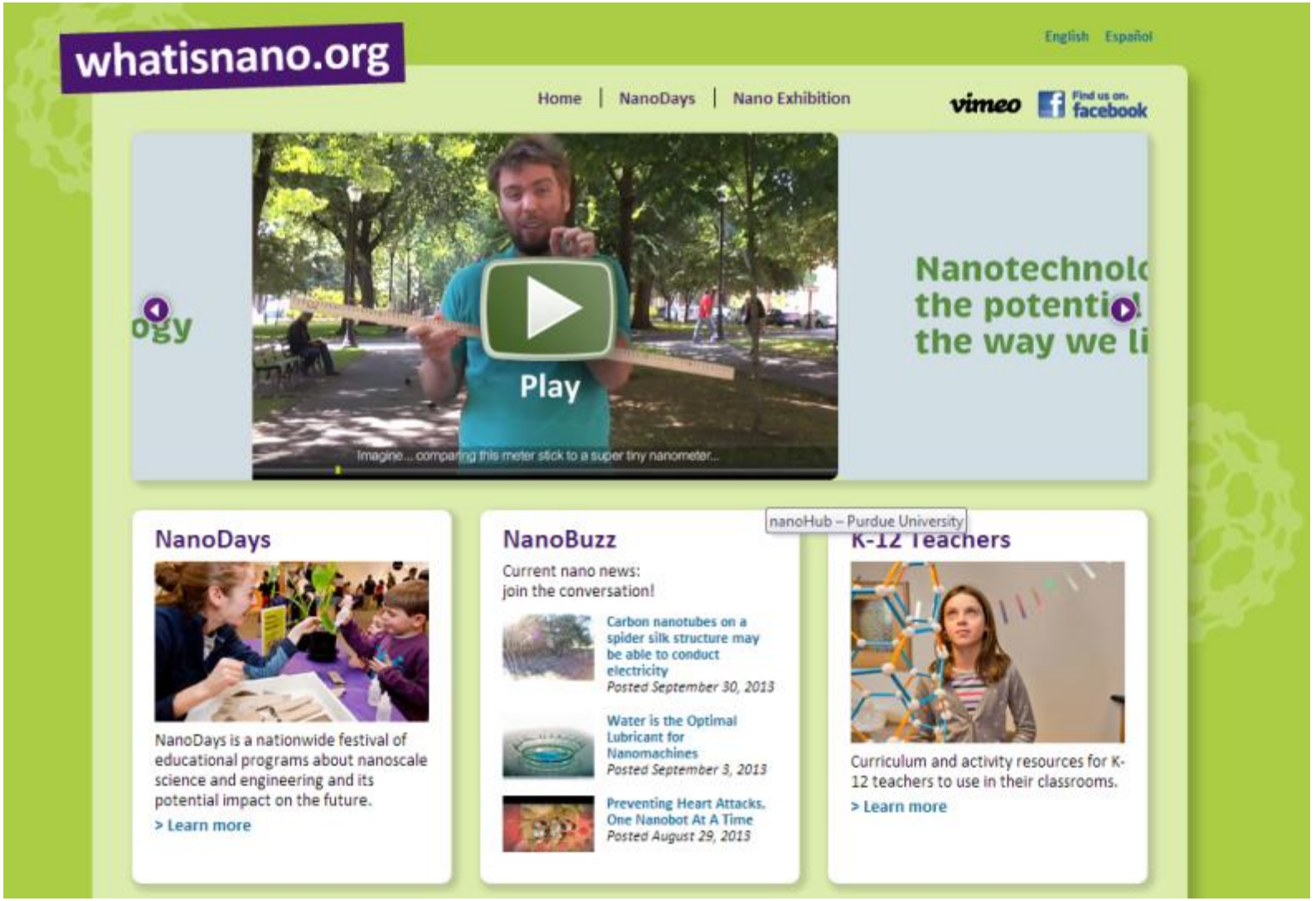
The students will learn to fabricate an artificial photosynthetic device using nanotechnology and plant pigments to capture sun's energy and convert it to electricity. Each Activity prepares students for the Design Project, in which they are challenged to create the most efficient dye-sensitized solar cell, using vegetable and/or fruit dyes, that is capable of powering an electronic device.

The **new** math extension deals with a variety of math topics, linked by subject matter or a key word or concept to the material presented in the activities and design project. These include density and specific gravity of materials, growth curves (a simple model and two more complex ones), waves and electromagnetic spectrum data (represented by NASA-type problems) and lastly, electric current and resistance problems.

When advanced or particularly difficult problems are included, they have been marked with an asterisk (*) in the Table of Contents.

Module At-a-Glance | **Connecting to Your Curriculum** | **Resources**

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)

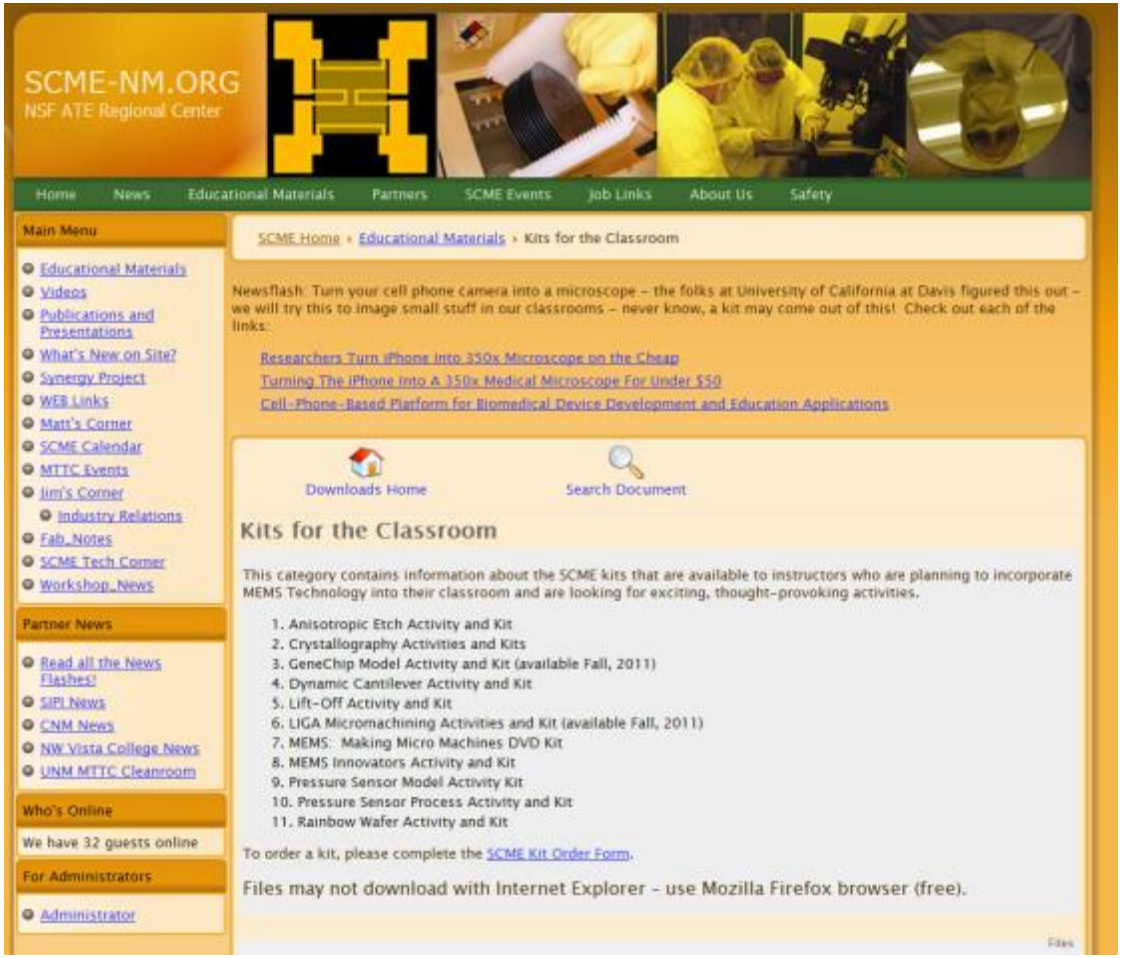
Need Helpful Web Resources?

- 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/

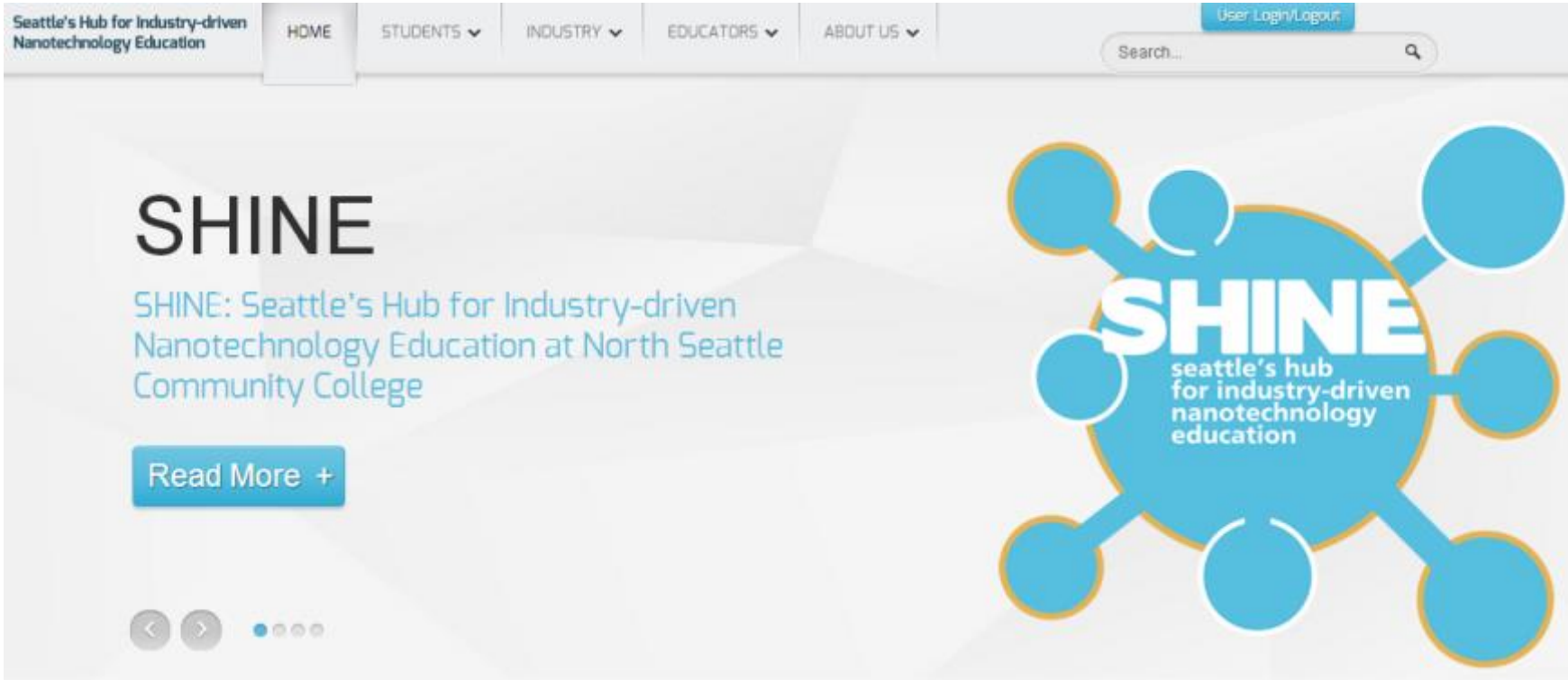
(included in handout)

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

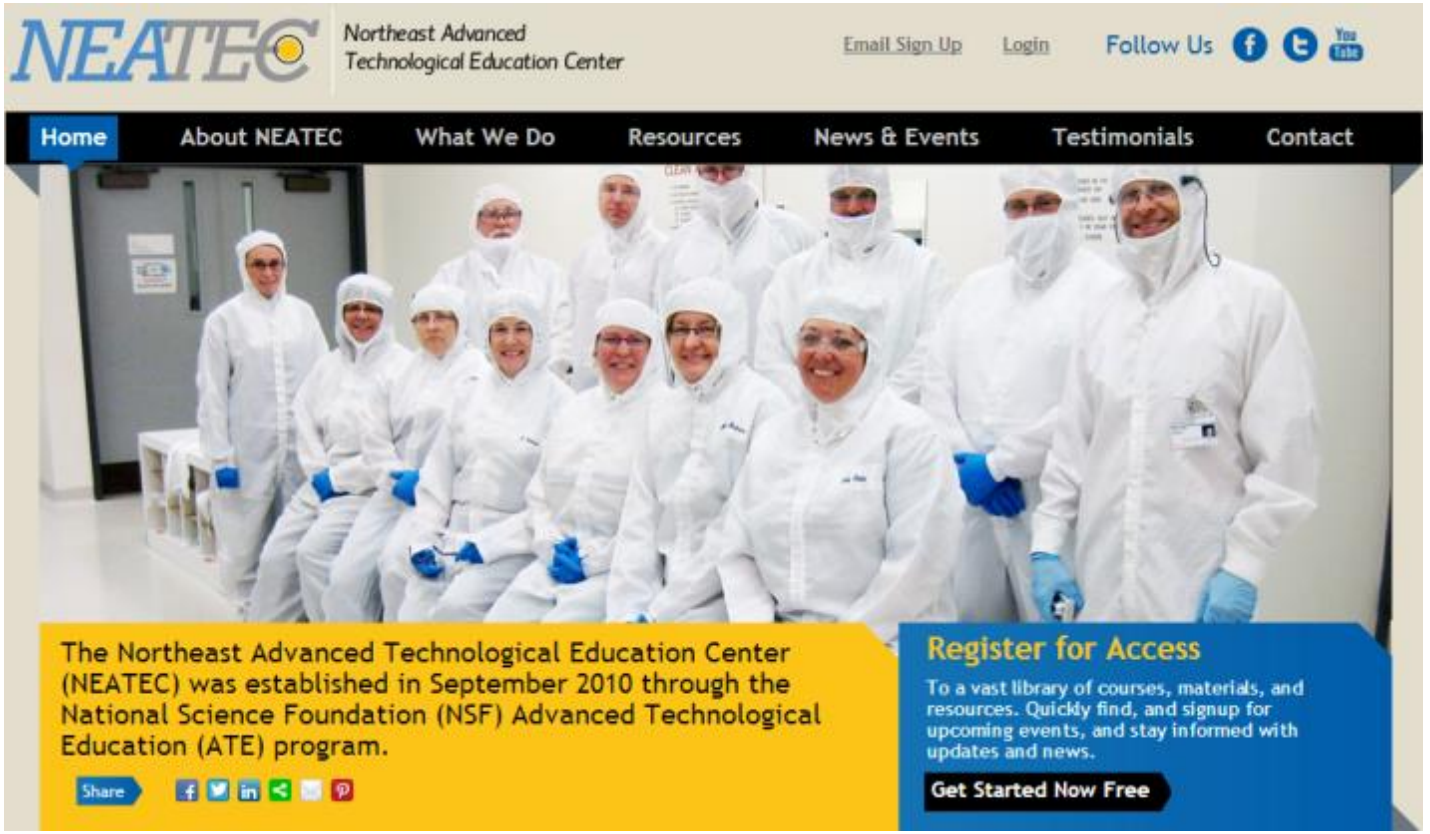
Nano-Link – Based in Rosemount, MN

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.

Nano-Link
Midwest Regional Center for Nanotechnology Education

NEATEC – based in Albany, NY



Some **Additional 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/

Resources for Educators

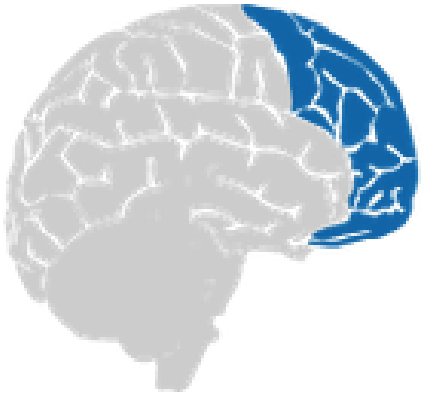
To engage today's learners we need to:

- Present content and information in different ways
- Provide multiple means of engagement
- Universal Design for Learning: http://www.cast.org/udl/

Recognition Networks
The "what" of learning

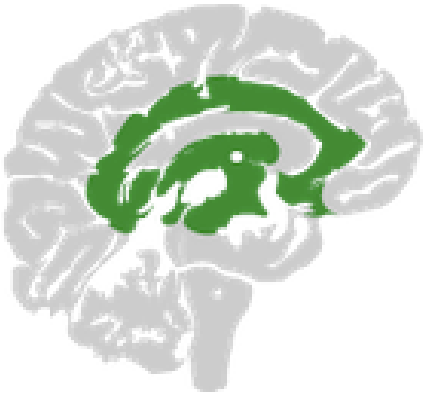
How we gather facts and categorize what we see, hear, and read. Identifying letters, words, or an author's style are recognition tasks.

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…

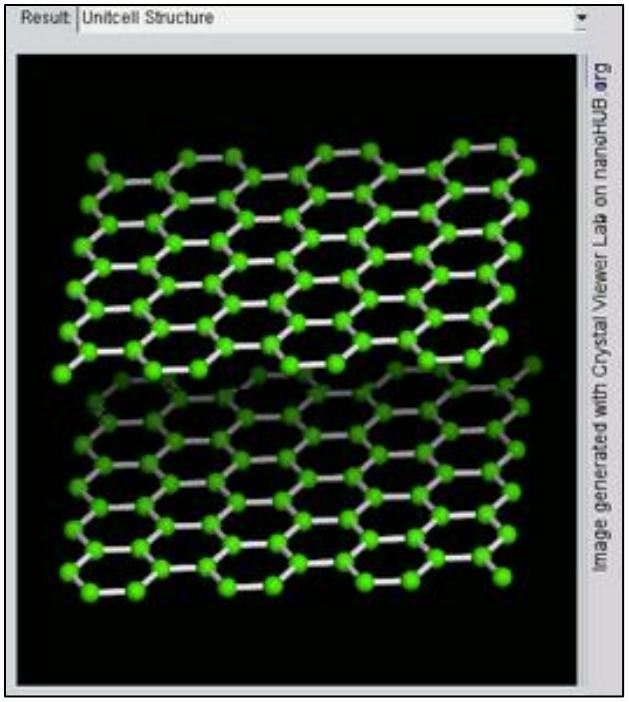
You just want to show something in a different way

Multimedia Possibilities

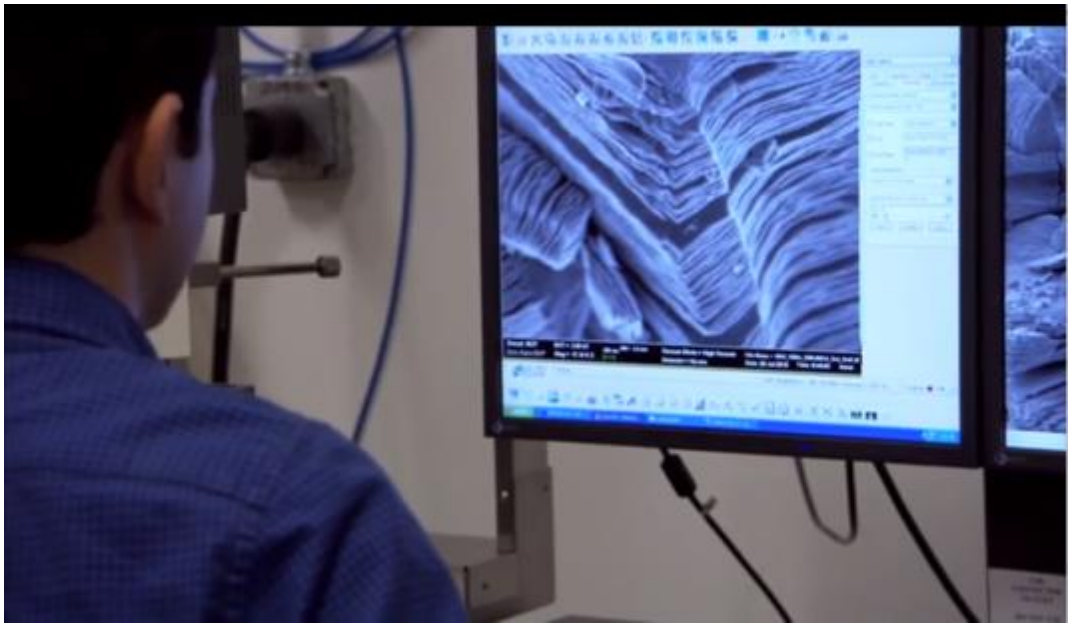
- Show:
  - Animations
  - Interactives
  - Video
- Do:
  - Simple simulations
  - Complex simulations and emulations

Nanotechnology Animation Gallery

nanoHUB - https://nanohub.org/resources/8882



Nanomaterials for Energy Efficiency

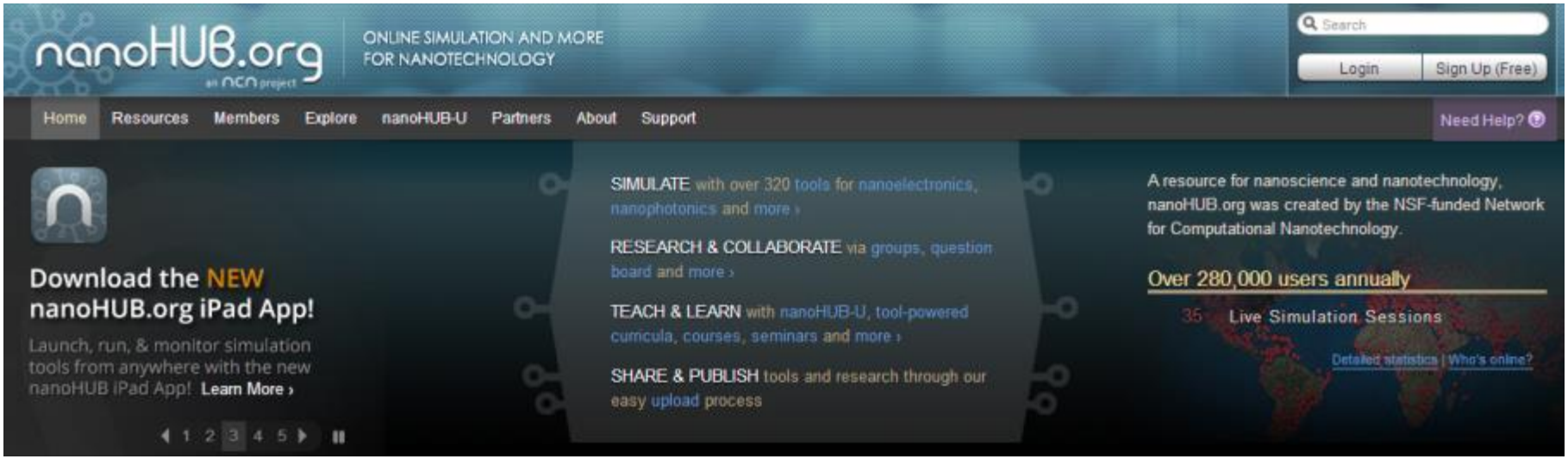


http://www.youtube.com/watch?feature=player_embedded&v=-WQ28DJWhZk#!

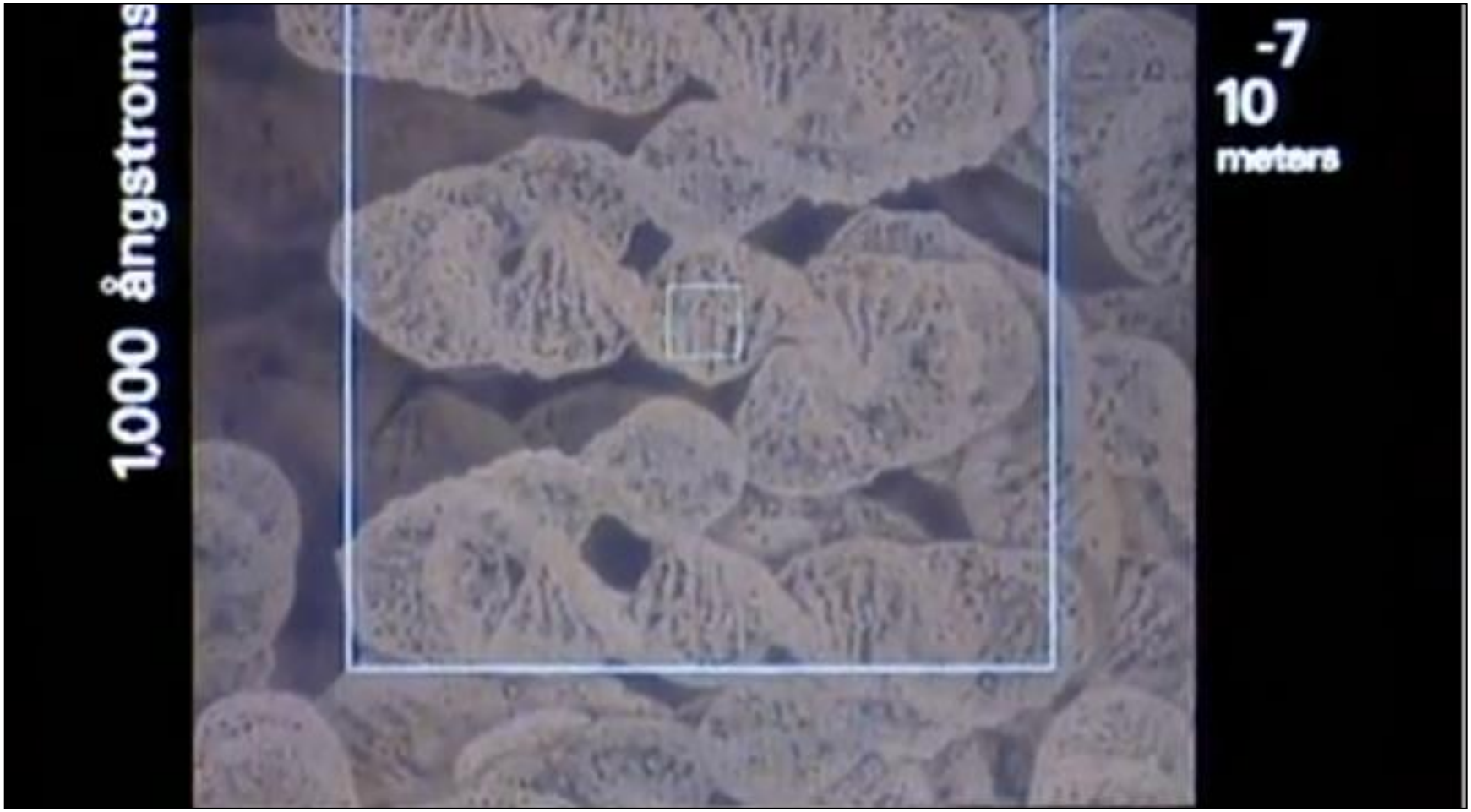
Spanish Language Videos on Nanotechnology

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			
Title	**Description**	**Objective**	**Link**
How a CMOS Device Works	An animation of how a CMOS device Works.	Identify the required electrical variables that allow a CMOS device to operate.	Launch iPod / iPhone video
n-Channel Enhancement MOSFET Characteristic Curves	This is an animation of a n-Channel Enhancement MOSFET Characteristic Curves.	Determine the active non-active operation regions of an n-Channel MOSFET gate.	Launch
The Making of the CMOS Microchip	How a CMOS Microchip is made.	Determine the process steps needed to complete a CMOS device.	Launch
The Deposition Process	An animation of the chemical vapor deposition process.	Identify the process of chemical vapor deposition.	Launch
Workflow in the CVD Tool	Animation of Workflow in the CVD Tool.	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	Launch

www.matec.org/animations

Thank You!

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This presentation will be available for viewing on:
http://nano4me.org/educator-resources