NACK CENTER
Building College-University Partnerships for Nanotechnology Workforce Development

Opportunities in Nanotechnology

February 26, 2021

PennState

Welcome

Building College-University Partnerships for Nanotechnology Workforce Development

Bob Ehrmann

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www.nano4me.org
www.cneu.psu.edu

PennState

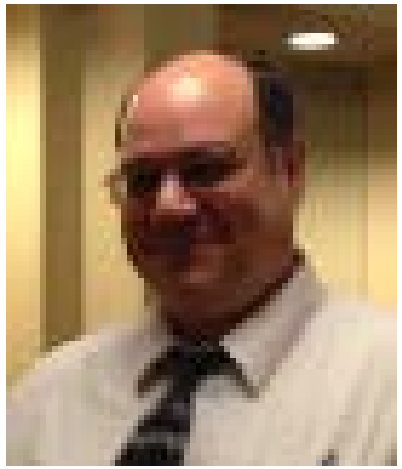
Penn State Center for Nanotechnology Education and Utilization (CNEU)

Welcome

Tony Dalessio

Professor of Electrical Engineering Technology
Chair of Nanotechnolgy
Erie Community College
Williamsville, NY

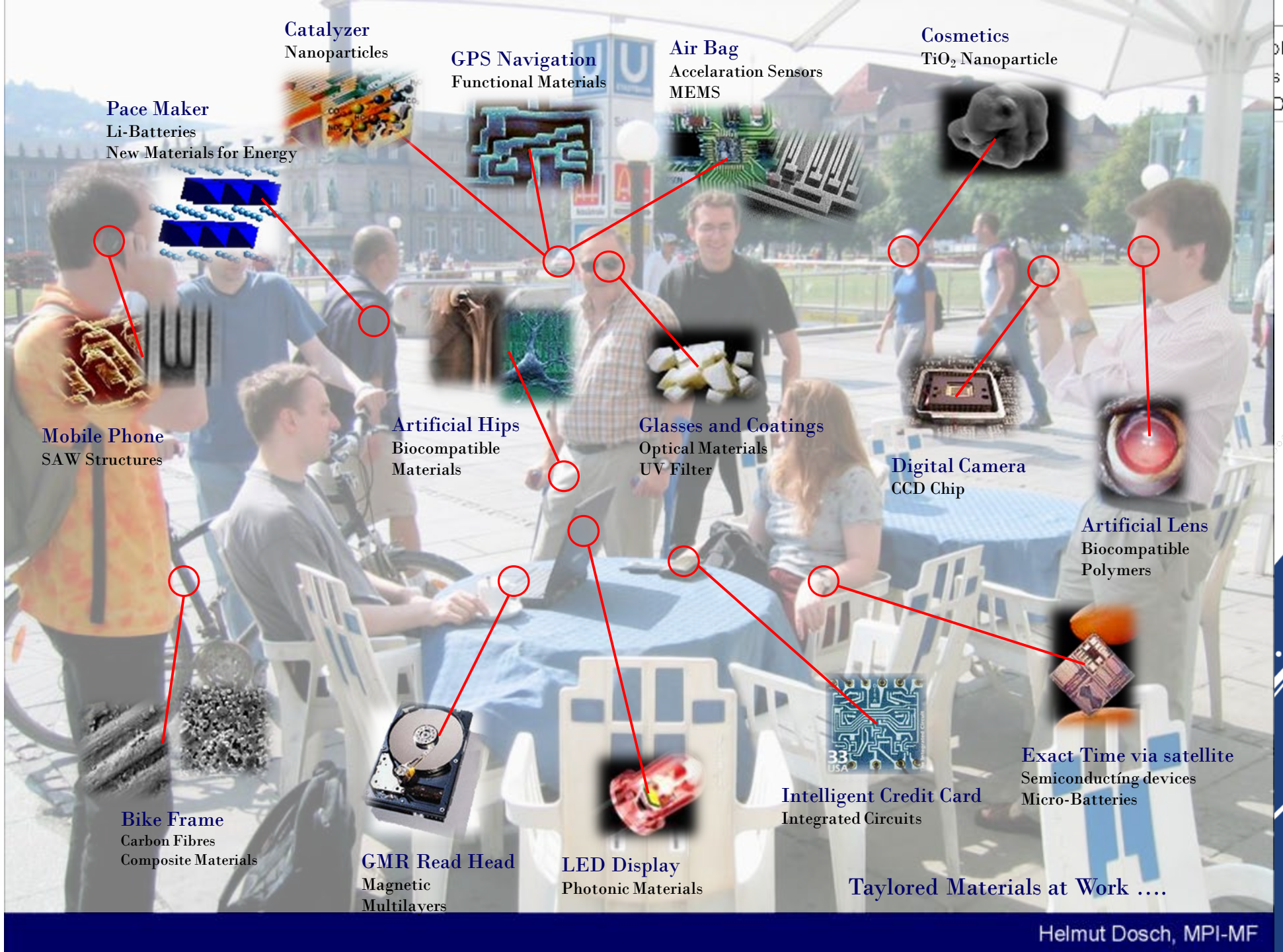
Dalessio@ecc.edu



Opportunities in Nanotechnology

Nano is all around you!


On a typical day...
Anywhere in the world….
Helmut Dosch, MPI-MF

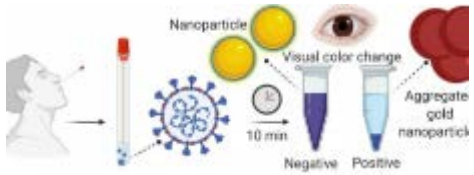

Catalyzer
Nanoparticles
GPS Navigation
Functional Materials
Air Bag
Accelaration Sensors
MEMS
Cosmetics
TiO_2 Nanoparticle
Pace Maker
Li-Batteries
New Materials for Energy
Mobile Phone
SAW Structures
Artificial Hips
Biocompatible
Materials
Glasses and Coatings
Optical Materials
UV Filter
Digital Camera
CCD Chip
Artificial Lens
Biocompatible
Polymers
Bike Frame
Carbon Fibres
Composite Materials
GMR Read Head
Magnetic
Multilayers
LED Display
Photonic Materials
Intelligent Credit Card
Integrated Circuits
Exact Time via satellite
Semiconducting devices
Micro-Batteries
Taylored Materials at Work ....
Helmut Dosch, MPI-MF

Where is Nano?

Biomimicry

Diagnostics

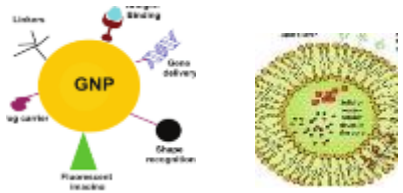
eg Covid Testing



Materials

Microelectronics

Drug Delivery

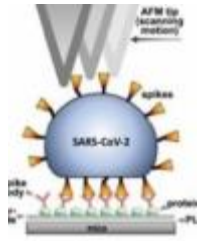


Energy

Environment

Household

Basic Research



Textiles

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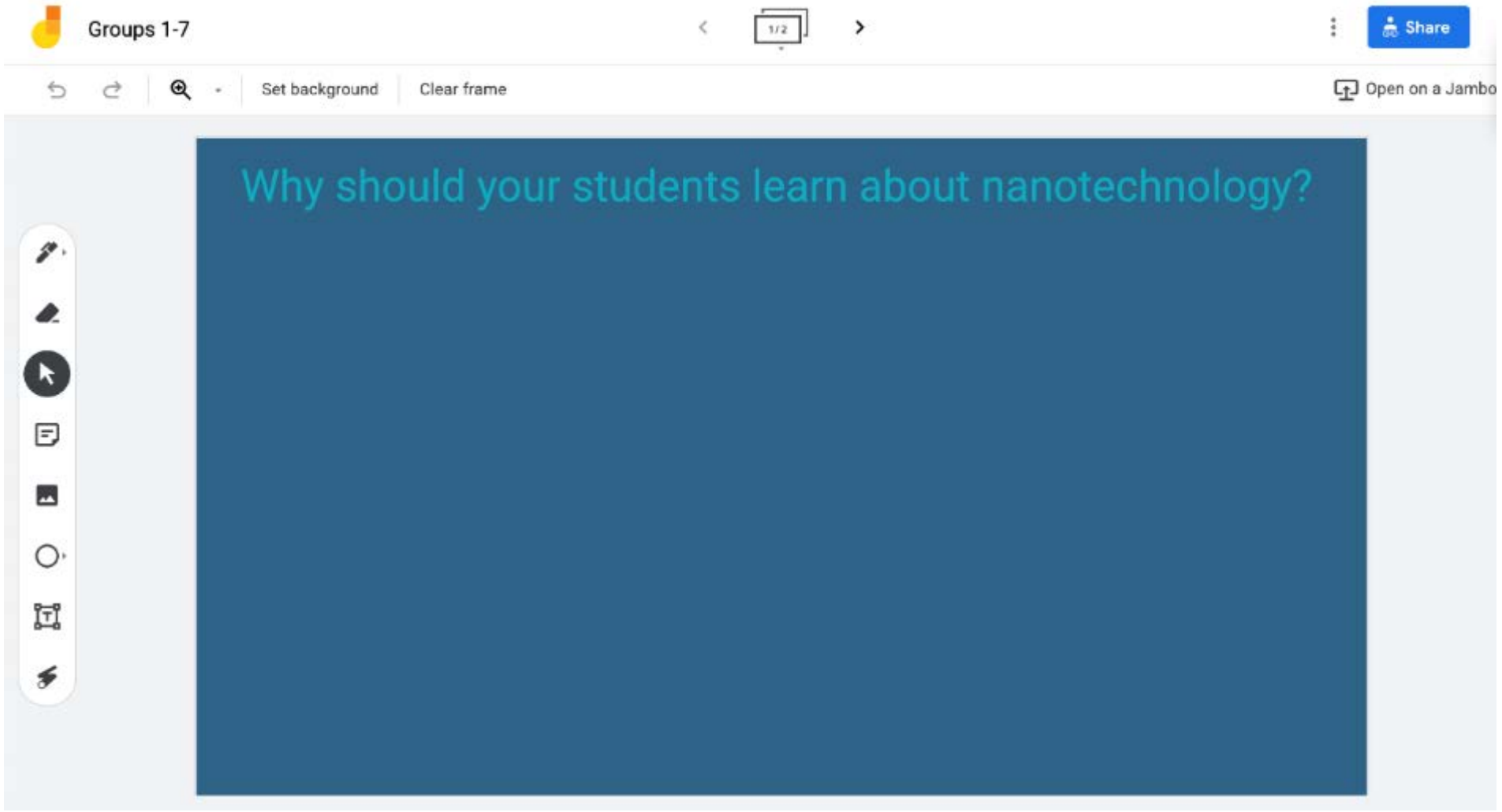
Why your students should know this

Recall our Jamboard breakout from week #1:



Why should your students learn about nanotechnology?

Nanotechnology will impact their future careers.

Invokes creativity and critical thinking.

For the practical applications of nano into solving real world problems. Grand Challenges

It is important to understand the technology they use to get the best from it.

Creating "wonder" to gain students' interest

Teachers have to know to prepare students

There is something relevant to every student.

Biomedicine will create medical breakthroughs via nanotech

In my country, children don't lea nanotechnology a their schools.

Nanotechnology will contribute to solving the Grand Challenges prioritized by the National Academy of Engineering.

Students will be part of the change in the world. Be aware of future choices for them.

Students need to learn about nano technology because it is affecting them as we speak. Many technologies are merging, and the internet of things will soon connect us all. I also think that nanotechnology and biotechnology go hand and hand.

Explains the electronics in their phones. Underlies biotech. Cellular level.

In all sectors - manufacturing, healthcare, etc. Something for every interest.

Knowing about this technology will assist their understanding of other subjects.

It's almost in EVERYTHING that we make!

It is the future of how technology will evolve in the future. Every new discovery will be on the nano level. It will change the future of batteries, energy and medicine.

so many jobs!

They have to know about this because the technology is here.

Nano science is the fastest growing field of science. Nano-technology is the driving force behind research and development and all areas of industry today. Many new jobs will be created as nano-technology driven fields grow. It is the "plastics" of the 21 st century.

Helps students make sense of characteristics and properties of materials and living organisms.

I work with rural students and teaching nanotech opens up all kinds of science and engineering they are not exposed to.

Interdisciplinary

Giving the kids a "wow" effect

Understanding of emerging technologies

A lot of uses for nanotechnology

Promoting nanotechnology for kids

Advocacy

Nanotechnology is in almost everything we use

National Nanotechnology Initiative (2000)

Vision: A future in which the ability to understand and control matter on the nanoscale leads to a revolution in technology and industry that benefits society.

Goals:

- Advance a world-class nanotechnology research and development program.
- Foster the transfer of new technologies into products for commercial and public benefit.
- Develop and sustain educational resources, a skilled workforce, and a dynamic infrastructure and toolset to advance nanotechnology.
- Support responsible development of nanotechnology.

DOE
HHS/NIH
OSTP
OMB
NSF
DOD
DOC/NIST
HHS/FDA
NASA
USDA/NIFA
USDA/ARS
HHS/CDC/ NIOSH
USDA/FS
DOS
EPA
DOTr
NRC
DOT
DOC/ USPTO
IC/DNI
DOI/ USGS
DOJ
DOL
DOC/EDA
DOC/BIS
DHS
CPSC
ITC
DOEd
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Why should we be excited about nanotechnology?

- Global market predicted value: $2,231.4 million by 2025
- Surge in adoption of nanotechnology in medical diagnoses
- Emergence of self-powered nanotech devices
  - Applicable in:
    - Sensing
    - Medical science
    - Defense technology
    - Personal electronics

https://www.alliedmarketresearch.com/nanotechnology-market

A Forecast from 2016:

“By 2020, 70% of all new advanced technology products will incorporate nanotechnology.”

* M. Roco

Market and Jobs Information

- As the market expands, the number of **jobs** needing different skill levels in nanotechnology will increase.

- Thus, it is essential that a sufficient **supply** of qualified **workers** be developed to fill that need.

Nanotechnology Workforce Video

Building College-University Partnerships for Nanotechnology Workforce Development

Workforce Readiness

International Credentialing

ASTM E2996
Standard Guide for Workforce Education in Nanotechnology Health and Safety

ASTM E3001
Standard Practice for Workforce Education in Nanotechnology Characterization

ASTM E3034
Standard Guide for Workforce Education in Nanotechnology Pattern Generation

ASTM E3059
Standard Guide for Workforce Education in Nanotechnology Infrastructure

ASTM E3071
Standard Guide for Nanotechnology Workforce Education in Materials Synthesis and Processing

ASTM E3089
Standard Guide for Nanotechnology Workforce Education in Material Properties and Effects of Size

ASTM E56 Education Standards

- Suite of 6 standards are now published covering basic skill sets for nano workforce
- Can be accessed at https://www.astm.org/COMMITTEE/E56.htm

ASTM Personnel Certificates in Nanotechnology

The current mission is to create 4 certificates which cover the ASTM Nanotechnology Workforce Education Standards that can be attained by individuals completing programs and passing corresponding tests

ASTM Workforce Certificate in Nanotechnology
Health and Safety

ASTM Workforce Certificate in Nanotechnology
Characterization

ASTM Workforce Certificate in Nanotechnology
Fabrication & Processing

ASTM Workforce Certificate in Nanotechnology
Material Properties and Effects of Size

back

NACK Building College-University Partnerships for Nanotechnology Workforce Development

ASTM INTERNATIONAL

PennState

The Value of These Nano Workforce Certificates

- Presently working with Industry (across the country) to make them aware of these nano-workforce international certificates
  - Attaining certificates will show that a prospective student/applicant has retained relevant nanotechnology workforce knowledge
  - They know their stuff!

Non-academic Micro-credentials (Badges)

SCME offers MEMS badges in several topical areas:

- MEMS Foundations
- BioMEMS
- MEMS Fabrication

Institutions That Have Hired Capstone Semester Graduates for Micro- and Nanotechnology Jobs

II-VI Corporation
Accellent
Adhesives Research, Inc
Advanced Acoustic Concepts
Advanced Cooling Technologies
Advanced Gas Technologies
Advanced Powder Products
Advantech
AGAM
Agere
Alcoa
Allied Electronics
Alden Products
AMAX Minerals
Amedeo
Amgen Inc.
Apogee Photonics
Aptagen
Aquion Energy
Arrow International
ASML
Avail Technologies
B. Braun
Berry Plastics
BioElectroSpec
Boston Applied Technologies
BD (Becton, Dickinson)
BP Solar
Bridge Semiconductor
Busch Vacuum
Cabot
Cabot Microelectronics
Carbon NanoProbes
Celgene-LifebankUSA
Chemcut
Correge Sensors
Cosmos Technologies
Cree
Crystalplex
Cyoptics
Dendreon
DRS Laurel Technologies
Dana Corporation
Doucette
Don's Salads
Dow Chemical
Drexel University
Dupont
Eastman Chemical Company
East Penn Manufacturing
Emerson Network Power
Ex One
Fairchild Semiconductor
Fincor Automation
First Energy
F.S. Elliott
General Dynamics Robotic System
General Electric
Glass automatic
GlaxoSmithKline
Globalfoundries
GTS
Haraeus Noblelight
Hale Products
Hershey Medical Center
IBM
Illuminex
IM Flash Technologies
Infinera
Inovative Micro Technology
Intel Corporation
iNOEX
IQE
Johnson & Johnson
Johnson Matthey
Judson Technologies
Keystone Communications
Keystone Engineering
Keystone Research & Pharmaceuticals
Kongsberg Defense
Kurt J. Lesker
Kyowa America
Lawrence Livermore National Lab
LCM Technologies
Lehighton Electronics
Lockheed Martin
Lucent Technologies
Lutron Electronics
Macron Dynamics
Maxima Technologies
Max Levy Autograph
Meadow Burke Products
Membrane Assays
Merck
Micron Technology
Mintera Corporation
MXL Industries
NanoHorizons
Nanovus
Nascent Devices
Natural Nano, Inc
NIST
North American Hoganas
North Carolina State University
Northrup Grumman, Inc
Optellios
Optinel Systems
P2I
Penn State CNEU
Penn Stae Dubois
Penn State –Advanced Coatings - ARL
Penn State Applied Research Lab
Penn State Electro-Optics Center
Pennsylvania Dept of Environmental Protection
Pfister Energy
Philips Medical Systems
Philips Respironics
Plextronics
Probes Unlimited
Proconex
PPG
PPL
QorTek
Qorvo
Restek
Rhetech
Rohm and Haas
Ross Technologies
RJ Lee
Schroeder Industries
Scientific Systems
Seagate Technologies
Siemens Co.
SI International
Slack Pek
Solar Innovations
Solarity
Solvay OLED
Spectrum Technologies
SPI Supplies
Strainrite
Strategic Polymers
Structure Probes.
SuperPower
Synoptics
Synthes
Telecardia
Textron Lycoming
Thermo Electric PA
Tokyo Electron Ltd
Transene
Tyco Electronics
US Air Force
US Army Research Laboratory
Uniroyal Optoelectronics
Universal Display Corporation
University of Florida
University of North Carolina - Charlotte
University of Pittsburgh
Vectron International
Velox Semiconductor
Western Digital
Westfalia Technologies
Westmoreland Mech. Testing & Research
Xactix

Job Titles for Nanotechnology Graduates

Biological Laboratory Tech.

Biofuels Tech.

Chemical Laboratory Tech.

Cleanroom Tech.

Deposition Tech.

Device Tech.

Equipment Maintenance Tech.

Engineering Tech.

Etch Tech.

Failure Analysis Tech.

Laboratory Tech.

Lithography Tech.

Materials Science Lab Tech.

Medical Devices Tech.

Microfabrication Tech.

Nanobiotech Researcher

Nanoelectronics Expert

Nanofabrication Tech.

Nanotechnologist

Process Tech.

Production Scientist

Quality Control Tech.

Research Assistant

SEM Operator

SPM Operator

Scientist Specialist

Solid State Tech.

Test Tech.

Thin Films Tech.

Vacuum Tech.

Opportunities for you and your classroom

Some Highlighted Resources:

K-12 Resources in Nanotechnology

January 31, 2014 **Webinar Handout**

Joyce Palmer Allen

Key Messages:

- Reasons K-12 students need to be exposed to nanoscale science and engineering (NSE) information.
- Big Ideas of NSE and their connections to science standards.
- Resources for introducing students to NSE.
- Resources for connecting NSE to curriculum.
- Examples using NSE resources.

16 pages of annotated "A to Z" Resource Links by Joyce

See: www.nano4me.org/Webinars

NACK_webinar_handout_K12_Resources_013114.pdf (nano4me.org)

Some Highlighted Resources:

INTRODUCTION TO NANOTECHNOLOGY EDUCATORS WORKSHOP

January - February 2021

Dr. Mariel Kolker

Classroom Resources

- Text Resources
- Introductory Videos
- Paper
- Size & Scale
- Size Dependent Properties
- Fabrication
- Characterization
- Other resources and news

Mariel's Favorites !!

Canvas: Supplemental Materials

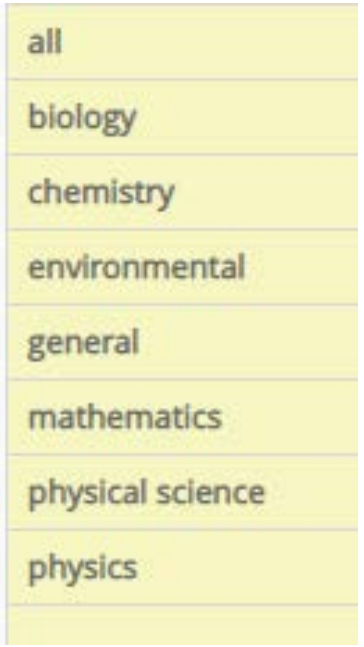
Intro to Nanotechnology Resources.pdf

Some Highlighted Resources:

From NNCI on nanoHUB

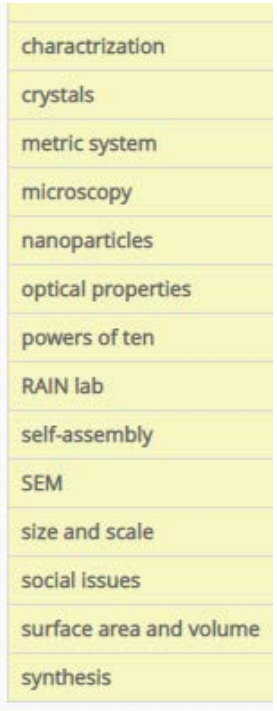
Matrix of NNCI Education Materials

By Subject:



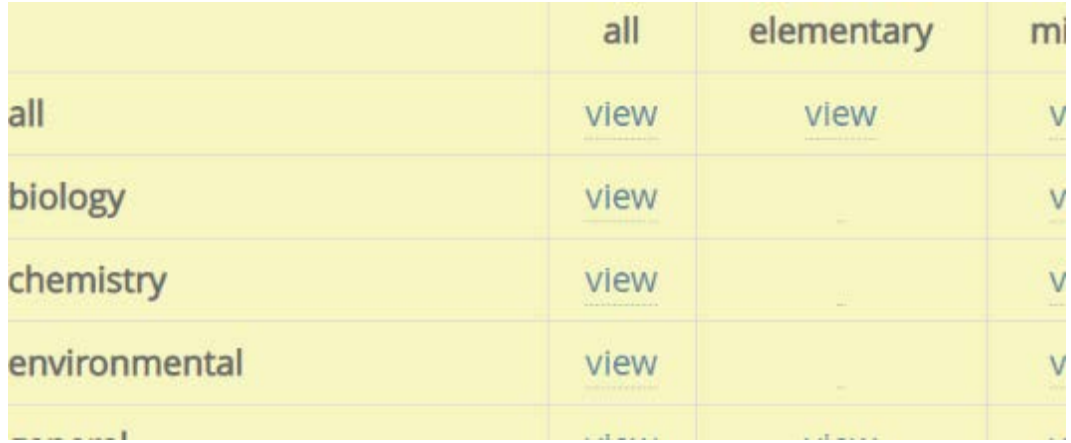
or

By Topic:



Looking for one thing in particular?

All sorted by Education Level Tags:
Elementary, Middle, HS, Undergrad, etc



[nanoHUB.org - Group: Joe Cychosz Research Group ~ Bingo Card Test - NNCI Content]

Some Highlighted Resources:

NSF ATE Resources on nanoHUB:

nanoHUB.org - Group: NACK Network

nanoHUB.org - Group: Support Center for Microsystems Education (SCME)

Group: NEATEC (nanohub.org)

nanoHUB.org - Group: Nano-Link

nanoHUB.org - Group: SHINE: Seattle's Hub for Industry-driven Nanotechnology Education ~ Resources

www.nano4me.org

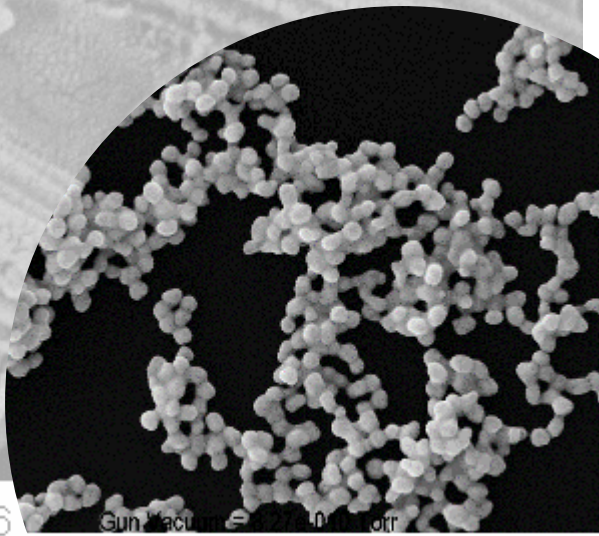
www.cneu.psu.edu

Some Highlighted Resources:

Texts / Background Resources:

- **Nanotechnology: A Gentle Introduction to the Next Big Idea (Ratners)**
- **Nanoscale Science: Activities for Grades 6-12 (NSTA)**
- **The Big Ideas of Nanoscale Science and Engineering: A Guidebook for Secondary Teachers (Stevens)**
- **Nanotechnology For Dummies 2nd Edition (Boyson, ….)**
- **Basic Principles of Nanotechnology (Sanders)**
- **Nanotechnology Past and Present (Newberry)**

Remotely Accessible Instruments for Nanotechnology (RAIN)



- Arizona State University (NCI-SW at ASU)
- Cattaraugus-Allegany-Erie-Wyoming Board of Cooperative Educational Services (CABOCES)
- Colorado Shared Instrumentation in Nanofabrication and Characterization (COSINC)
- Coppin State
- Erie Community College (ECC)
- Forsyth Tech Community College
- Georgia Institute of Technology
- Georgia Southern University
- Nebraska Nanoscale Facility
- Norfolk State University (SCENE)
- Northcentral Technical College (NTC)
- Normandale Community College
- Northwest Vista College, Workforce Programs
- North Seattle College (NSC - SHINE)
- Oakton Community College (O.R.A.N.G.E.)

REMOTE ACCESS INSTRUMENTS FOR NANOTECHNOLOGY

RAIN

- Pasadena City College (PCC)
- Pennsylvania State University (CNEU - NACK Network)
- Research Triangle Nanotechnology Network (RTNN)
- Salt Lake Community College (SLCC)
- Stanford University (nano@Stanford)
- SUNY Polytechnic Institute
- University of Iowa
- University of California San Diego
- University of Texas at San Antonio (UTSA)
- University of New Mexico (SCME)
- Utah Valley University (UVU)

Current RAIN Network Nodes

Currently Available RAIN Equipment

Scanning Electron Microscope (SEM)

A scanning electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that can be detected and that contain information about the sample's surface topography and composition. The electron beam is generally scanned in a raster scan pattern, and the beam's position is combined with the detected signal to produce an image. SEM can achieve resolution better than 1 nanometer. Specimens can be observed in high vacuum, in low vacuum, in wet conditions (in environmental SEM), and at a wide range of cryogenic or elevated temperatures. Read more

Remote Accessibility:

NCI-GW at Arizona State University - (Phenom Pro)
CABOOSE - (Phenom ProX & JEOL-JSM-IT51PLUS/LA)
Erie Community College - (JEOL JSM-6010LA)
Northcentral Technical College - (Hitachi TM 3030)
Northwest Vista College - (Hitachi TM 3030 Plus)
Cekon Community College - (Hitachi TM 3000)
North Seattle College - (Aspex Explorer)
Pasadena City College - (Phenom ProX)
Pennsylvania State University - (ZEISS 55 Ultra FESEM)
Research Triangle Nanotechnology Network - (FEI Quanta 200 Field Emission Gun)
Salt Lake Community College - (Hitachi TM3000)
SUNY Polytechnic Institute - (Hitachi TM3000 w/ x-ray (EDS))
University of California San Diego - (Zeiss Sigma 500 SEM)
University of Texas at San Antonio - (Hitachi S5500 STEM)
SCME at University of New Mexico - (Phenom ProX)

Energy Dispersive Spectroscopy (EDS)

Energy-dispersive X-ray spectroscopy (EDS, EDX, or XEDS), sometimes called energy dispersive X-ray analysis (EDXA) or energy dispersive X-ray microanalysis (EDXMA), is an analytical technique used for the elemental analysis or chemical characterization of a sample. It relies on an interaction of some source of X-ray excitation and a sample. Its characterization capabilities are due in large part to the fundamental principle that each element has a unique atomic structure allowing unique set of peaks on its X-ray emission spectrum. Read more

Remote Accessibility:

Erie Community College - (JEOL JSM-6010LA)
North Seattle College - (Aspex Explorer)
Cekon Community College - (Quanta 70)
Pasadena City College - (Phenom ProX)
Pennsylvania State University - (Oxford Instruments X-act)
University of Texas at San Antonio - (Hitachi S5500 STEM)

Atomic Force Microscope (AFM)

Atomic-force microscopy (AFM) or scanning-force microscopy (SFM) is a very high-resolution type of scanning probe microscopy (SPM), with demonstrated resolution on the order of fractions of a nanometer, more than 1000 times better than the optical diffraction limit. Read more

Remote Accessibility:

Forsyth Tech Community College - (Nanosurf Flex Scan head AFM)
Northcentral Technical College - (Nanosurf easyScan 2)
North Seattle College - (Nanosurf easyScan 2)
Cekon Community College - (Nanosurf easyScan 2 FlexAFM)
Pennsylvania State University - (Bruker Innova)
Salt Lake Community College - (Agilent 5400 AFM/SPM & Nanosurf easyScan 2)

Profilometer

Profilometer is a measuring instrument used to measure a surface's profile, in order to quantify its roughness. Read more

Remote Accessibility:

North Seattle College - (Bruker Dektak XT)
Cekon Community College - (Bruker Dektak XT)
Pennsylvania State University - (Veeco Dektak 6M)

Ultraviolet–visible Spectrophotometer

Ultraviolet–visible spectroscopy or ultraviolet-visible spectrophotometry (UV-Vis or UV/Vis) refers to absorption spectroscopy or reflectance spectroscopy in the ultraviolet-visible spectral region. This means it uses light in the visible and adjacent (near-UV and near-infrared (NIR)) ranges. The absorption or reflectance in the visible range directly affects the perceived color of the chemicals involved. Read more

Remote Accessibility:

Coppin State - (UV-VIS-NIR Spectrophotometer)
Georgia Institute of Technology - (Thermo UV-VIS Spectrometer)
Pennsylvania State University - (Cary 300)

REMOTE ACCESS INSTRUMENTS FOR NANOTECHNOLOGY
RAIN

Confocal Microscope

Confocal microscopy is an optical imaging technique for increasing optical resolution and contrast of a micrograph by means of adding a spatial pinhole placed at the confocal plane of the lens to eliminate out-of-focus light. It enables the reconstruction of three-dimensional structures from the obtained images. Read more

Remote Accessibility:

Stanford University - (Keyence 3D Laser Confocal Scanning Microscope)
North Seattle College - (Olympus Fluoview FV10i)

Optical Microscope

The optical microscope, often referred to as light microscope, is a type of microscope which uses visible light and a system of lenses to magnify images of small samples. Optical microscopes are the oldest design of microscope and were possibly invented in their present compound form in the 17th century. Basic optical microscopes can be very simple, although there are many complex designs which aim to improve resolution and sample contrast. Read more

Remote Accessibility:

Pennsylvania State University - (Leitz Ergolux)

Molecular Analyzer

The molecular analyzer is used for the measurement of the size, electrophoretic mobility of proteins, zeta potential of colloids and nanoparticles, and optionally the measurement of protein mobility and microrheology of protein and polymer solutions.

Remote Accessibility:

Georgia Institute of Technology - (Malvern Zetasizer Nano ZS)

Fourier Transform Infrared Spectroscopy (FTIR)

Fourier transform infrared spectroscopy (FTIR) is a technique which is used to obtain an infrared spectrum of absorption or emission of a solid, liquid or gas. An FTIR spectrometer simultaneously collects high spectral resolution data over a wide spectral range. This confers a significant advantage over a dispersive spectrometer which measures intensity over a narrow range of wavelengths at a time. Read more

Remote Accessibility:

Georgia Institute of Technology - (Thermo Scientific i520 FT-IR Spectrometer)

X-ray fluorescence (XRF)

X-ray fluorescence (XRF) is the emission of characteristic "secondary" (or fluorescent) X-rays from a material that has been excited by bombarding with high-energy X-rays or gamma rays. The phenomenon is widely used for elemental analysis and chemical analysis, particularly in the investigation of metals, glass, ceramics and building materials, and for research in geochemistry, forensic science, archaeology and art objects such as paintings and murals. Read more

Remote Accessibility:

Nebraska Nanoscale Facility - (Rigaku Supermini200 X)

Fabrication Tools

The following fabrication tools are available:

Raith Voyager Electron Beam Lithography tool

Electron Beam Deposition, Angstrom Engineering, Model 450

Reactive Ion Etching tool, MGP80, Oxford Instruments

Remote Accessibility:

University of Iowa

RAIN

- Nano education **connective tissue** and **tool access** – RAIN Network

- Available for **your use** @ www.nano4me.org/remoteaccess
- Tell a colleague

PennState

www.nano4me.org/remoteaccess

Opportunities to network / shape the national micro-nano direction

MNT^eSIG

MICRO NANO TECHNOLOGY
education
SPECIAL INTEREST GROUP

NACK CENTER
Building College-University Partnerships for Nanotechnology Workforce Development

Become a part of the national MNT community

Mission:

Foster collaboration between educators at all levels, industry, and agencies for relentless improvement ***of the micro and nano technology workforce.***

https://www.mntesig.net

PennState

1. **Professional Development**
2. **Curriculum**
3. **Outreach and Recruitment**
4. **Industry**
5. **Distance Education**

Join an MNT Working Group

Opportunities for High Schools

Natural Sciences & Technologies

- Lecture topics in Earth Science, Chemistry, Biology, Physics
- Laboratories possible via remote access, or combination of in-class local and remote access
- Laboratory experiments in Forensics (gunshot residue using EDS)
- Laboratory experiments In Construction/Building Trades (Sulphur detection in wallboard/sheetrock using EDS)
- Laboratory experiments in Machining (view cutting edge on endmills to compare new and used bits using SEM)
- Laboratory experiments for Beautician (view split ends under SEM, treat with hair products and then compare the following week(s))

Academic Micro-credentials

- Students can earn college credits via Advanced Studies / Middle Early College / Early College High School etc. (names vary regionally)
- Students can potentially earn an academic micro-credential in a chosen technology area, whether from a local college or via remote access from a college in another region or state. (More on micro-creds later)

Opportunities for Two Year Colleges

Individual Courses

- Either a single course can be introduced into, or the material can be added into several courses in Majors such as:
  - Electrical, Mechanical, and Electro-Mechanical Engineering Technology
  - Mechatronics, Manufacturing Technology, Biotechnology
  - Engineering Science, Materials Science
  - Biology, Chemistry, Physics

Academic Micro-credentials

Not all university systems and private colleges have implemented micro-credential policies. Within SUNY, a micro-credential is defined as:

- 6 - 23 credit hours of study
- Can (and should) be stackable towards a certificate or degree program
- Should be a course grouping wanted by industry
- Only needs to be approved at the individual campus via traditional governance committees, System or State approval not required
- The award will show up on the student's academic transcript

Certificate Program (typically one year of study)

Usually offered based on needs of local industry. Some examples:

- MEMS – Lorain County CC (OH)
- Microscopy – Salt Lake CC (UT)
- Vacuum Technology – Normandale CC (MN)
- Semiconductor Technology – Hudson Valley CC (NY)
- Nanotechnology – Ivy Tech CC (IN)
- Biotechnology – Lone Star College (TX)

Associate Degrees

Usually based on local, State, or Regional needs. Some examples:

- Microelectronics – Portland CC (OR)
- Nanotechnology – Erie CC (NY)
- Electron Microscopy – San Joaquin Delta College (CA)
- Advanced Materials Technology – Northwest Vista College (TX)
- Biotechnology – Forsyth Tech CC (NC)
- Nanofabrication Manufacturing Technology – Montgomery CCC (PA)