The National ATE Center for Nanotechnology Applications and Career Knowledge (NACK)

Webinar Handout

K-12 Resources in Nanotechnology

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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.

Additional Resources

Internet Resource List by Joyce Palmer Allen

Multi-media

AMNH
This link portrays geologic time on a 24 hour clock = 4.5 billion years of Earth's existence, but maybe same thing could be done with size scale.
http://www.amnh.org/education/resources/rfl/web/earthmag/peek/pages/clock.htm

AFM
Shows how an AFM works
http://www.parkafm.com/AFM_guide/how_afm_works.php

American Chemical Society Nanotation
(journal)
http://community.acs.org/nanotation

Apples to Atoms Lesson
Apples to atoms
http://community.nsee.us/index.php?option=com_content&view=article&id=102:apples-to-atoms

Azonano
Video with discussion of how ferrofluid works.
http://www.azonano.com/nanotechnology-video-details.aspx?VidID=160

Carbon

The following sites can be used for finding properties of carbon allotropes

*Wikipedia – http://en.wikipedia.org

Properties of Diamonds –http://www.stevesque.com/research/

Diamonds – http://ist-socrates.berkeley.edu/~eps2/wisc/Lect6.html

Graphite Properties Page by John A. Jaszczak –

http://www.phy.mtu.edu/~jaszczak/graphprop.html

The World of Carbon – http://invsee.asu.edu/nmodules/Carbonmod

Properties of Carbon and C60 – http://www.creative-science.org.uk/propc60.html

Fullerene, C60 -

http://www.chemicalland21.com/arokorhi/industrialchem/organic/FULLERENE%20C60.htm

Physical Properties of Carbon Nanotubes –http://www.pa.msu.edu/cmp/csc/ntproperties/

Carbon Based Computers
Pod cast over carbon based computers.
http://www.nsf.gov/news/mmg/mmg_disp.jsp?med_id=75200&from=
One of the examples that can be found at NSF Multimedia Gallery at
http://www.nsf.gov/news/mmg/?s=4&page=1

CDC
Resource
http://www.cdc.gov/niosh/topics/nanotech/

Center for Advanced Materials & Nanotechnology
Lehigh University resource page
http://www.lehigh.edu/nano/

Center for Affordable Nanoengineering of Polymeric Biomedical Devices at Ohio State University: Lessons that can be used in high school classrooms.
http://www.nsec.ohio-state.edu/outreach_la.html

Central UCLA
http://cnsi.ctrl.ucla.edu/nanoscience/pages/homepage
Contains experimental units that include Biotoxicity, Photolithography, Self-Assembly, Solar Cells, Super Capacitors, Super Hydrophobic surfaces, Water Purification

Chemeddl
Online tutorials provide ways for students to visualize organic molecules, translating them from "flat" molecules to manipulable 3-D structures.
http://www.chemeddl.org/resources/stereochem/threed1.htm

Cleanroom
http://www.mcrel.org/nanoleap/remote_acess/cleanroom.asp
Dr. Mike Deal leading a remote cleanroom tour at Ga Tech MiRC
http://grover.mirc.gatech.edu/cameras
A view inside the cleanroom at MiRC.

Concord Consortium-Molecular Literacy Project and Molecular Workshop: Interactive simulations and lessons for biotechnology and nanotechnology.
http://molit.concord.org
http://mw.concord.org/

Consumer Product Safety Commission
As more consumer products employ nanotechnology, concerns are increasing regarding potential health effects associated with human exposure to this technology.
http://www.nano.gov/node/139

Cornell University Center for Materials Research: Teacher resources & lending library of experiments
http://www.ccmr.cornell.edu/education

Cosmic View
Has "Cosmic view: The universe in 40 jumps"
http://www.vendian.org/mncharity/cosmicview/pages/page35.html

Diigo (nanotechnology web-seminars)
The National Science Digital Library resource page
http://www.diigo.com/list/nsdlworkshops/web-seminar-nano

DiscoverNANO at Northwestern University: Nano101, history and lessons.
http://www.discovernano.northwestern.edu/

DFT PRESS
http://www.dftvpress.org/index.html
Lessons include Size and scale, Scanning Probe Microscopy, The Music of Spheres, The allotropes of Carbon, Why does a light bulb burn out, Modern Information Storage Media, the Five Kingdoms of biology (yeast), What is Friction, What is that in your dog dish (microbes and biofilms), Iridescence, Biominerals, Biological Structural materials, Engineered Materials, the World of Liquid Crystals, DNA-Infinite Variety in such small packets, the Morphology and use of Gold films, Osmotic Pressure in Red Blood Cells and Plant Cells

Dragonfly TV-Nanosphere: Videos on nanotechnology with games, activities and interviews with scientists.
http://pbskids.org/dragonflytv/nano/index.html

EDKIT
Curricula explore the concept of characterization, and the development of scientific tools. Five part unit that has evaluation instruments.
http://www.stanford.edu/group/cpima/education/EDKIT/html/probemain.htm

Engineering –Go for It!: Lessons, activities, resources on engineering including nanotechnology.
http://teachers.egfi-k12.org/

EPA Center for Environmental
Implications of Nanotechnology
http://www.ceint.duke.edu/

Ferrofluid
Explains what ferrofluid is and how it works.
http://mrsec.wisc.edu/Edetc/background/ferrofluid/index.html

Foresight
Foresight's mission is to:

- speed development of nanotechnology and other key fundamental technologies,
- promote beneficial uses of these revolutionary technologies, and
- reduce misuse and accidents potentially associated with them.
  http://www.foresight.org/

Student resources such as institutes that give nano degrees, research and Internships
http://www.foresight.org/cms/resources/58

GeckoMan
A nanotechnology forces game from Northeastern University.
http://www.northeastern.edu/chn/geckoman/

Institute for Chemistry Education at University of Wisconsin-Madison: Lessons for the K-12 science classrooms & after school groups.
http://ice.chem.wisc.edu/

Inspire STEM Education
A website from our education partner, Hitachi America. Contains information primarily related to **scanning electron microscopy** including a cartoon booklet on SEM ,lesson plans , and information on how you can BORROW a scanning electron microscope for your classroom

Institute of Nanotechnology.
Lots of great nanoscale images.
http://www.nano.org.uk/images.htm

Intel
Videos and curriculum related to computer chips, clean rooms, technology , etc.
http://www.intel.com/museum/onlineexhibits.htm
http://educate.intel.com/en/thejourneyinside

Kavli Foundation
In dept interview with George Whiteside (50 minutes long) In this special interview, Professor Whitesides discusses nanoscience. He describes how nanoscience may change our society forever, as well as the way we think about the small scale. He also points out several observations about our current technologies and where nano-technologies may lead us.
http://www.kavlifoundation.org/nanoscience-george-whitesides

Materials World Modules and National Center for Learning and Teaching in Nanoscale Science & Engineering:
Instructional materials & video broadcasts
http://www.nclt.us
http://www.materialsworldmodules.org/

Matter of Scale
Of Mice and Elephants: A Matter of Scale -- Good overview of the development of scaling laws in the 1980s and 1990s, including an extension from the animal world into the plant world. Nice discussion of the universality of these laws revealing underlying pattern and structure.
The link From the Small to the Huge, how body size and energy consumption differ on this site goes to a picture of a log-log graph and elephant comparing the metabolic rates of mammals which shows that bigger mammals are more efficient in energy consumption.
The link Like an Ant, Only Bigger?, strength vs. proportion on this site goes to a picture of Superman and an explanation from DC Comics that Superman's strength comes from different scaling laws on his home planet of Krypton.
http://hep.ucsb.edu/courses/phb_99/0111299si=ci-scaling.html

McRel
Physical science unit from Mcrel that connects nano to forces and interactions.
http://www.mcrel.org/nanoleap/ps/index.asp
Chemistry unit on Nanoscale materials and their properties
http://www.mcrel.org/nanoleap/chemistry/index.asp
Library of resources that include videos, animations, interactives, remote access.
http://www.mcrel.org/nanoleap/multimedia/index.asp

MegaPenny Project
The MegaPenny Project aims to help by taking one small everyday item, the U.S. penny, and building on that to answer the question: "What would a billion (or a trillion) pennies look like?" Site provides a nice concrete anchor for students' conceptions of quantity.
http://www.kokogiak.com/megapenny/default.asp

MicroMagnet
Web site that has size and scale video Secret Worlds: The Universe within and also information about microscopes, and a gallery of images.
They have an online guidebook for teachers on the resources available on the website.
http://micro.magnet.fsu.edu

Miami Science
Pacing Earth' history using galactic orbits.
http://www.miamisci.org/ph/lpextend1.html

Modules
Good scale charts (logarithmic with images of objects and which microscopes function at which scale). Has figure captioned "Scale of our material world: from galaxies to atoms." Also has diagram "overview of the history of microscopes" including chart of when developed and scale of use.
http://invsee.asu.edu/Modules/size&scale/unit3/unit3.htm

Molecular Expressions Virtual Microscopy Website
Includes an interactive Java-powered virtual microscopes that we have constructed. These virtual microscopes explore specimen focus, illumination intensity, magnification, and translation---operating essentially in a manner that is identical to real-life microscopes.
http://micro.magnet.fsu.edu/primer/virtual/virtual.html

Molecular Workbench Project.
Describes software that allows students to enter the atomic-scale world and see what the results of their experimentation in the macroworld, such as increased salinity, has on the atomic-scale world. They can create their own simulations. Other simulations available include Transistor, STM, Semiconductor, Plasma, Molecular Rover, Chemical Bonding, Chemical resp, Diffusion, Heat and temperature, Electrostatics, Phase Change, DNA to Protein, Mission: Immunity, Lipids and Carbs, Tree of Life, Proteins and DNA , Harvest of Light, Quantum Mechanics, Crystallography, ELISA, STM, Transistor, Plasma, Semiconductor
http://mw.concord.org

Molecularium
Teacher Guide & "Kid's site" about the atomic world—From Rensselaer Polytechnic Institute.
http://www.molecularium.com/
Has teacher resource guides for grades K-4 and also Molecules to the Max for grades 5-8.
http://nanospace.molecularium.com/

MRSEC at University of Wisconsin-Madison:
A variety of kits and resources focused on nanoscale science and engineering, including societal and environmental issues.
http://education.mrsec.wisc.edu/modules/index.html

Multi-Media
Multi-Scale graph of objects that you can sort by size
http://www.mcrel.org/nanoleap/multimedia/nanosize_me.swf

Nanopolis (Exploring Nanotechnology)
http://nanotech.nanopolis.net

NBTC
(NBTC) It's a Nanoworld - a traveling 3,000 square feet hands-on, interactive museum exhibition that introduces children (5-8 yrs old) and their families to the biological wonders of the nano world .
http://www.nbtc.cornell.edu/

Nano Dictionary
Dictionary of nano terms - including visuals.
http://nanodic.com/

Nano Education Portal of the Nanotechnology Center for Learning & Teaching (NCLT)
http://community.nsee.us/index.phpoption=com_content&view=frontpage&Itemid=227

NanoExperiences: SMALL SCIENCE. BIG OPPORTUNITIES.
NanoEx is a hands-on, minds-on, career-creating opportunity! Learn cool, real-world nanoscience and technology. Build important relationships. Uncover your own strengths and potential in the workforce. Develop key job skills. Have fun doing it!
http://www.nanoexperiences.org/

NanoHUB
Online simulation for nanotechnology and also includes high school and middle school resources to get to their pages.
http://nanohub.org/groups/ms
http://nanohub.org/groups/hs

Nano-Infusion
NanoInfusion is Nano-Infusion promotes integration and inclusion of nanoscale concepts into high school and college level education. Lessons include crystals, magic sand, mystery fish of science, cross link polymers, ring polymers, sunscreen, thin films.
http://www.nano-link.org/nano-infusion-project/what-is-nano-infusion

National Institute of Standards & Testing
Resources
http://www.nist.gov/nanotechnology-portal.cfm

Nano For Me
NACK's mission is to provide quality Resources to K-12 & Post-Secondary educators. Nano4me Resources are free for registered users.
http://nano4me.org/educator-resources.php

NanoKids
The NanoKids™ educational outreach program is dedicated to increasing public knowledge of the nanoscale world and the emerging molecular research and technology that is rapidly expanding internationally. Based on actual anthropomorphic molecules synthesized in the laboratory, the NanoKids™ visual concept utilizes universally recognized forms exhibiting human characteristics to instruct, motivate, and entertain.
http://www.nanokids.rice.edu/

Nano-Link
Classroom materials.
http://www.nano-link.org

NanoLeap
Two units, one physical science and one chemistry that promote interdisciplinary nanoscale core concepts.
http://www.mcrel.org/nanoleap/

NanoMission
NanoMission(TM) is a cutting edge gaming experience which educates players about basic concepts in nanoscience through real world practical applications from microelectronics to drug delivery. Must register to play games such as Nanomedicine or Nanoscaling.
http://nanomission.org/

Nanooze
A Nanocure game that is on the Nanooze web site.
http://www.nanooze.org/english/games.html
Online and print magazine with some information on the website.
http://www.nanooze.org/main/Nanooze/English.html

Nanoreisen
A virtual discovery journal into the worlds of micro-and nano-cosmos.
http://www.nanoreisen.de/

Nanoscience Instruments
Downloads, scanning probe microscope animation gallery, online simulations,
http://www.nanoscience.com/education/index.html

Nanoscale
Simulations and also a variety of resources on the nanoscale.
http://concord.org/search/node/Nanoscale

NanoSense
Lesson plans and activities designed for teaching nanoscience at the high school level.
http://nanosense.org/
Units that include Size Matters, Clear Sunscreen, Clean Energy, Fine Filters
http://nanosense.org/activities.html

NanoTecNexus
Bringing together business and education.
http://www.nanotecnexus.org/nanobionexus

Nanowerk
Has a tab called Introduction to Nanotechnology where there is a definition to nanotechnology and other items.
http://www.nanowerk.com/

Nano You (European Union)
NANOYOU (Nano for Youth) is a project funded by the European Commission's Seventh Framework Programme that aims to increase young people's basic understanding of nanotechnologies (NT) and to engage in the dialogue about its ethical, legal and social aspects (ELSA).
http://nanoyou.ed

Nanozone at the Lawrence Hall of Science
Interactive games, videos, scale, and meet a scientist—in the Nanozone!
http://nanozone.org

National Cancer Institute
Resource information on nanotechnology in cancer treatment.
http://nano.cancer.gov/learn/

National Nanotechnology Initiative
NNI (not to be confused with NNIN) is the overarching program encompassing all U.S. government nanotechnology activities. This site has an Education Center link which provides information for K-12 students and teachers.
http://www.nano.gov

Resources from NNI for teachers. They also have resources for students K-12 and undergrad and graduate students.
http://www.nano.gov/education-training/teacher-resources

National Nanotechnology Infrastructure network (NNIN)-
Nano Educational Portal
http://www.nnin.org/nnin_edu.html

Nano Letters
(journal)
http://pubs.acs.org/journal/nalefd

Nano-World
Swiss virtual site. Has a site where you can see inside a nano lab at
http://www.nano-world.org/nano/en

NanoZone
Educational resource for children.
http://nanozone.org/index.htm

NASA
Research in nanotechnology supported by NASA
http://www.nasa.gov/centers/ames/research/technology-onepagers/nanotechnology-landing.html

Voyage of the Nano-Surgeons -NASA-funded scientists are crafting microscopic vessels that can venture into the human body and repair problems – one cell at a time.
http://science.nasa.gov/headlines/y2002/15jan_nano.htm

National Institute of Standards & Testing
Advancing nanoscale measurement science, standards, and nanotechnology is an important component of NIST's mission to promote U.S. innovation and industrial competitiveness.
http://www.nist.gov/nanotechnology-portal.cfm

Nature
Web site where you can get current research in nanoscale science and engineering.
http://www.nature.com/nnano/index.html

Next Big Future
Covers current news about nanotechnology
http://nextbigfuture.com/

New Scientist
Graphic showing objects down to the nanoscale.
http://www.newscientist.com/movie/nanotechnology-interactive

NIOSH Safety & Health Topic: Nanotechnology
Online resource data
http://www.cdc.gov/niosh/topics/nanotech/about.html

NISENET
The NISE Net is a national community of researchers and informal science educators dedicated to fostering public awareness, engagement, and understanding of nanoscale science, engineering, and technology.
http://www.nisenet.org/

NSEE
List of units that teachers can download or purchase
http://community.nsee.us/index.php?option=com_content&view=category&id=71:nano-lessons-and-courses-&Itemid=74

NSF
NSF website that shows discoveries in the area of Nanoscience.
http://www.nsf.gov/discoveries/index.jsp?prio_area=10

Paper Cube
Paper cube you can print off comparing sizes.
http://www.vendian.org/howbig

PBS
Has 58 nanotechnology related items in the teachers resources section. Example is a video Nano:Kids on Nanotechnology for grades 4-6.
http://www.pbslearningmedia.org

Nova Making Stuff Series (2011):
http://www.pbs.org/wgbh/nova/tech/making-stuff.html

Hour-long video series on how nanotechnology is making stuff stronger, smaller, cleaner, and smarter.
How Small Is A Nanometer? (You Tube)
http://www.youtube.com/watch?v=o2aas8P_jgY

Powers of Ten
From the “Time” portion of the website (at 10 ^19 seconds), LINKS BETWEEN LARGE AND SMALL 10+19 seconds is 300 billion years or 100 times the age of the Moon--a time period far beyond our realm.
http://www.powersoften.com/

Powers of Ten
http://www.wordwizz.com/pwrsof10.htm

Powers of Ten
Relates pH to powers of 10 (an example of a logarithmic scale).
http://www.miamisci.org/ph/hextend1.html

Powers of Ten
Students create mathematics manipulatives to explore powers of ten.
http://www.miamisci.org/ph/lpextend1.html

Scale Diagram
A length scale diagram
http://www.alcyone.com/max/physics/orders/metre.html

Scales and Timelines
A variety of scales and timelines including geological, evolutionary and cosmological
http://www2.astro.psu.edu/users/niel/scales/scales.html

Scaling the Universe to Your Desktop
Scaling the Universe to your Desktop -- Jumps by three orders of magnitude to develop a sense of relative scale within those three orders of magnitude, then links from one jump to the next larger or smaller. “Rooms” each contain objects spanning 3 orders of magnitude within them.
http://www.vendian.org/envelope/dir1/scaling_to_desktop.html

ScienceCentral, Inc
Information and videos on current research, including nanotechnology.
http://www.sciencentral.com

Sciencedaily (Nanotechnology)
The latest news in research.
http://www.sciencedaily.com/news/matter_energy/nanotechnology

Science Museum UK Online: Information about nanotechnology and how scientists are using it to improve our daily lives. Includes an interactive game.
http://www.sciencemuseum.org.uk/antenna/nano/

Southwest Center for Microsystems Engineering (SCME)
Center resource
www.scme-nm.org

Self- Assembly
Shows examples of self-assembly by capillary forces, electrostatic forces and magnetic forces.
http://www.math.udel.edu/MECLAB/Projects/SelfAssembly/selfassembly1.htm

SEM
Photography captured through scanning electron microscopes showing small structures.
http://vimeo.com/5108749
Video showing how an Electron Microscope works. http://wn.com/Scanning_Tunneling_Microscope

Size and Scale
Interactive size and scale chart.
http://learn.genetics.utah.edu/content/begin/cells/scale

Size and scale
Resources for teaching size and scale including a size and scale cube.
http://www.vendian.org/howbig/

Small Times
Nanotech articles
http://www.electroiq.com/nanotech.html

Technyou
Lessons from an Australian site. Nano lessons include Properties, Personal Care, Space elevator, Memory Shape Alloy, Investigating Forms of ?Carbon, Scale and measurement, The Nanotechnology Scale, Glass, Social Issue, Textiles, Performance Materials, Scale and new Technologies, Critical thinking, Gold, health and medicine.
http://education.technyou.edu.au/curriculum

The Nanotechnology Group Inc.
http://www.tntg.org/

The Project on Emerging Nanotechnologies (PEN)
http://www.nanotechproject.org

Try Nano
Resources, lessons, general information.
http://www.trynano.org/resources.html

UCLA: California Nanosytems Institute
High School nanoscience program with lessons.
http://cnsi.ctrl.ucla.edu/nanoscience/pages/

Understanding Geologic Time
Has explorations through time including "Understanding Geologic Time."
http://www.ucmp.berkeley.edu/education/explotime.html

University of Illinois at Urbana-Champaign: CEMMS
Online labs that include nano-silver, gold and investigating chocolate.
https://nano-cemms.illinois.edu/materials

USDA
Nanotechnology at the USDA.
http://www.csrees.usda.gov/nanotechnology.cfm

Vega Science Trust, England
Videos on a range of science topics including nanotechnology & how it will change the world. Includes interviews with Nobel Prize winners
http://www.vega.org.uk/
http://www.vega.org.uk/video/programme/3

Project on Emerging Nanotechnology at Woodrow Wilson International Center: This site contains many resources related to society and the safe development of nanotechnology. The site also has a list of currently available consumer products.
http://www.nanotechproject.org/

University of Puerto Rico
Resource
http://www.upr.edu/

Virtual Lab-University of Virginia: Interactive animations on nanotechnology related topics including Atomic Force Microscopes, Scanning tunneling Microscopes, Transistors, Integrated Circuits, CD/DVD Players, DNA
http://virlab.virginia.edu/VL/home.htm

Wisconsin
Project engages adults in weighing the benefits and risks of nanotechnology in areas such as health care, energy, and defense.
http://ice.chem.wisc.edu/NanoDecisions/index.html

Web site uses interactive tutorials to introduce middle school and high school students to current chemistry and engineering research.
http://ice.chem.wisc.edu/TSTS.html