Teacher's Guide

Nanooze and Teaching Middle School STEM

Nanooze is designed for grades 5-8 and is considered a physical science publication but because it is about nanoscale science and engineering it also covers topics from the life sciences and chemistry.
Nanooze is available at: www.nanooze.org and http://www.nnci.net/nanooze. Classroom packs (30/pack) of each of the 16 issues are available for free (issues 1 and 2 are out of print). Contact info@nanooze.org to request issues. **PLEASE NOTE:** If multiple teachers at one school plan to order issues, please combine your orders so that one shipment can be made.

***Nanooze* and NGSS**
Grade 5

- **5-PS1 Matter and Its Interactions**
  - PS1.A: Structure and Properties of Matter
  - Crosscutting Concepts
    - Cause and Effect
    - Scale, Proportion, and Quantity
- **5-ESS3 Earth and Human Activity**
- 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
  - Crosscutting Concepts
    - Science Addresses Questions about the natural and material World.
    - Science findings are limited to questions that can be answered with empirical evidence. (5- ESS3-1)
- **3-5-ETS1 Engineering Design**
  - Crosscutting Concepts
  - Influence of Engineering, Technology, and Science on Society and the Natural World
    - People's needs and wants change over time, as do their demands for new and improved technologies. (3- 5-ETS1-1)
    - Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands. (3-5-ETS1-2)
- **Connections to ELA/Literacy**
  - RI.5.7 Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently. (5-PS1- 1)
  - W.5.7 Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic. (5-PS1-2),(5-PS1-3),(5-PS1-4)
  - W.5.8 Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources. (5-PS1-2),(5-PS1-3),(5-PS1-4)
  - W.5.9 Draw evidence from literary or informational texts to support analysis, reflection, and research. (5-PS1-2),(5-PS1-3),(5-PS1-4)

- **Connections to Mathematics –**
  - 5.NBT.A.1 Explain patterns in the number of zeros of the product when multiplying a number by powers of 10, and explain patterns in the placement of the decimal point when a decimal is multiplied or divided by a power of 10. Use whole-number exponents to denote powers of 10. (5-PS1-1)
  - 5.MD.A.1 Convert among different-sized standard measurement units within a given measurement system (e.g., convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real-world problems. (5-PS1-2)
  - 5.MD.C.3 Recognize volume as an attribute of solid figures and understand concepts of volume measurement. (5-PS1-1)
  - 5.MD.C.4 Measure volumes by counting unit cubes, using cubic cm, cubic in, cubic ft, and improvised units. (5-PS1-1)

Middle School Science

- **Connections to ELA/Literacy**
  - RST.6-8.1 Cite specific textual evidence to support analysis of science and technical texts.
  - RST.6-8.2 Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.
  - WHST.6-8.1 Write arguments focused on discipline content.
  - WHST.6-8.2 Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.
  - WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
  - WHST.6-8.8 Gather relevant information from multiple print and digital sources, using search terms effectively; assess the credibility and accuracy of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and following a standard format for citation.
  - WHST.6-8.9 Draw evidence from informational texts to support analysis, reflection, and research.

Connections to Nature of Science

- Scientific Knowledge Assumes an Order and Consistency in Natural Systems
  - Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.
- Science Addresses Questions about the Natural and Material World
  - Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes.
- Science is a Human Endeavor
  - Advances in technology influence the progress of science and science has influenced advances in technology. (MS-PS4-3)

Connections to Engineering, Technology, and Applications of Science

- Interdependence of Science, Engineering, and Technology
  - Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.
  - The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by

differences in such factors as climate, natural resources, and economic conditions.
    - Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations.

Middle School Physical Science

- **MS-PS1 Matter and its Interactions**
    - MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.
    - MS-PS1-3. Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.
- **DCI**
    - **PS1.A: Structure and Properties of Matter**
    - **Crosscutting Concepts**
        - **Patterns**
        - Macroscopic patterns are related to the nature of microscopic and atomic-level structure. (MS-PS1-2)
        - **Cause and Effect**
        - Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS1-4)
        - **Scale, Proportion, and Quantity**
        - Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small. (MS-PS1-1)
        - **Energy and Matter**
        - Matter is conserved because atoms are conserved in physical and chemical processes. (MS-PS1-5)
        - The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS1-6)
        - **Structure and Function**
        - Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used. (MS-PS1-3)
- **MS-PS2 Motion and Stability: Forces and Interactions**
    - MS-PS2-4. Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects.
    - MS-PS2-5. Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
- **DCI**
    - PS2.A Forces and Motion
    - PS2.B Types of Interactions
- **Crosscutting Concepts**
    - Cause and Effect
    - Systems and System Models
        - Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. (MS-PS2-1),(MS-PS2-4)
    - Stability and Change
        - Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales. (MS-PS2-2)

- **MS-PS3 Energy**
    - MS-PS3-3. Apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer.
- **DCI**
    - PS3.A: Definitions of Energy
    - PS3.C: Relationship between Energy and Forces
- **Crosscutting Concepts**
    - Scale, Proportion, and Quantity
    - Systems and System Models
    - Energy and Matter
- **MS-PS4 Waves and Their Applications in Technologies for Information Transfer**
    - MS-PS4-2. Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.
- **DCI**
    - PS4.A: Wave Properties
    - PS4.B: Electromagnetic Radiation
- **Crosscutting Concepts**
    - Patterns
        - Graphs and charts can be used to identify patterns in data. (MS-PS4- 1)
    - Structure and Function

Middle School Life Science

- MS-LS1 From Molecules to Organisms: Structures and Processes
- MS-LS1-8. Gather and synthesize information that sensory receptors respond to stimuli by sending messages to the brain for immediate behavior or storage as memories.
- **DCI**
    - LS1.A: Structure and Function
        - All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular). (MS-LS1-1)
- **Crosscutting Concepts**
    - Cause and Effect
    - Scale, Proportion, and Quantity
    - Systems and System Models
    - Energy and Matter
    - Structure and Function

Middle School Earth Science

- **MS-ESS1 Earth's Place in the Universe**
    - MS-ESS1-3. Analyze and interpret data to determine scale properties of objects in the solar system.
- **DCI**
- **ESS1 .A: The Universe and Its Stars**
    - Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (MS-ESS1-2)
- **Crosscutting Concepts**
    - Scale, Proportion, and Quantity

***Nanooze* and Lessons:**

Lessons on size and scale can be used with any issue as each volume has a section on what is nanotechnology. To understand the nanoscale, students must understand how small it is. In addition, any discussion of nanotechnology should begin with size and scale. Below are activities to help students with size and scale.

Size and Scale: Number line/size sorting:
http://nanosense.sri.com/activities/sizematters/sizeandscale/SM_Lesson2Student.pdf;
https://www.nnci.net/node/5305;
http://wise.ssl.berkeley.edu/documents/scalerealmsuniverse.pdf;
https://www.nnci.net/node/5392

Interactives:
http://www2.mcrel.org/NanoLeap/multimedia/
http://www2.mcrel.org/NanoLeap/multimedia/Nanosize_me.swf
http://scaleofuniverse.com/
http://www.eamesoffice.com/the-work/powers-of-ten/
http://www.cneu.psu.edu/edToolsActivities.html
http://www.cellsalive.com/howbig.htm
http://micro.magnet.fsu.edu/primer/java/scienceopticsu/powersof10/

Game:
http://www.nisenet.org/catalog/programs/exploring_size_-_powers_ten_game_nanodays_2011

Lessons:
How Big is a Nanometer? - https://www.nnci.net/node/5388
How Small is That? - https://www.nnci.net/node/5290
Noodling Around - https://www.nnci.net/node/5389
Powers of Ten with the Blue Morpho Butterfly - https://www.nnci.net/node/5313
Shrink Me - https://www.nnci.net/node/5380

Issue #3: The Five Senses Part 1 "Seeing"
Lessons:
Powers of Ten with the Blue Morpho Butterfly - https://www.nnci.net/node/5313 (magnification lesson)
Micro Macro Worlds - https://www.nnci.net/node/5390
Lego AFM - https://www.umassk12.net/nano/materials/AFMlego.pdf
Be a Scanning Probe Microscope - http://tryengineering.org/lessons/spm.pdf
Scanning Probe Microscopy - https://www.nnci.net/node/5334
Understanding Waveguides - https://www.nnci.net/node/5387 (exploring light)
Graphics: Bits and Points - http://tryengineering.org/lesson-plans/graphics-bits-and-points (pixels)
Stations of Light - https://www.teachengineering.org/activities/view/cub_energy2_lesson03_activity1 (elementary)
Investigating light - https://www.teachengineering.org/lessons/view/cub_soundandlight_lesson6 (elementary)
Exploring Light - https://www.teachengineering.org/activities/view/van_troll_lesson02_activity1 (middle)

Diffraction Glasses – What's in a color? - https://spie.org/Documents/resources/diffraction%20glasses%20worksheet.pdf
Spectra of Lights: An Interactive Demonstration with Diffraction Gratings https://www.globeatnight.org/dsr/dsee/Dark%20Skies%20Activities/Spectra%20of%20Lights%20Activity/Spectra%20of%20Lights%20Activity.pdf
Diffraction Grating - http://www.diffractiongrating.com/our_services.html
Measuring Light Pollution: http://teachers.egfi-k12.org/measuring-light-pollution/
Mini Manipulation of Light in the Nanoworld - https://www.materialsworldmodules.org/index.php/modules-and-user-support/mini-modules/mini-light-module

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Issue #4 The Five Senses Part 2: "Smell" and "Taste"
Lessons:
Exploring Size – Scented Balloons http://nisenet.org/catalog/programs/exploring_size_-_scented_balloons; using scented balloons students can explore that they can smell things that are too small to see. Also can be used to discuss concentrations and how molecules will move from a higher pressure to a lower pressure.
Exploring Products – Nano Food http://nisenet.org/catalog/exploring-products-nano-food; simple demo to show how the size of the food can impact taste.
Investigating Chocolate - http://nano-cemms.illinois.edu/materials/investigating_chocolate_desc.html
Silver Socks - https://www.nnci.net/node/5331 (high school lesson but to use with younger students use colloidal silver)
Smell Experiments grades 1-6 - https://faculty.washington.edu/chudler/chsmell.html
Taste experiments grades 6-12 - https://faculty.washington.edu/chudler/chtaste.html
Mystery of the Senses – Smell - http://www.pbs.org/wgbh/nova/education/activities/22s2_smell.html
Mystery of the Senses – Taste - http://www.pbs.org/wgbh/nova/education/viewing/22s3_taste.html
A Tasty Experiment - http://teachers.egfi-k12.org/tasty-experiment/
Taste Investigations - http://sciencounters.chem.wisc.edu/node/22

Issue #5 The Five Senses Part 3 "Touch" and "Sound"
Lessons
My Mechanical Ear Can Hear - https://www.teachengineering.org/lessons/view/cub_biomed_lesson06
Teach Engineering – search for hearing aid lessons (www.teachengineering.com)
Robot Sensors and Sounds - https://www.teachengineering.org/activities/view/umo_sensorswork_lesson01_activity1
Teach Engineering - search for touch screens (www.teachengineering.com)
Oobleck lessons to explore how liquid armor may work -- http://beam.ucla.edu/sites/default/files/docs/Oobleck.pdf; http://seplessons.ucsf.edu/node/3465
Oobleck The Cornstarch And Water Experiment ScienceBob.com. https://sciencebob.com/oobleck-the-corn-starch-and-water-experiment/
Funny Putty – Serious Stuff - http://teachers.egfi-k12.org/funny-putty/
Understanding Wave Motion - https://www.nnci.net/node/5325
Understanding Wave Guides - https://www.nnci.net/node/5387
Hearing experiments - https://faculty.washington.edu/chudler/chhearing.html
Touch experiments - https://faculty.washington.edu/chudler/chtouch.html
Your Skin - http://faculty.washington.edu/chudler/receptor.html
The Ear Game: http://www.nobelprize.org/educational/medicine/ear/game/index.html

Sound Wave Reflections - http://teachers.egfi-k12.org/lesson-sound-wave-reflections/

Issue #6 Self Assembly

Lessons

Bubbles and Biosensors - https://www.teachengineering.org/activities/view/van_oddsofcancer_lesson02_activity1 (high school)

Bubbles – assorted resources and activities -http://www.proteacher.com/110070.shtml

Dry Ice bubbles and self assembly – *Demonstrations to Save the World* by Tom Brown and Michael Dias Science Scope 2003 p.20. (available at NSTA.org)

Exploratorium's Bubble page – http://www.exploratorium.edu/ronh/bubbles/

Giant Dry Ice Bubble Sphere - https://sciencebob.com/the-giant-dry-ice-bubble-sphere/

Thin Films - Demo at SENIC Nanotech Demo Guide http://senic.gatech.edu/education-and-outreach/education-resources/

Nanoscale thin films - http://umassk12.net/nano/materials/web2015/rob/oleic.html

Modeling Self Assembly - https://www.nnci.net/node/5614 (middle school version)

Self Assembly - http://highschoolnanoscience.cnsi.ucla.edu/experiments Permission to access lesson is required (see SENIC demo guide for short version: http://senic.gatech.edu/wp-content/uploads/sites/239/2016/07/SENIC-Outreach-Demo-Guide-04-16.pdf)

Snowflake lessons - http://beyondpenguins.ehe.osu.edu/teaching-about-snowflakes-a-flurry-of-ideas-for-science-and-math-integration; (K-4)

https://gpb.pbslearningmedia.org/resource/lsps07.sci.phys.matter.lpsnowflakes/why-do-snowflakes-come-in-so-many-shapes-and-sizes/#.WOPVDOQm7IU (middle grades)

Exploratorium bubble lessons - https://www.exploratorium.edu/snacks/tag/bubbles

Molecular Workbench Self Assembly simulation - http://mw2.concord.org/public/student/nano/self.cml Requires Java to use MW simulations- http://mw.concord.org/modeler/

Insulators and Conductors - http://tryengineering.org/sites/default/files/lessons/insandcond.pdf

Is it Shocking? https://www.teachengineering.org/activities/view/ucd_electricity_lesson01_activity1

Issue #7 The Food Issue

Lessons

Edible encapsulation - see SENIC Nano Demo Book for Dragonfly TV activity - http://senic.gatech.edu/wp-content/uploads/sites/239/2016/07/SENIC-Outreach-Demo-Guide-04-16.pdf Dragonfly Nanosphere: http://kids.pbskids.com:8080/dragonflytv/nano/index.html

Exploring Products – Nano Food http://nisenet.org/catalog/exploring-products-nano-food; simple demo to show how the size of the food can affect taste.

Investigating Chocolate - http://nano-cemms.illinois.edu/materials/investigating_chocolate_desc.html

The Secrets of Smart Paper in Journal of Chemical Education - http://pubs.acs.org/doi/abs/10.1021/ed086p464A

Making Stuff Activity Guide (PBS) Magnetic Microbot Models (model of nanomachines) from the PBS series Making Stuff: https://gpb.pbslearningmedia.org/resource/nvms-sci-msactguide/making-stuff-activity-guide/#.WSy_sGiGPIU Visit http://www.bristlebots.org/ to learn more about the model machines used.

Biosensors for Food Safety - https://www.teachengineering.org/lessons/view/mis_biosensors_lesson01 Associated lesson: Who's Hitchhiking in your Food - https://www.teachengineering.org/activities/view/mis_biosensors_lesson01_activity1

Get Biotech Smart - http://www.glassbarn.org/educator-resources/get-biotech-smart/ lessons related to biotechnology and food sources

High Tech Food in your Shopping Cart - http://www.agclassroom.org/teacher/matrix/lessonplan.cfm?lpid=21&search_term_lp=high
Design Challenge: The Ideal Meal http://www.teacherstryscience.org/lp/design-challenge-ideal-meal
Would you Buy That? Nano and safety. http://nisenet.org/catalog/would-you-buy-nanodays-2014
Nano and Society – You Decide http://nisenet.org/catalog/programs/exploring_nano_society_-_you_decide
Helpful Bacteria - https://www.ck12.org/life-science/Helpful-Bacteria-in-Life-Science/lesson/Helpful-Bacteria-MS-LS/
Materials World Modules Food Packaging: http://www.materialsworldmodules.org/index.php/online-store/categories/environment-food-water/food-packaging
Digest This - http://teachers.egfi-k12.org/digest-this/
Snack Attack – Food Packaging - http://teachers.egfi-k12.org/snack-attack-food-packaging/
Package these Foods - http://teachers.egfi-k12.org/package-those-foods/
Mini Food Packaging - https://www.materialsworldmodules.org/index.php/modules-and-user-support/mini-modules/mini-food-module

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Issue #8 The Nanomedicine Issue
Lessons
Edible encapsulation - see SENIC Nano Demo Book for Dragonfly TV activity - http://senic.gatech.edu/wp-content/uploads/sites/239/2016/07/SENIC-Outreach-Demo-Guide-04-16.pdf (use as a model for drug delivery) DragonFly TV Nanosphere: http://kids.pbskids.com:8080/dragonflytv/nano/index.html; https://leelab.engineering.osu.edu/sites/nsec.osu.edu/files/uploads/ModelingNanoparticleEncapsulation.pdf
Microfluidic Devices and Flow Rate - https://www.teachengineering.org/lessons/view/van_feelbetter_lesson02
Making Microfluidic Devices Using Jello - https://www.teachengineering.org/activities/view/van_feelbetter_lesson02_activity_02
Hype or Help: The Ethics of Bio-Nanotechnology - https://www.teachengineering.org/lessons/view/van_feelbetter_lesson02
Lab on a Slab (Microfluidics) - http://www.nnin.org/education-training/k-12-teachers/nanotechnology-curriculum-materials/lab-slab
Gelatin Microfluidics - http://www.nnin.org/education-training/k-12-teachers/nanotechnology-curriculum-materials/gelatin-microfluicics
DNA Extraction - http://www.apsnet.org/edcenter/K-12/TeachersGuide/PlantBiotechnology/Pages/Activity1.aspx; https://www.scientificamerican.com/article/squishy-science-extract-dna-from-smashed-strawberries/; https://www.engr.uky.edu/paducah/files/2011/06/DNA-Fruit-Isolation.pdf; http://teachers.egfi-k12.org/lesson-extract-dna-from-a-banana-2/
Genome: The Secret of How Life Works - http://genome.pfizer.com/docs/teach_act_guide.pdf
DNA Learning Center - https://www.dnalc.org/programs/fieldtrips/msschool.html Lots of lessons by grade level
Digest This - http://teachers.egfi-k12.org/digest-this/
Mini Nanoscale Drug Delivery - https://www.materialsworldmodules.org/index.php/modules-and-user-support/mini-modules/mini-drug-module

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Issue #9 The Space Issue

Lessons

Allotropes of Carbon - http://tryengineering.org/lesson-plans/power-graphene; a variety of activities at: http://education.mrsec.wisc.edu/222.htm

Surface area – https://www.nnci.net/node/5328; http://tryengineering.org/lesson-plans/exploring-nanoscale

Interactive - http://www.shodor.org/interactivate/activities/SurfaceAreaAndVolume/

Game Carbon is 4 Ever - http://homepage.eircom.net/~dizer/carbon/content/selector.htm

http://public.wsu.edu/~omoto/papers/Diffusion.pdf;

http://www.wvhs.wlwv.k12.or.us/cms/lib8/OR01001812/Centricity/Domain/1404/Agar%20Cube%20Lab.pdf;

Faster explosions activity with alka seltzer in: http://senic.gatech.edu/wp-content/uploads/sites/239/2016/07/SENIC-Outreach-Demo-Guide-04-16.pdf

Sugar crystal challenge- http://www.trynano.org/pdf/sugarnano.pdf

DNA – a variety of activities at Teach Engineering:

https://www.teachengineering.org/curriculum/browse?q=dna; Also DNA extraction activities under Issue #7

PCR- BioTech Project: http://biotech.bio5.org/activities;

Paper PCR - http://www.nslc.wustl.edu/elgin/genomics/gsc/PaperPCR.pdf; PCR animation - https://www.dnalc.org/resources/animations/pcr.html

Biomimicry - http://teachers.egfi-k12.org/biomimicry-natural-designs/; http://teachers.egfi-k12.org/index.php/?s=biomimicry; http://tryengineering.org/lesson-plans/biomimicry-engineering

Get Me Off this Planet - http://teachers.egfi-k12.org/get-me-off-this-planet/

Mission to Mars - https://www.teachengineering.org/curricularunits/view/cub_mars_curricularunit

Action Reaction Rocket - https://www.teachengineering.org/sprinkles/view/cub_rocket_sprinkle1 (informal science)

Mars River Racers - http://teachers.egfi-k12.org/mars-rover-races/

Ripening fruits in space - http://teachers.egfi-k12.org/ripening-fruit-in-space/

Are we Alone? - http://teachers.egfi-k12.org/are-we-alone/

Balloon Aeronautics - http://teachers.egfi-k12.org/balloonautics/

Build a Lunar Lander - http://teachers.egfi-k12.org/lesson-build-lunar-lander/

A Garden on the Moon - http://teachers.egfi-k12.org/lesson-a-garden-on-the-moon/

Issue #10 Atoms – Get the Facts Issue

Lessons

PBS Learning Media – The Atom:

https://gpb.pbslearningmedia.org/resource/lsps07.sci.phys.matter.theatom/the-atom/#.WOTnKOQm7IU;

Periodic Table - https://gpb.pbslearningmedia.org/resource/phy03.sci.phys.matter.lp_pertable/the-periodic-table-of-the-elements/#.WOTrmeQm7IU

Chem4Kids - http://www.chem4kids.com/files/atom_intro.html

Dogs Teaching Chemistry – The Atom https://www.youtube.com/watch?v=addK0b2Isw8; chemical bonds: https://www.youtube.com/watch?v=_M9khs87xQ8;

American Chemical Society Middle School Chemistry Resources - http://www.middleschoolchemistry.com/

Use the Allotropes of Carbon activities *Nanooze* Issue #9 (Kroto interview)

Molecular Workbench simulations - http://mw2.concord.org/public/index.cml
Periodic Table Visualizing the Unseen - http://teachingcommons.cdl.edu/noyce/newsevents/documents/PT_Noyce_Conferencce.pdf
Pinterest has several activities about the Periodic Table, which appear engaging. Here is one link: https://www.pinterest.com/explore/periodic-table/?lp=true
Structure of Matter: http://www.nobelprize.org/educational/physics/matter/4.html
How Small is an Atom (TED ED) - https://ed.ted.com/lessons/just-how-small-is-an-atom
Atoms and Molecules - https://www.myips.org/cms/lib8/IN01906626/Centricity/Domain/8123/atomic%20structure%20and%20periodic%20table.pdf

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Issue #11 Molecules – Lots of Shapes and Sizes Issue
Lessons
Molecular Workbench - http://mw2.concord.org/public/index.cml
DNA lessons in Issues #7 & 9
Amino Acids and eggs - http://www.uen.org/Lessonplan/preview.cgi?LPid=1178
DNA paper chain activity - https://middleschoolscience.com/2015/11/25/dna-paper-protein-chains-activity/
DNA sequence bracelets or key rings: http://www.yourgenome.org/activities/sequence-bracelets Plus other activities at You Genome: http://www.yourgenome.org/activities/
DNA Build: https://www.teachengineering.org/activities/view/cub_biomed_lesson09_activity2
The Metric System from Big to Small - https://www.nnci.net/node/5327
The RNA Decoder Ring: Deciphering the Language of Life - https://www.asm.org/index.php/educators/k-12-classroom-activities/23-education/k-12-teachers/8211-the-rna-decoder-ring-deciphering-the-language-of-life
AFM activities for Issue #3
DNA extraction from strawberries activities such as: http://www.imb.uq.edu.au/download/large/strawberryDNAextraction.pdf; http://www.gs.washington.edu/outreach/dhillon_dnaprocedure.pdf
Measuring in nanometers: http://nanozone.org/nanoruler_print.htm; http://nanozone.org/nanocalculator.htm;
Playing with Polarity - http://sciencounters.chem.wisc.edu/node/25
Molecular assemblers – lesson attached at end

Issue #12 Molecules in Motion Issue
Lessons
Moving Molecules - http://pbskids.org/dragonflytv/superdoit/moving_molecules.html
Molecular Workbench - http://mw2.concord.org/public/index.cml (Simulations and models)
Brownian Motion - http://molo.concord.org/database/activities/40.html; https://teachezy.com/brownian-motion-quick-science-introduction-activity/
A Boy and his Atoms: The World's Smallest Movie - https://www.youtube.com/watch?v=oSCX78-8-q0
AFM activities for Issue #3
Thermometers and Temperature Scales - https://cehd.gmu.edu/assets/docs/cehd/mhaley/EDCI%20519/EDCI%20519%20Unit%20Lesson%20Plan-%20Weather.pdf
Temperature and Temperature Scales (includes videos) - https://www.ck12.org/chemistry/temperature-and-temperature-scales/lesson/Temperature-and-Temperature-Scales-CHEM/

Simple Science Experiment: Oil, Water, and Food Coloring - https://www.metrofamilymagazine.com/May-2012/Simple-Science-Experiment-Oil-Water-and-Food-Coloring/ and also at: http://www.growingajeweledrose.com/2013/04/science-for-kids-experiments.html
Thermal energy - https://gpb.pbslearningmedia.org/resource/lsps07-sci-phys-thermalenergy/thermal-energy-transfer ; http://www.middleschoolchemistry.com/lessonplans/chapter1/lesson3 ; https://learn.concord.org/resources/656/melting-ice

Issue #13 The Unexpected Properties Issue
Lessons
Forces at the Nanoscale - http://nisenet.org/catalog/programs/exploring_forces_-_gravity_nanodays_08_09_10
How Dry am I? https://www.nnci.net/node/5298
Properties of Magic Sand – https://www.nnci.net/node/5372
Microfluidics and Laminar Flow - http://nano-cemms.illinois.edu/materials/microfluidics_and_laminar_flow_full.html
Laminar Flow demo - https://www.stevespanglerscience.com/lab/experiments/twist-in-time-laminar-flow/
Magnetism and Nanotechnology - Surface Tension and Suminagashi - https://www.teachengineering.org/activities/view/gat_surface_tension_activity1
Numerous lessons on surface tension at https://www.teachengineering.org/curriculum/browse?q=surface+tension including: Break the Tension - https://www.teachengineering.org/activities/view/cub_earth_lesson2_activity4; http://sciencounters.chem.wisc.edu/sites/sciencounters.chem.wisc.edu/files/Surface%20Tension.pdf
Tension Racers - https://www.teachengineering.org/activities/view/cub_earth_lesson2_activity4
Any of the activities on allotropes of carbon for issue #9
Nano in Sunblock - http://teachers.egfi-k12.org/lesson-explore-nano-in-sunblock/
How light interacts with matter Sunscreens: http://nanosense.sri.com/activities/clearsunscreen/index.html and in particular lesson one: http://nanosense.sri.com/activities/clearsunscreen/introduction/CS_Lesson1Teacher.pdf
Nano Waterproofing - http://teachers.egfi-k12.org/nano-waterproofing/

Issue #14 The Energy Issue
Lessons
Solar Ovens: Understanding energy transfer - https://www.nnci.net/node/5386 (Google for other versions online); http://teachers.egfi-k12.org/lesson-solar-cooking/
Solar Water Heater - http://teachers.egfi-k12.org/solar-hot-water/
Build a Solar Still (desalination) - http://teachers.egfi-k12.org/lesson-build-a-solar-still/
Teach Engineering units on energy - https://www.teachengineering.org/curriculum/browse?q=energy
Try Engineering units on energy - http://tryengineering.org/lesson-plans?cat=37&keyword=&sort_by=title
Engineering Go for It units on energy - http://teachers.egfi-k12.org/index.php/?s=energy
Power of Graphene - - http://tryengineering.org/lesson-plans/power-graphene
Battery units at Teach Engineering - https://www.teachengineering.org/curriculum/browse?q=batteries
How Batteries Work - http://sciencenetlinks.com/esheets/how-batteries-work/
Squishy Circuits - http://teachers.egfi-k12.org/squishy-circuits/
Sensing the Sun - http://sciencounters.chem.wisc.edu/node/17
SciEncounters units on energy - http://sciencounters.chem.wisc.edu/activities?page=4

#15 The Environment Issue

Groundwater Pollution Detectives - http://teachers.egfi-k12.org/groundwater-detectives/
Water Cleanup - kids.pbskids.com:8080/dragonflytv/parentsteachers/nano
SciEncounters units on Green Chemistry - http://sciencounters.chem.wisc.edu/activities?page=2 and http://sciencounters.chem.wisc.edu/activities?page=3
Nanoparticle Pollutants - https://www.nnci.net/node/5340 (designed for high school but can be adapted for middle)
Nanoparticles: Land to Ocean - https://www.nnci.net/node/5339 (designed for high school but can be adapted for middle, especially earth science)
Water Filtration and Purity of Water - https://www.nnci.net/node/5323
Mini Biosensors - https://www.materialsworldmodules.org/index.php/modules-and-user-support/mini-modules/mini-biosensors-module
Mini Biodegradable - https://www.materialsworldmodules.org/index.php/modules-and-user-support/mini-modules/mini-biodegradable-materials-module
Mini Environmental Catalysis - https://www.materialsworldmodules.org/index.php/modules-and-user-support/mini-modules/mini-env-cat-module
Make Sense of Sensors - http://tryengineering.org/lesson-plans/making-sense-sensors
Pollution Patrol - http://tryengineering.org/lesson-plans/pollution-patrol

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#16 Biomimetics

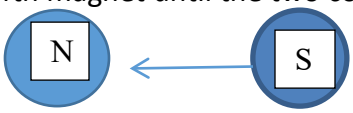
Lessons
Biomimicry - http://teachers.egfi-k12.org/biomimicry-natural-designs/; http://teachers.egfi-k12.org/index.php/?s=biomimicry; http://tryengineering.org/lesson-plans/biomimicry-engineering
Designs from Nature - http://teachers.egfi-k12.org/design-from-nature/
Biomimicry parts 1 and 2 - http://sciencounters.chem.wisc.edu/node/85
http://sciencounters.chem.wisc.edu/node/32
Nanoscience in Nature: A webquest - http://ice.chem.wisc.edu/Nature/Nanoscience_in_Nature/Introduction.html
Biomimicry Institute - Biomimicry Education Network; Sharing Biomimicry with Younger People; Youth Design Challenge (middle and high school versions) https://biomimicry.org/
Center for Biologically Inspired Design at Georgia Tech - http://www.cbid.gatech.edu/resources/educational-resources/ (educational resources for K-12 including connections to the standards, lessons, explanations, PowerPoint)

This work is sponsored by the National Science Foundation

ECCS #542174 & ECCS #1626153

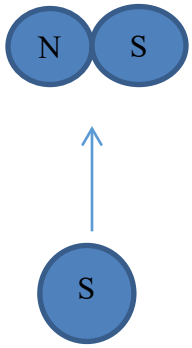
Separate one of the magnets from the other four. Set the four magnets down on a flat surface so that each of them has the same magnetic pole facing upward (so that they will repel each other) and set the fifth magnet down so that its opposite pole is facing upward (so it will attract the other magnets).

1) Set the fifth magnet away from the other four. Pull one of the magnets out of the set of four and move it towards the fifth magnet until the two come in contact. Refer to the diagram below.



2) In your journal make a drawing of the magnet pattern. Provide a name that would describe this pattern based on connecting an imaginary line between the centers of each of the magnets.

3) Leave your magnet pair in tack.. Tale a second magnet from the set of four and move it towards the magnet pair at a 90^0 angle until contact is made with the magnet pair. Refer to the diagram below;



4) Make a drawing of the magnet pattern. Provide a name that would describe this pattern based on connecting an imaginary line between the centers of each of the magnets. Answer the following question-Why does this combination of three magnets end up in this particular arrangement?

5) Leave your magnet threesome intact. Take a third magnet from the original set of four and move it towards the trio at a 90^0angle and in line with the center magnet of this group until contact is made with this magnet.

6) Make a drawing of the magnet pattern. Provide a name that would describe this pattern based on connecting imaginary lines between the centers of each of the outer magnets. Answer the following question - Why does this combination of four magnets end up in this particular arrangement?

7) Leave your magnet quartet intact. Bring the last magnet from the original set of four towards this quartet by moving it in midway between any two of the outside magnets until it contact the center magnet in the group.

8) Make a drawing of the magnet pattern; provide a name that would describe this pattern based on connecting imaginary lines between the centers of each of the outer magnets.

9) Answer the following question- Why does this combination of five magnets end up in this particular arrangement?