NANOTECHNOLOGY

LESSON PLAN FOR GRADE 8 - NANOVISION

8

Alberta
Freedom To Create. Spirit To Achieve.

Alberta Innovates Technology Futures

Science Teachers,

This lesson plan was designed for grade 8 and meet Alberta Education curriculum learning outcomes for science (see the following page for program of studies reference). The plans are easy to understand and implement without any specialized training, additional work or study. Best of all, they make this interesting subject matter engaging to teach.

The lesson plans were focus tested in seven schools throughout Alberta, incorporating teacher's feedback, and received great reviews. These plans provide the tools necessary to guide students through interactive experiences with nanotechnology that will help them understand this aspect of science. Included in the lesson plans are:

- a short explanation on what is nanotechnology,
- an activity description,
- time requirements,
- materials,
- an assessment rubric, and
- an in-depth teacher's background for reference.

Each lesson was designed in a way that allows you to quickly adapt it to your specific class needs and/or level of knowledge. If you wish to go deeper into the material, you can use the links provided under References or Bibliography. These lesson plans are complemented by a Nano Resource DVD for additional resources such as comic strips, videos, photos and more information related to teaching and understanding nanotechnology. These resources are also available for downloading at **nanolessonplans.alberta.ca**.

Did You Know?

The University of Alberta, the University of Calgary, and the Northern Alberta Institute of Technology all offer nanotechnology programs to train the next generation of curious and bright minds.

As you can see, the subject of nanotechnology is rich with opportunities for learning. We hope you will find the lesson plans worth implementing and include this fascinating area of science in your science program for the year.

If you require more information on additional nanotechnology learning experiences, or have any questions about the information provided, please contact nanoAlberta at 780-450-5111 or email nano@albertainnovates.ca. For grades 7 to 12 check out our travelling Scanning Electron Microscope (SEM) program and book it for your school today. This free program supplies the Microscope for a week and an Alberta certified science teacher will come and work with you and your class or school. A great complement to the nano lesson plans.
Visit **nanolessonplans.alberta.ca** for more information on the SEM program.

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These lesson plans are available to view online and can be downloaded free at **nanolessonplans.alberta.ca**

Limited additional copies are available for ordering from the Learning Resource Centre at **lrc.education.gov.ab.ca**

For information, including reproduction for commercial purposes, please contact:
Alberta Innovates - Technology Futures
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Phone: 780-450-5111
Email: nano@albertainnovates.ca

Program of Studies Reference:

Grade 8 Science – Light and Optical Systems

Skills

- Performing and Recording
- Analyzing and Interpreting
- Communication and Teamwork

Attitudes

- Scientific inquiry
- Collaboration

STS

- Investigate and explain the science of image formation and vision
- Investigate the transmission of light
- Investigate the development of microscopes, telescopes and other optical devices

Check out these other great Nanotechnology Lesson Plans

Nanotechnology: Lesson Plan for Grade 4 Science
Slippery Leaves

Nanotechnology: Lesson Plan for Grade 5 Science
Small is Different–Classroom Chemistry

Nanotechnology: Lesson Plan for Grade 6 Science
Forestry Nano Superheroes–Trees and Forests

Nanotechnology: Lesson Plan for Grade 7 Science
Nanotechnology and the Environment–Smart Dust

Nanotechnology: Lesson Plan for Grade 9 Science
Carbon's Nanocaper–Matter and Chemical Change

Nanotechnology: Lesson Plan for Science 10
"BRANE" Work–Cycling of Matter in Living Systems

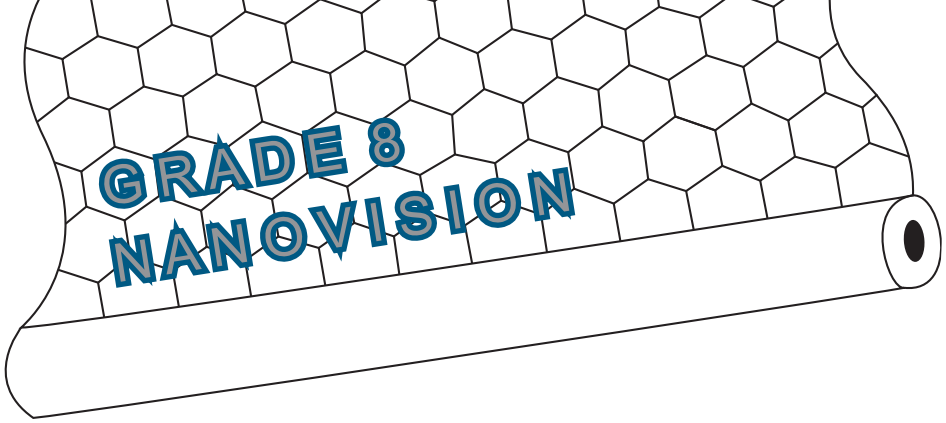
Nanotechnology: Lesson Plan for Chemistry 20
Putting it Together-Self Assembly
–The Diversity of Matter and Chemical Bonding

Nanotechnology: Lesson Plan for Biology 30
Medical Applications of Nanotechnology
–Cell Division, Genetics, and Molecular Biology

Did You Know?

Nanotechnology opens students to a wide variety of occupations in an even wider variety of industry sectors. Consider that nanotechnology may be encountered and used in some way by:

- Applications Technician
- Bio Material Engineer
- Cancer Researcher
- Characterization Scientist
- Chemical Technologist/Engineer
- Chemist
- Coating Scientist
- Computational Physicist
- Contact Metallization Process Engineer
- Electron Microscopy Technician
- Materials/Nanotechnology Scientist
- Materials/Metallurgical Engineer
- Mechanical Engineering
- Molecular Biologist
- Molecular Imaging Technologists
- Nanobiologist
- Nanoparticle Development Scientist
- Nanotechnology Business Manager
- Nanotechnology Laboratory Technician
- Nanotoxicologist
- Optical Engineer
- Pharmacologist
- Process Quality Engineer
- Product Marketing Manager
- Tissue Engineer
- Wafer Fabrication Development/Process Engineer



ACTIVITY DESCRIPTION

Students investigate objects by examining them with increasingly sophisticated optical equipment. They then take their examination one step further by observing digital images of objects too small for even light to see.

TIME REQUIRED

One morning or afternoon class of up to 80 minutes.
May require additional classes if more than one activity is discussed.
More time is required for extensions.

MATERIALS

- graphite–material used as a dry lubricant (a small amount of pencil lead will work; see note)
- small organic object, (a hair, part of a feather, etc.)

KEY CONCEPTS

- Microscopes
- Contribution of technologies to scientific development
- Transmission of light
- Images
- Vision and lenses
- Imaging technologies

EQUIPMENT

- magnifying glasses
- dissecting microscopes
- optical microscopes
- rulers (marked in mm)

It is assumed that the school science facilities have optical microscopes and that the students can share these in appropriate numbers (2 -3 students). Should this not be the case, use the alternate technique listed.

*** Note**

Pencil graphite (pencil lead) is a mixture of graphite and clay. Different mixtures create different darknesses (2H, HB, 2B, etc.). Use a file or sandpaper to scratch off some pencil graphite mixture. Try to choose the smallest grains for observation. To obtain finer grains or thinner particles, try this technique: Sandwich a few particles between the sticky sides of two pieces of clear cellulose tape. When the two pieces of tape are separated, some graphite should stick to one tape sheet and some to the other, making the particle smaller.

Source: How to make a graphene sheet
http://www.youtube.com/watch?v=rphiCdR68TE

GLOSSARY
- graphite, graphene
- nanotechnology
- magnification

Teacher background

Adapted from the following source:

Addressing Science Standards Using the Big Ideas in Nanotechnology by Nancy Healy and Janet Palmer.

NANOTECHNOLOGY

- **Nano** is the scientific term meaning one-billionth (1/1,000,000,000). It comes from the Greek word meaning “dwarf”.
- A **nanometre** is one one-billionth of a metre. One centimetre equals 10 million nanometres (nm). A sheet of paper is about 100,000 nm thick. A human hair measures roughly 50,000-100,000 nm across. A fingernail grows at a rate of one nm per second.
- Most biologically-relevant molecules (proteins, DNA, lipids) are on the **nanoscale**, which allows them to interact with man-made materials of this size.
- **Nanoscience** and nanoengineering are the creation, study, and control of matter that is 1-100 nm in size.
- The smallest objects observable with the human eye are 10,000 nm (10 micrometres) in size. Objects on the nanoscale can only be observed using laboratory instruments like the electron micro scope or the scanning probe microscope.

NANOTECHNOLOGY CON'T...

- The behaviour of matter (optical, electrical, and mechanical properties) at the nanoscale is sometimes different that of the same material at the macro scale. Quantum mechanics are required to predict the characteristics of matter at this size.
- Nanoscience spans chemistry, biology, physics, and computer science, and has applications in health, the environment, and information technology.

Even the simplest optical system, the human eye, depends on lenses and light-activated detectors. Depending on the sophistication of the optical system, smaller and smaller objects can be observed using magnifiers and microscopes. But just how small can optical systems allow us to see? This activity takes students through the technological steps from unaided vision to microscopes and beyond, introducing them to the science and technology associated with nanoscale objects. This activity may be used to introduce students to basic optical instrumentation while searching for the very small.

CLASS PREPARATION

Introduction

Review the terminology related to object size—centimetre, millimetre, micrometre, nanometre—and their relative relationship to each other. Magnifying glasses and microscopes are used to make smaller objects appear larger.

Examination of a human hair: Each student should carry out each of the observations

STEP 1

Students examine a human hair with the naked eye.

STEP 2

Students place the hair to be observed across the ruler and estimate the size of the hair. This should be recorded on the Student Sheet.

STEP 3
Students then examine the hair with a magnifying glass. They should observe that moving the magnifying glass further away from or closer to the sample will result in larger or smaller images, improving the magnification. At optimal magnification, students should again estimate the size of the hair and record it on the Student Sheet.

STEP 4
Using a dissecting microscope, students repeat their observation of the hair. If the microscopes have calibrated eyepieces, then the size of the hair can be better estimated. Record any observations and the estimated size of the hair.

STEP 5
Finally, each student should observe the hair under a laboratory light microscope. What other things can the student see using this piece of equipment?

STEP 6
Teachers explain the concept of nanoscale objects. If a human hair is about 50,000 nanometers in diameter, what type of equipment might be needed to see individual atoms or molecules that are mere nanometres in size?

Examination of graphite:
Each student should carry out each of the observations

STEP 1
Students examine a few grains of graphite with the naked eye.

STEP 2
Students place the graphite grains to be observed on the ruler and estimate their size. This should be recorded on the Student Sheet. Any other observations (colour, surface texture, etc.) should also be recorded, if they can be observed.

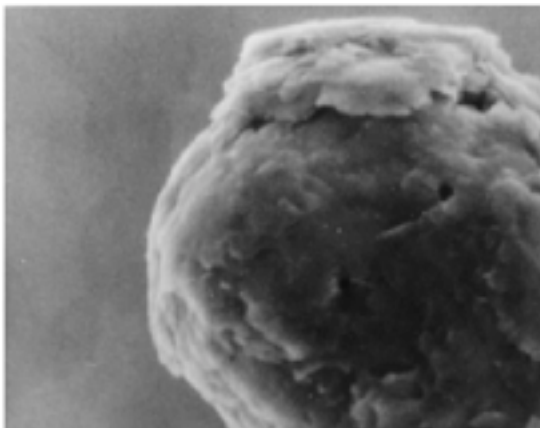
STEP 3
Students then examine the graphite with a magnifying glass. At optimal magnification, students should again estimate the size of the grain and record it on the Student Sheet. If the grain shows some structure, this could be drawn or described as well.

STEP 4
Using a dissecting microscope, students repeat the observation, again estimating the size and looking for shape or structure.

STEP 5
Finally, each student should observe the grain under a laboratory light microscope. How does this compare with the hair?

EXTENDING GRAPHITE OBSERVATIONS WITH OTHER INSTRUMENTATION

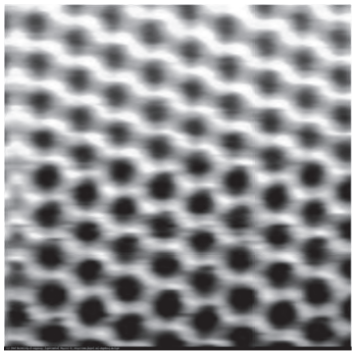
High-quality optical microscopes have a practical limit of enlargement of about 1,000 times, which would allow objects that are in the range of 500 nanometres to be observed. Another limitation of optical microscopes is that to observe something, light must either reflect off the sample or pass through it. As objects get smaller, the object itself becomes smaller than the wavelength of visible light required to see it. Therefore, other techniques are required to "look" at nanoscale objects.



SEM image of a graphite grain
Used with permission of Sachiko Amari.

Typical microscopes available at the junior or senior high school level have a magnification of about 500, which will allow objects in the 1 micrometre (1 µm) range (1,000 nanometres) to be observed.

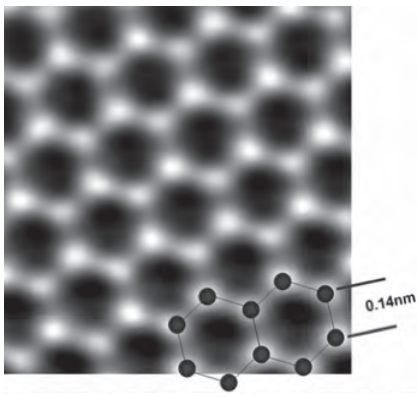
Two other instruments used to look at small objects:



Used with permission of
University of Augsburg.

Scanning Electron Microscopes use electrons instead of light to “look” at samples. Electrons are considerably smaller than light, so they can be used to view smaller objects. See reference below to the SEM project that could bring an SEM to your school.*

Atomic Force Microscopes have an extremely sensitive tip that scans the forces found very close to the atoms in the sample. With this type of microscope, objects smaller than a nanometre can be “observed”.



Used with permission of
The Royal Society of Chemistry.

* See nanolessonplans.alberta.ca for more information on the Alberta SEM pilot program.

ALTERNATE TECHNIQUE: PHOTOGRAPHS

The following set of photographs represent graphene (single and multiple sheets) at different powers of magnification, all examined under an optical microscope. Pictures are used with permission of Oezyilma Barbaros, taken from http://www.youtube.com/watch?v=rphiCdR68TE

The scale on this first image was not specified. By comparing this frame of the view with others the approximate size of the material of interest is about 0.1 mm. This would make the final image 10 micrometers across or the graphene sheet of interest, 1000 nanometers across. The indicated object is a single sheet of graphene while the darker objects are multisheet graphene.

About 2.5 times larger than first

About 5 times larger than first

10 times larger than first

25 times larger than the first (very roughly 10 µm across), with the graphene sheet of interest 1 µm across

ASSESSMENT

These rubrics for assessing science skills are kindly shared by Julie Arsenault BSc., MSc., Avonmore School (Nellie McClung program).

SCIENCE LAB PORTFOLIO - PERFORMING AND RECORDING

CRITERIA	4 ▪ WOW!	3 ▪ YES!	2 ▪ YES, but...	1 ▪ NOT QUITE
RESEARCH AND INFORMATION GATHERING	Effectively and efficiently accesses and retrieves relevant information from a variety of reliable electronic resources	Accesses and retrieves relevant information from a range of electronic resources; reliability of select resources may be in question	Accesses and retrieves some relevant information from electronic resources; reliability of several resources may be in question	Accesses, but has difficulty retrieving, relevant information from a limited number of electronic resources; reliability of resources may also be an issue
LOCATES INFORMATION BASED ON RESEARCH QUESTIONS	Selects and organizes specific, comprehensive information related to the issue or experiment	Selects and organizes information related to the issue or experiment	Selects and organizes information partially related to the issue or experiment	Selects irrelevant or inaccurate information related to the issue or experiment

SCIENCE LAB PORTFOLIO - PERFORMING AND RECORDING

CRITERIA	4 ▪ WOW!	3 ▪ YES!	2 ▪ YES, but...	1 ▪ NOT QUITE
DATA COLLECTION	Collects relevant data and enters it accurately in the data table; recorded measurements are neat and complete	Collects data and completes data sheet correctly; measurements are neat, but not all information is relevant	Collects data, but data sheet contains some errors; measurements are neat, but not all information is relevant	Collects little data and produces an incomplete data sheet; measurements are illegible
LOCATES INFORMATION BASED ON RESEARCH QUESTIONS	Conducts exhaustive trials to provide complete, valid, and accurate data in the given experiment	Conducts sufficient trials to be considered a fair test and provides relevant and accurate data for the given experiment	Conducts simple tests that provide incomplete data about the effects of the given experiment	Conducts tests that provide little data about the given experiment

SCIENCE LAB PORTFOLIO - COMMUNICATION AND TEAMWORK

CRITERIA	4 ▪ WOW!	3 ▪ YES!	2 ▪ YES, but...	1 ▪ NOT QUITE
CLARIFIES AND SHAPES IDEAS IN A GROUP	Clarifies and shapes understanding through effective and extensive collaboration with others	Clarifies and shapes understanding through collaboration with others	Shares understanding with others	Shares little or no understanding with others
PARTICIPATES IN AND CONTRIBUTES TO GROUP WORK	Contributes enthusiastically and invites suggestions from other group members throughout task	Contributes to group and accepts others' ideas throughout task	Contributes to group throughout portions of task	Participates only when encouraged during the task
TASK DISTRIBUTION	Completes her share of the work and encourages each member to do what they would like	Completes her share of the work and allows each member the opportunity to do what they like	Completes some of her share of the work, but does not always allow all members the opportunity to do what they would like	Completes little work and participates only when encouraged
COMMUNICATION THROUGHOUT LAB	Communicates clearly with group members regarding instructions resulting in a seamlessly performed lab	Communicates well with group members regarding instructions, and the lab is well-performed	Communicates with members of the groups regarding instructions, and the lab is completed	Communicates with members of the groups regarding instructions, and the lab is completed

SCIENCE LAB PORTFOLIO - ANALYZING AND INTERPRETING

CRITERIA	4 ▪ WOW!	3 ▪ YES!	2 ▪ YES, but...	1 ▪ NOT QUITE
PRESENTS DATA	Uses technology to effectively display data that is organized and easy to interpret	Uses technology to display data that is accurate and clear	Uses technology to display compiled data, but presentation may contain errors or be unclear	Uses technology to present incomplete data that does little to assist in solving the problem
CONCLUSIONS	Uses data to provide convincing support for conclusions	Uses data to support conclusions	Uses data to provide partial support for conclusions	Draws conclusions that are not related to data
IDENTIFIES ALTERNATIVES AND EVALUATES EFFECTS	Uses data and observations to provide a clear and logical explanation of which design characteristic led to peak performance	Uses data and observations to provide a reasonable explanation of which design characteristic led to peak performance	Uses data and observations to provide some support for their choice of design characteristic that led to peak performance	Choice of design characteristics are not based on data or observations
GRAPH CONSTRUCTION AND MECHANICS	Graph is thoroughly complete, neat and accurate, including a detailed title, axes labels, and units where needed	Graph is neat and accurate, buy may be missing detail in title, axes labels, or units where needed	Graph is accurate, but is missing details in title, axes labels, or units, and its neatness is questionable	Graph is messy or incomplete and is missing most details for proper graph construction

SCIENCE LAB PORTFOLIO - ANALYZING AND INTERPRETING

CRITERIA	4 ▪ WOW!	3 ▪ YES!	2 ▪ YES, but...	1 ▪ NOT QUITE
ANALYSIS QUESTIONS	Questions are answered thoroughly and accurately, and demonstrate clear understanding of the relationship between _____ and _____	Questions are answered accurately and demonstrate understanding of the relationship between _____ and _____	Questions are answered, but may not be completely accurate, and student's understanding of the relationship between _____ and determining _____ is unclear	Questions are incomplete and may not be completely accurate, and student's understanding of the relationship between _____ and _____ is unclear

EXTENSIONS AND RESOURCES

- Virtual Microscope (PC and Mac versions available). This could be projected using a SmartBoard (see note below) http://virtual.itg.uiuc.edu/downloads/#interface

- nanoAlberta has sponsored a traveling Scanning Electron Microscope that will visit Alberta schools. For more information about this program, go to nanolessonplans.alberta.ca

- *The Dance of the Molecules: How Nanotechnology is Changing Our Lives by Ted Sargent*

BIBLIOGRAPHY

1. *"How to make grapheme sheets from graphite flakes and cellophane tape." YouTube. 3 June 2009. Online Video. 12 April 2011. http://www.youtube.com/watch?v=rphiCdR68TE*

2. *Healy, Nancy, and Janet Palmer. "Addressing Science Standards Using the Big Ideas in Nanotechnology." National Nanotechnology Infrastructure Network; National Science Foundation; Georgia Tech Nanotechnology Research Center. Teacher workbook. 2009.*

3. *Sargent, Ted. The Dance of the Molecules: How Nanotechnology is Changing Our Lives. New York: Basic Books, 2006.*

4. *Amari, Sachiko. "Graphite grain at the scale of micrometers." Washington University, St. Louis. n.d. Online Image. 12 April 2011. http://www.psrd.hawaii.edu/WebImg/GraphiteOnion.gif*

5. *"Revealing the hidden graphite-atom." University of Augsburg. n.d. Online Image. 12 April 2011. http://www.physik.uni-augsburg.de/exp6/imagegallery/afmimages/afm-image-graphite.jpg*

6. *"Atomic-resolution image of a graphene sheet." Dato, Albert, Zonghoon Lee, Ki-Joon Jeon, Rolf Erni, Velimir Radmilovic, Thomas J. Richardson and Michael Frenklach. "Clean and Highly Ordered Graphene Synthesized in the Gas Phase." Chemical Communications. 40. (2009): 6096. Web. http://dx.doi.org/10.1039/b911395a*

7. *Arsenault, Julie. "Science Lab Portfolio." Avonmore School, Nellie L. McClung Program. Edmonton. n.d. Evaluation Rubric.*

STUDENT SHEET 1

Human Hair

Naked Eye - Estimated Size: _____

Observations:

_____

_____

_____

_____

Draw your observation here:

Magnifier - Estimated Size: _____

Observations:

_____

_____

_____

_____

Draw your observation here:

Dissecting Scope - Estimated Size: _____

Observations:

_____

_____

_____

_____

Draw your observation here:

Light Microscope - Estimated Size: _____

Observations:

Draw your observation here:

STUDENT SHEET 2

Graphite

Naked Eye - Estimated Size: _____

Observations:

_____

_____

_____

_____

Draw your observation here:

Magnifier - Estimated Size: _____

Observations:

_____

_____

_____

_____

Draw your observation here:

Dissecting Scope - Estimated Size: _____

Observations:

_____

_____

_____

_____

Draw your observation here:

Light Microscope - Estimated Size: _____

Observations:

_____

_____

_____

_____

Draw your observation here:

NOTES:

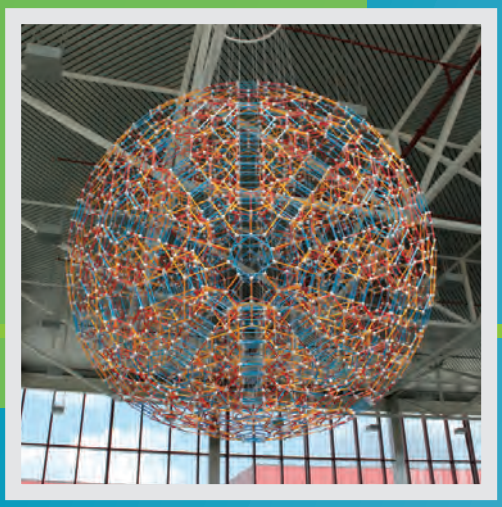
WHAT YOU'LL FIND HERE

- a "pick-up-and-go" lesson plan that will add science currency to your science program
- activities that meet science curriculum learning outcomes
- interesting subject matter that is engaging to teach
- easy to implement experiments (no specialized training needed)
- a quickly adaptable lesson with worksheets and rubrics for your class needs

Nano is... the scientific term meaning one-billionth (1/1,000,000,000). It comes from the Greek word meaning "dwarf".

Nano Science is... the discovery, research and understanding of all things nano.

Nanotechnology is...
the application of science at the molecular level.



Nanotechnology
is revolutionizing medicine, energy production, environmental protection, bioindustries and more!

Government of Alberta