Science Teachers,

This lesson plan was designed for grade 7 and meets 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.

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.
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 8 Science - Nanovision–Light and Optical Systems
- 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

Program of Studies Reference: Grade 7 Science – Interactions and Ecosystems

STS
- Identify intended and unintended consequences of human activities within local and global environments
- Illustrate, through examples, the limits of scientific and technological knowledge in making decisions about life-supporting environments

Skills
- Initiating and Planning
- Performing and Recording
- Communication and Teamwork

Attitudes
- Stewardship
- Collaboration
- Mutual respect

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
Over two to three class periods, students discuss technology and its societal impacts—both positive and negative. Following an introduction to nanotechnology, the students consider whether they do or do not support the use of “motes”, or Smart Dust, to monitor burrowing owl habitats in the grasslands of south western Alberta. They will decide if the motes should be used or not and explain their reasoning. Decisions are presented to the class in PowerPoint, poster, or brochure form, and then the class decides as a group whether the motes should be used or not.

TIME REQUIRED
Part 1: one class
• Activity 1: Technology impacts (30 minutes)
• Activity 2: What is nano? (10-15 minutes)

Part 2: over two classes
• Activity 3: Smart dust: to deploy or not to deploy? (30-40 minutes)

KEY CONCEPTS
• Environmental monitoring/Environmental impacts
• Science and technology are developed to meet human needs and expand human capability.
• Science and technology have contributed to human well-being and have influenced, and been influenced by, social development.
• Science and technology have both intended and unintended consequences for humans and the environment.
Teacher background
Adapted from the following sources:
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 microscope or the scanning probe microscope.
• The behaviour of matter (optical, electrical, and mechanical properties) at the nanoscale is sometimes different than 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.

GLOSSARY

• nanotechnology
• nanometre
• nanoscale
• Smart Dust
• motes
• nanoparticle

MATERIALS

• grains of sand
• poster board or materials for brochures (electronic or hard copy)
• student sheets (included)
SMART DUST/MOTES

Motes
• miniature self-contained, battery-powered computers that use wireless links to exchange information
• also known as Smart Dust, motes will be designed to be so tiny, inexpensive, and connected that thousands of millimetre–sized computers could be distributed into a field or sensitive environment to form a network of completely connected sensors
• environmental monitoring application: monitoring the microclimates around the burrow of a rare bird, habitat monitoring without disruption to the bird (Great Duck Island, Maine - http://ucberkeley.citris-uc.org/research/projects/great_duck_island)
• motes are comprised of miniature computer, batteries, memory, and wireless transmitter-receivers
• built-in sensors measure temperature, humidity, pressure, and infrared light
• information is relayed from mote to mote to the computer base station, and then to a satellite link, which gives researchers real-time access to data via the internet no matter where they are.

CLASS PREPARATION:
Adapted from “Rocks and Nanobots”
http://www.mrsec.wisc.edu/Edetc/IPSE/educators/soclmp1.html

ACTIVITY 1:
Impact of technology
10 -15 minutes

• Divide class into groups of three. Ask them to name some of the technologies they use every day (smart phones, MP3 players, TV, computers).
• Have them choose one technology and work in their small groups to list all the positive and negative impacts they can think of that have arisen from use of the technology. They can use Student Sheet #1 to record their ideas. Here is an example to seed discussion, if necessary.
<table>
<thead>
<tr>
<th>TECHNOLOGY</th>
<th>POSITIVE EFFECTS</th>
<th>NEGATIVE EFFECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMPUTERS</td>
<td>Automation of tasks and increased speed of execution.</td>
<td>Allows new kinds of crime, like hacking.</td>
</tr>
<tr>
<td></td>
<td>Easy access to and ability to work with huge amounts of information.</td>
<td>Creates new kinds of nuisances, like e-mail spam.</td>
</tr>
<tr>
<td>CELL PHONES</td>
<td>Easy and constant communication with others.</td>
<td>Using them while driving can cause accidents.</td>
</tr>
<tr>
<td></td>
<td>Useful in emergencies such as car breakdowns.</td>
<td>Create pollution due to the toxic nature of some components and discarded obsolete models.</td>
</tr>
</tbody>
</table>

- Have students share some of their ideas with the class.
- In the large group, repeat the procedure using examples of emerging technologies, such as those cited in science fiction.

**EMERGING TECHNOLOGIES FUTURE SCENARIOS:**

To think about the positive and negative effects of future technologies, ask students to list science fictions examples of “nanotype” technologies. Some suggestions:

- Star Trek (the Borg, Geordie, Data, nanites)
- Andromeda (nanobots)
- Stargate (replicators)

There are bound to be some students who are sci-fi fans and can talk about the characteristics and suggested capabilities of these technologies. Students might go away and do some research to give them the information to formulate the pros and cons of these futuristic technologies. The idea is to get them to understand that all technologies have both positive and negative effects and consequences.
ACTIVITY 2
Introduction to nanotechnology
10 -15 minutes

• Ask students if they’ve ever heard of nanotechnology.
• How big is nano? Try this demonstration. Give each student a grain of sand. Have students form a circle about four metres in diameter. Explain that the human hair is the smallest object a human eye can see unaided, and tell them to imagine they are standing on the circumference of a human hair. Put your grain of sand on the floor in the circle. The grain of sand represents the size of a nanometre if the circle is the size of a human hair. 50,000 nanometres would fit across the diameter of a human hair.
• Nanotechnology works at a very small scale (the size of atoms, called “nanoscale”). “Nano” means one-billionth. There are one billion nanometres in a metre.
• Students can also do the paper cutting exercise included in Student Sheet 1

ACTIVITY 3
To deploy or not to deploy Smart Dust—Where do you stand?
30 -40 minutes

• Present the following hypothetical scenario:

Smart Dust NanoApps Inc., a company formed by the commercialization of some research done at the Alberta Innovates—Technology Futures (AITF) has developed a mote that can be used to monitor a number of factors impacting wildlife habitats. They are trying to convince the University of Alberta to use the motes in their studies of burrowing owls in south western Alberta. Public hearings are being held to encourage input from a number of groups who may be affected by the use of this technology in the wild.

As a member of the general public, you’ve been asked to make a decision whether or not these motes should be released into the environment. To do this, you will meet with two other citizens and review the background information given out by the public hearing organizers. You will present your opinion to the class and create a PowerPoint presentation, a brochure, a poster, or a blog post to help make your point.

• Present students with Student Sheets 4-8 and have them discuss the questions and respond on their sheets. The group will create a poster illustrating their views and present it to the class. If a student or student disagrees with the group, they could present a “minority report”, or dissenting opinion.

• The class can vote on whether the motes should be used or not.
ASSESSMENT
Sample rubrics kindly shared by Julie Arsenault BSc., MSc., Avonmore School (Nellie McClung program). These are suggestions only, but provide some examples of the types of criteria that might be included.

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>4 • WOW!</th>
<th>3 • YES!</th>
<th>2 • YES, but...</th>
<th>1 • NOT QUITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLARIFIES PROBLEMS</td>
<td>Shows an insightful understanding of the problem by making pertinent predictions that can be researched and/or tested</td>
<td>Shows an understanding of the problem by making reasonable predictions that can be researched and/or tested</td>
<td>Shows a partial understanding of the problem by making predictions that may be difficult to research and/or test</td>
<td>Shows minimal understanding of the problem by making predictions that are not testable and would be difficult to research</td>
</tr>
<tr>
<td>DESIGNS AND CARRIES OUT A PLAN</td>
<td>Sets up and carries out a procedure designed to provide complete, relevant, and accurate data</td>
<td>Sets up and carries out a procedure designed to provide accurate data</td>
<td>Sets up and carries out a procedure that provides incomplete data</td>
<td>Sets up and carries out a procedure that provides little data</td>
</tr>
<tr>
<td>CREATE A HYPOTHESIS</td>
<td>Makes an insightful and testable hypothesis based on logical reasoning</td>
<td>Makes a testable hypothesis</td>
<td>Makes a hypothesis that may be difficult to test</td>
<td>Makes a hypothesis that is not testable</td>
</tr>
</tbody>
</table>
## SCIENCE LAB PORTFOLIO - COMMUNICATION AND TEAMWORK

<table>
<thead>
<tr>
<th>CRITERIA</th>
<th>4 • WOW!</th>
<th>3 • YES!</th>
<th>2 • YES, but...</th>
<th>1 • NOT QUITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clarifies and shapes understanding</td>
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<td></td>
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<tr>
<td>through effective and extensive</td>
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<tr>
<td>collaboration with others</td>
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</tr>
<tr>
<td>Shares understanding with others</td>
<td></td>
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</tr>
<tr>
<td>Shares little or no understanding</td>
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<td></td>
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<tr>
<td>with others</td>
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<tr>
<td>Participates enthusiastically and invites suggestions from other group members throughout task</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Contributes to group and accepts others’ ideas throughout task</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contributes to group throughout portions of task</td>
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<tr>
<td>Participates only when encouraged during the task</td>
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<tr>
<td>Completes her share of the work and encourages each member to do what they would like</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Completes her share of the work and allows each member the opportunity to do what they would like</td>
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<tr>
<td>Completes some of her share of the work, but does not always allow all members the opportunity to do what they would like</td>
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<tr>
<td>Completes little work and participates only when encouraged</td>
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<tr>
<td>Communicates clearly with group members regarding instructions, and the lab is well-performed</td>
<td></td>
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</tr>
<tr>
<td>Communicates well with group members regarding instructions, and the lab is completed</td>
<td></td>
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<tr>
<td>Communicates with members of the groups regarding instructions, and the lab is completed</td>
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<tr>
<td>Communication with group members is lacking and lab execution suffers as a result</td>
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</tr>
<tr>
<td>CRITERIA</td>
<td>4 - WOW!</td>
<td>3 - YES!</td>
<td>2 - YES, but...</td>
<td>1 - NOT QUITE</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>--------------------------------------------------------------------------</td>
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<tr>
<td>RESEARCH AND INFORMATION GATHERING</td>
<td>Effectively and efficiently accesses and retrieves relevant information from a variety of reliable electronic resources</td>
<td>Accesses and retrieves relevant information from a range of electronic resources, but reliability of select resources may be in question</td>
<td>Accesses and retrieves some relevant information from electronic resources, but reliability of several resources may also be an issue</td>
<td>Accesses, but has difficulty retrieving, relevant information from a limited number of electronic resources, and reliability of resources may also be an issue</td>
</tr>
<tr>
<td>LOCATES INFORMATION BASED ON RESEARCH QUESTIONS</td>
<td>Selects and organizes specific, comprehensive information related to the issue or experiment</td>
<td>Selects and organizes information related to the issue or experiment</td>
<td>Selects and organizes information partially related to the issue or experiment</td>
<td>Selects irrelevant or inaccurate information related to the issue or experiment</td>
</tr>
<tr>
<td>DATA COLLECTION</td>
<td>Collects relevant data and enters it accurately in the data table; recorded measurements are neat and complete</td>
<td>Collects data and completes data sheet correctly; measurements are neat but not all information is relevant</td>
<td>Collects data, but data sheet contains some errors; measurements are neat and not all information is relevant</td>
<td>Collects little data and produces an incomplete data sheet; measurements are illegible</td>
</tr>
<tr>
<td>CONDUCTS EXPERIMENTS</td>
<td>Conducts exhaustive trials to provide complete, valid, and accurate data in the given experiment</td>
<td>Conducts sufficient trials to be considered a fair test and provides relevant and accurate data for the given experiment</td>
<td>Conducts simple tests that provide incomplete data about the effects of the given experiment</td>
<td>Conducts tests that provide little data about the given experiment</td>
</tr>
</tbody>
</table>
Rubrics for assessing various presentation formats can be found below

*PowerPoint Presentations:*
This one is for university students, but has some good ideas about criteria to include
http://www.uwstout.edu/static/profdev/rubrics/pptrubric.html

*Posters:*
http://teacherweb.com/ME/JALeonardMiddleSchoolOldTown/Ecologywebquest/page3.htm

*Blogs:*
http://edweb.sdsu.edu/courses/edtec296/assignments/blog_rubric.html
http://www.masters.ab.ca/bdyck/Blog/

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

- **Size and Scale**
  http://www.cellsalive.com/howbig.htm
  http://www.nnin.org/doc/Microsoft_Word_-_Linda_lesson_2_TG.pdf
  http://www.nanozone.org/nanoruler_print.htm

- **Burrowing Owls**

- **Smart Dust/Motes**
  http://computer.howstuffworks.com/mote.htm
  http://robotics.eecs.berkeley.edu/~pister/SmartDust/
  http://www.emory.edu/BUSINESS/mote/MarchOfTheMotes.pdf


### STUDENT SHEET 1
Pros and Cons of Familiar Technologies

Use this sheet to write down your group’s ideas. One example is given for you.

<table>
<thead>
<tr>
<th>TECHNOLOGY</th>
<th>POSITIVE EFFECTS</th>
<th>NEGATIVE EFFECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMPUTERS</td>
<td>Tasks get done faster</td>
<td>Allow new kinds of crime, like hacking</td>
</tr>
<tr>
<td></td>
<td>Easy access to and ability to work with huge amounts of information</td>
<td>Gives rise to new kinds of nuisances, like email spam</td>
</tr>
</tbody>
</table>

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Alberta Innovates – Technology Futures
nanolessonplans.alberta.ca
# STUDENT SHEET 2
Pros and Cons of Possible Future Technologies

Use this sheet to write down the class’ ideas.

<table>
<thead>
<tr>
<th>TECHNOLOGY</th>
<th>POSITIVE EFFECTS</th>
<th>NEGATIVE EFFECTS</th>
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</tbody>
</table>
STUDENT SHEET
How Small is a Nanometre?

• Trace around your 30 cm ruler and cut out the tracing.
• Cut the tracing in half to get a 15 cm piece.

![Diagram of a 30 cm ruler with a dotted line at 15 cm, labeled "Cut in half on dotted line (15 cm)"

• A nanometre is one billionth of a metre. It takes 50,000 nanometres to go across a human hair. Predict how many more times you will need to cut the 15 cm piece in half to get a nanometre-sized piece.

Prediction: ______________________________

• Keep cutting each half in half as far as you can. How many cuts did you get?

Number of Cuts: ______________________________

You would have to cut the piece in half 28 times to get to a nanometre!
STUDENT SHEET 4
Smart Dust Burrowing Owl Scenario

Smart Dust NanoApps Inc., a company formed by the commercialization of some research done at the Alberta Innovates—Technology Futures (AITF), has developed a mote that can be used to monitor a number of factors impacting wildlife habitats. They are trying to convince the University of Alberta to use the motes in their studies of burrowing owls in southwestern Alberta. Public hearings are being held to encourage input from a number of groups who may be affected by the use of this technology in the wild.

As a member of the general public, you’ve been asked to make a decision whether or not these motes should be released into the environment. To do this, you will meet with two other citizens and review the background information given out by the public hearing organizers. You will present your opinion to the class and create a PowerPoint presentation, a brochure, a poster, or a blog post to help make your point.

STUDENT SHEET 5
Motes / Smart Dust

- motes are tiny, self-contained battery-powered computers that use wireless links to exchange information
- motes are made up of a miniature computer, sensors, batteries, memory, and wireless transmitters
- sometimes called “smart dust”, motes will be so small and inexpensive that they could be distributed into a field or sensitive environment to form a network of connected sensors
- they have been used to monitor the nests of burrowing birds in Maine
- their sensors will measure temperature, humidity, pressure, and infrared light
- the information is sent from mote to mote to the computer base station, and onward to a satellite link to allow real-time internet data access

STUDENT SHEET 6
Possible advantages of using motes for environmental monitoring

• Burrowing owls are designated as a threatened species, which means they risk becoming endangered if changes are not made.

• Motes will make burrowing owl researchers’ jobs much easier, because they’ll be able to get data about the owls in their labs without going into the field.

• Motes will allow researchers to gather information about habitat without disturbing owls.

• Smart Dust NanoApps Inc. will open a manufacturing facility in Alberta to make the motes and will provide jobs for Albertans.

• Environmentalists appreciate the fact that this research will help save one of Canada’s threatened species.

• The Alberta Government (Sustainable Resource Development Branch) supports the Burrowing Owl Recovery program.

• Landowners in the area agree with preserving the grassland ecosystem, which includes the owls.

• Motes consume 1/1,000 of the power of other wireless devices like cell phones.
STUDENT SHEET 7
Concerns about using motes for environmental monitoring

• Some citizens are concerned about privacy and that motes might be used to gather other kinds of information about people’s activities.

• Landowners wonder what might happen if their stock accidentally eats a mote.

• Environmental groups are concerned that there have been few studies on the possible health and safety risks of nano-sized technologies.

• What are the implications of the manufacturing process? What materials are used and what is their toxicity level? Are the materials biodegradable?

• Where will the base station be? What will it look like? What are the possible environmental consequences of its placement?

• How long do motes last? Are they retrieved after they stop working and if so, how? Or are they abandoned?

• How are they actually delivered to the burrows? How much disruption is really caused by delivery and pickup?

• Technology like this is often expensive. Can we afford to use it?
STUDENT SHEET 8
Smart Dust: to deploy or not to deploy?

Decision Sheet

What does your group think are the positive impacts of using motes/Smart Dust?

What does your group think are the negative impacts of motes/Smart Dust?

Should motes be used at all? Explain why or why not.

Who will pay for the motes? Government, university researchers, environmental organizations, the public, or the manufacturers? Explain.
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!