Education and Outreach: Nanotechnology Activity Guides

Nanomedicine: Problem-Solving to Treat Cancer

Audience: Middle school class
Time Needed: 50 minutes

Objectives:

- Understand a ferrofluid application of nanotechnology
- Understand that manipulating atomic structure will alter observed properties at the larger scale
- Further develop problem-solving skills to address scientific issues
- Further develop their ability to communicate and debate scientific ideas
- Realize the pros and cons of scientific discoveries/technology

Related Wisconsin Model Academic Science Standards:

- *B.8.6* Explain the ways in which scientific knowledge is useful and also limited when applied to social issues
- *C.8.9* Evaluate, explain, and defend the validity of questions, hypotheses, and conclusions to their investigations
- *C.8.1* Identify questions they can investigate using resources and equipment they have available
- *C.8.5* Use accepted scientific knowledge, models, and theories to explain their results and to raise further questions about their investigations
- *F.8.1* Understand the structure and function of cells, organs, tissues, organ systems, and whole organisms
- *G.8.2* Explain how current scientific and technological discoveries have an influence on the work people do and how some of these discoveries also lead to new careers
- *G.8.3* Illustrate the impact that science and technology have had, both good and bad, on careers, systems, society, environment, and quality of life
- *G.8.4* Propose a design (or re-design) of an applied science model or a machine that will have an impact in the community or elsewhere in the world and show how the design (or re-design) might work, including potential side effects
- *G.8.5* Investigate a specific local problem to which there has been a scientific or technological solution, including proposals for alternative courses of action, the choices that were made, reasons for the choices, any new problems created, and subsequent community satisfaction
- *H.8.2* Present a scientific solution to a problem involving the earth and space, life and environmental, or physical sciences and participate in a consensus-building discussion to at a group decision
- *H.8.3* Understand the consequences of decisions affecting personal health and safety

Activity Materials:

- Ferrofluid demonstration tubes (4)
- Iron filing demonstration tubes (4)
- Empty demonstration inhalers ~ or pictures of some (4)
- Empty gel capsules (4)
- Cow magnets (4)
- Syringes without needles (4)
- Plastic storage boxes ~ the size of a shoe box (4)
- Handouts (4 sets)
- Transparencies of handouts
- Overhead projector
- Large sheets of paper (4)
- Markers (4+)

Activity Instructions:

Presenting the Problem (10 minutes):
Educators should inform the students that when they walked through the door of the classroom, they became real scientists faced with a real problem. Educators should explain to the students that local doctors have a problem that needs to be solved quickly. In order to do this, the students must form research teams. Educators should break the students randomly into groups. Once in a group, students should be given the "Attention Scientists" handout, and the educators should go over the handout with them. The students should be introduced to a profile of a patient who has lung cancer. Lung cancer symptoms and current treatment methods should be discussed by the educators and students. The educators should present the students with a new lung cancer drug, currently undergoing testing (clinical trials). However, this new cancer drug is very potent, and prolonged contact with other organs is harmful. The educators should stress that the new drug needs to be delivered directly to the lungs and remain there until it is absorbed.

To help students understand the anatomy involved in the treatment, the educators should show the class a picture of the patient's lungs and circulatory system to emphasize how easily a drug can travel from the lungs to the rest of the body.

Brainstorming (30 minutes):
Each group should receive a plastic box of materials that includes: a vial of ferrofluid, an empty pill capsule, a magnet, a vial of iron particles in mineral oil, a plastic syringe, and an empty inhaler. Before students receive these items, the educators should hold up each one and briefly describe it. Afterward, each group should receive a materials box and a copy of the "brainstorming" handout. Using the handout as a guide, students should be given 15-20 minutes to determine the best way to administer the new drug. During this time the educators should visit each group and discuss the properties of each material provided as a way to encourage students to make the connection between the unique properties of ferrofluid and its potential applications. At the end of the brainstorming time, each group should write down its solution on a big sheet of paper and explain why it would work the best. Representatives from each group should briefly present their ideas to the rest of the class. Members of other groups should be encouraged to ask questions.

Mini-Debate (10 minutes):

After the group presentations, the educators should lead the classroom in a mini-debate about the following question: "Is one idea a better solution for this situation than the others? Why?"
Following this, the educators should lead a discussion on the atomic properties of ferrofluid.

Topics might include: particle size, atomic arrangement, magnetite, liquid coating, and why nanosized particles might be important in biocompatibility. At the end of the activity, educators should explain to the students that the problem they just addressed is one that real scientists are working on in the lab. Cutting-edge research is attempting to use ferrofluid to deliver drugs. Current concerns with using ferrofluid in this manner should be discussed, including the fear of unknown side effects from ferrofluid's presence in the body and the uncertainty regarding ferrofluid's impact on the environment when it leaves the body.

Required Background Information:

Ferrofluid contains nano-sized particles with flow properties of liquids and magnetic properties of solids. They were first discovered by NASA when it was trying to control liquid in space. Ferrofluid consists of magnetite and a surfactant and is created according to the equation:

$2\ FeCl_3 + FeCl_2 + 8\ NH_3 + 4\ H_2O \rightarrow Fe_3O_4 + 8\ NH_4Cl$

The particle size and the ratio of magnetite to surfactant are critical for obtaining the desired properties. A mixture with too much or too little surfactant along with a large magnetite particle size will not display properties of a liquid. Ferrofluid can be used in computers disk drives, low friction seals, and loud speakers. UW MRSEC has previously developed a ferrofluid lab in which students synthesize ferrofluid. In addition, in order to allow students and the general public explore the properties of ferrofluid, UW MRSEC created a table-top demonstration using a vial or aquarium of ferrofluid and a cow magnet "Comparison tubes" that contain other metals such as iron fillings or cut-up paperclips have also been prepared to help students understand the special properties of ferrofluids.

Supplemental Materials:

- Handout: Student Worksheet (pdf)
- Handout: More Information about Ferrofluid (pdf)
- Order Supplies from Educational Innovations - http://www.teachersource.com

References:

- Ferrofluids - http://mrsec.wisc.edu/edetc/ferrofluid/index.html
- Lab Manual for Nanoscale Science and Technology - http://www.mrsec.wisc.edu/edetc/nanolab/index.html
- Loyola International Technology Research Institute - http://www.wtec.org/loyola/nanobase/
- Nanotechnology - http://www.zyvex.com/nano/
- Nanotechnology Information - http://www.aeiveos.com/nanotech/

- Nanotechnology, Myth or Miracle? - http://www.aeiveos.com/nanotech/ntmiracle.html
- Nanoworld Cineplex - http://www.mrsec.wisc.edu/edetc/cineplex/index.html

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| Return to this activity's summary page |

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