Nanoscience in the Environment
From lakes to oceans, from air to soil, from forests to deserts, from farms to cities.

How can small science help us protect such a big beautiful world?
How Big Is Nano?

This is one nanometer!
Nanotechnology is making significant improvements in technologies for protecting the environment. Nanoscale devices are being used for enhanced sensing, treating and remediating environmental contaminants.

Someday we may be able to prevent pollution with the help of nanotechnology.

On the other hand, nanotechnology's unique characteristics may also lead to unforeseen environmental problems.
Nanoscale Developments in the Environment

1. Nanosensors can be used to detect and track pathogens (germs), contaminants, nutrients, environmental characteristics (light/dark, hot/cold, wet/dry), heavy metals, particulates, and allergens. Nanotools can track agricultural products and improve their quality by detecting pesticides, fertilizers, and biological events.

2. Veterinarians can use gene insertion and gene therapy.
3. Nanodevices can be used to extract unwanted agricultural byproducts from soil and water.

4. Nanocatalysts will bioprocess waste into food, feed, industrial chemicals, biofuels and energy. (Catalysts are molecules that can quicken the pace of a chemical reactions by factors of billions. Additionally the benefit of nanosized particles increases the rate exponentially!)
5. Nano-filters and nano-bioreactor can be used to study enzymes and microbes in compost systems.
6. Trends in nanotechnology can be utilized to clean up toxic waste sites. Researchers have developed sponge-like nanoporous materials that will mop up pollutants in air and water, and break down noxious wastes therefore reducing greenhouse gases.
Cleaner Water with Nanotechnology

1. Nanotechnology can clean arsenic contaminated drinking water cheaply and simply enough to use in developing countries.

2. Researchers have developed nanocrystalline photocatalysts that purify water by accelerating a reaction that requires light. Nanoparticles use sunlight to break down organic pollutants, such as those in the oil industry. The performance of the nanocrystals has improved as well as the ability to recover them. Therefore they are more cost effective than previous nanocrystals.
Nanochemicals and Nanocatalysts

1. Nanochemicals and nanocatalysts can be used to purify exhaust.
   1. Researchers are working on a method to replace expensive platinum in catalytic converters with nickel.
   2. Gold is an inactive atom, but when gold is less than 6 nanometers, it becomes an active catalyst, helping oxygen combine with carbon monoxide to make carbon dioxide.

So, Isn’t This Great News?

To summarize and elaborate on positive points already made which promote the use of nanoparticles in the environment -

1. Nanoparticles in nature can be used to clean up polluted environments by weakening pollutants and hazardous organisms in the ground, air or water.

2. Pipes might be coated with nanoparticles to weaken pollutants as they pass through.

3. Nanoparticles could also monitor biochemical threats which would increase public safety.
But...

What might happen to the environment if they get out of control? They could cause unexpected and dangerous reactions in plants, animals or the environment.

What is the cost to the environment when we manufacture and use these nanomaterials and techniques?
Environmental Precautions

Technological advances which benefit and protect the environment are one reason to invest in nanotechnology research related to the environment.

A second reason to invest in nano-environmental research is because of the potential impact of nanoparticles in the environment.
Why Do Nanoparticles Have a Greater Impact?

1. The amount of surface area of a substance affects the interaction of chemicals in that substance with the environment. Smaller particles, nanoparticles, would result in a great deal of surface area. Thus there will be a dramatic increase in the interaction between that substance and the environment if its particle size changes from macro to micro to nano!
According to Professor Joel Pederson, Environmental Chemistry and Technology Program, UW-Madison, there are three main factors affecting the impact of nanoparticles in an environment:

1. For a given amount of matter, there’s a great deal more surface area when the paper/particles are smaller. To illustrate the increased amount of surface area when a material is ‘nanosized’, take a piece of paper and measure the perimeter of the paper. Then cut or tear the paper into smaller and smaller pieces. Calculate the total perimeter for that amount of paper now.
Environmental Factors

2. A second concern is that some core materials of the nanoparticles can be toxic to the environment.

3. Nanoparticles are often coated with a different material than the core. These coatings are expected to interact with the environment. But the core material may become exposed to the environment when the coating is worn away. (In the same way chocolate in an M&M is exposed when the coating melts away on a hot day.) For example, microscopic organisms, such as daphnia in water, digest the coating and expel the core material back into the environment.

3. Lastly, the environment itself affects the toxicity and fate of the nanoparticles.

Soil, water or particles in the air can interact with nanoparticles and affect what these particles become and where they eventually end up.
Evaluation Needed

Three main areas of nanoscience in the environment need to be researched to evaluate the impact of nanoparticles:

1. The appropriateness and effectiveness of present plans to identify and manage nanomaterials which have the greatest risk to the environment.

2. Evaluate our ability to minimize hazards and exposure to high-risk nanoparticles.

3. Evaluate present risk management plans for all nanomaterials.
1. Might these nanotechnology developments in the environment infringe on human rights?

2. Could any of them decrease privacy of individuals?

3. Could the use of nanotechnology have unwanted and negative environmental effects?

4. What economic impact could the use of nanotechnology in the environment have on producers, consumers, and other industries? Might they be negative or positive?
What About Your Rights?

If so, are these developments more important than

• Your privacy?
• Your rights as a citizen?
• Your rights as a human being?

Are the answers somewhere in between?
Research Questions

To prepare for your presentation, answer the following questions using reference materials which can include the websites linked to this webquest:

1. What can be done to maximize the chances that humans will benefit from, rather than be harmed by, new developments?

2. If we can develop these technologies, should we? Why?
Environment Websites

These websites can help you find more information on nanotechnology in the environment. The last link connects you to general nanoscience sites.

http://cben.rice.edu
http://blogs.chron.com/sciguy/archives/2006/02/a_call_for_more.html
http://scienceline.org/2006/09/22/env-cosier-nanotech/
http://www.nanocafes.org/environment
http://www.hpl.hp.com/environment/nanotechnology.html
http://www.foresight.org/nanodot/?cat=82
http://www.sciencedaily.com/releases/2008/04/080408132129.htm and/or do a search at this site
http://www.blonnet.com/businessline/blnus/34065012.htm
http://www.smalltimes.com/Articles/stm_category_display.cfm?c=Envir&CatName=Environment
http://online.sfsu.edu/~rone/Nanotech/nanotech.htm
http://www.mos.org/topics/nanotech_and_nanomedicine
http://www.nano.gov/
http://www.safenano.org/

A Presentation from Cynthia Folsom Murphy and David Allen, University of Texas, October 4, 2004

Numerous nanoscience sites are linked here: **Websites**
More Help

If you would like help breaking down your research into steps, click on the help button for an outline.