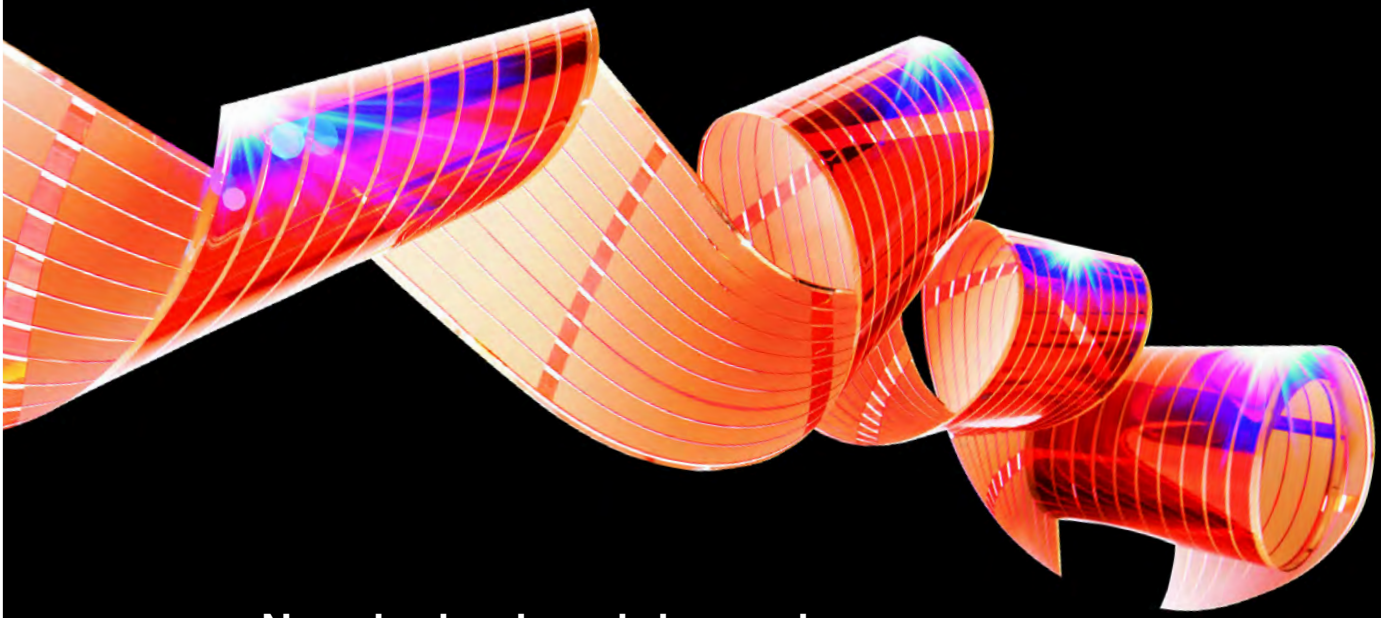
Will nanotechnology solve our energy crisis?



Nanotechnology is improving how we harness the sun's energy.

Nanotechnologies could deliver world-altering changes in the ways we create, transmit, store, and use energy. Scientists are working to develop super-efficient batteries, low-resistance transmission lines, and cheaper solar cells. However, the likelihood and time frame of these developments is unknown.

The next generation of solar cells is thin film solar cells—flexible sheets of solar panels—that are easier to produce and install, use less material, and are cheaper to manufacture. These sheets can be incorporated into a briefcase that charges your laptop, woven into wearable fabrics that charge your cell phone and iPod, or incorporated into windows that can supply power to high-rise buildings.

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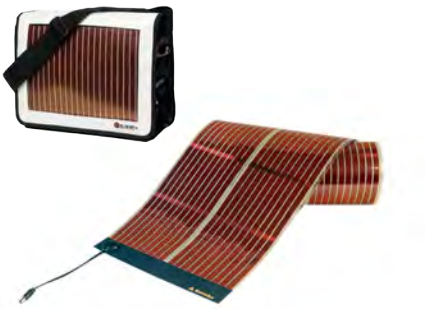
Nanotechnology-enabled energy production and distribution has the potential to solve a number of pressing energy issues. Reworking our enormous, highly integrated energy infrastructure will not be an easy task. How can these new technologies fit into domestic energy policies to best benefit society?

Energy



Can nanotechnology solve our energy crisis?

Well, we don't know. But imagine for a moment what it would be like if we had windows that supply power to buildings, affordable paint-on solar energy technologies or super-efficient batteries to power our cars. Rising energy costs, dwindling natural resources, pollution, and climate change concerns have drawn increasing attention to the relationship between human activity and the earth's environment. Alternative and renewable energy sources and efforts towards conservation are in the public eye and in the priorities of public service officials and industry leaders as never before.

Policymakers face difficult choices when deciding how to allocate funding for energy and the environment. How should nanotechnology research fit into domestic energy policies in the future? Should the bulk of research funding be dedicated to the implementation of existing technologies, or should more effort be dedicated to designing new technologies that could be of greater long-term impact? These are important questions and we as a society must decide to pursue this technology if we wish to see it developed.

What factors do we need to consider?

Nanoparticles could allow us to build ultra-efficient transmission lines for electricity, produce far more effective and inexpensive solar cells, make cheaper and more efficient biofuels from a wide variety of sources, and improve the safety and efficiency of existing nuclear reactors. Other developments made possible by nanotechnology might one day do far more to lessen the human impact upon the environment than current alternative and renewable energy options. Reaping these advantages, however, will not be easy. For instance:

1. The scope and timetable of nanotechnology's contribution to alternative and renewable energies is uncertain. Immediate action to address increasing energy costs and global climate change may be necessary, but the ultimate benefit, risk, and short-term effects of nanotechnology remain unknown.

2. Governments and corporations will have to decide how nanotechnology will be used to generate and distribute energy. One model focuses on making existing power plants more efficient or developing new types of power plants. This model is basically our current model where power is generated by large corporations and governments and then distributed to people who need it. Another model is to decentralize the generation of power through small solar cells. This could allow individuals to produce their own power and then use it as they see fit. Some argue that if people generate their own energy they will use less of it, but it may be that only wealthy people have the ability to generate their own power. We should consider how these technological decisions will affect people of all walks of life. We can certainly work on both approaches, but there will be interest groups trying to push policy in specific directions.

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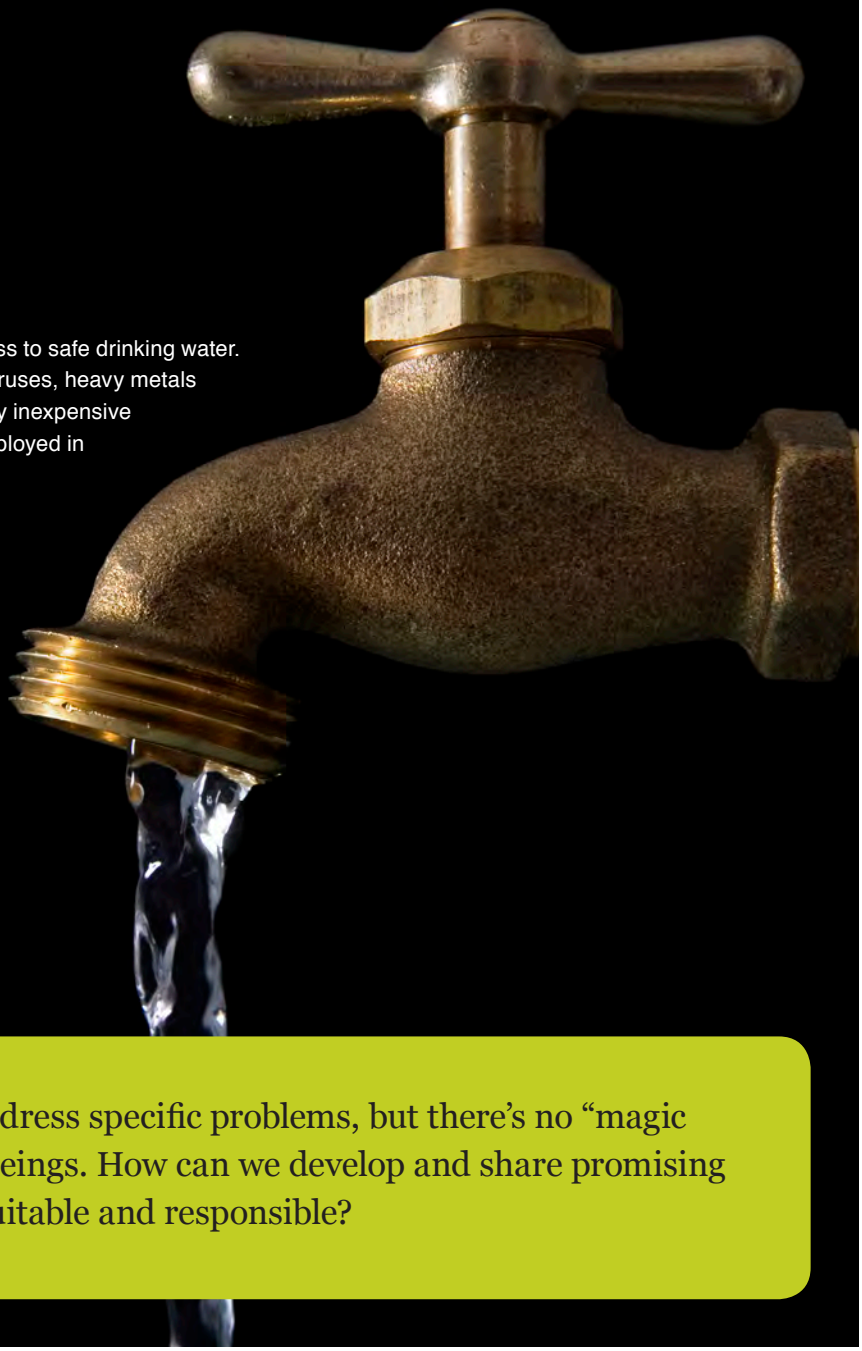
Will nanotechnology improve living conditions around the world?



Nanofilters can produce safe drinking water.

In many parts of the world, people don't have access to safe drinking water. New nanofiber water filters can remove bacteria, viruses, heavy metals and organic materials from water. They're relatively inexpensive and easy to use, so nanofilters could be widely employed in developing countries.

Providing pure drinking water would help prevent disease in many parts of the world, but it wouldn't resolve many basic inequalities.

Emerging technologies can help us address specific problems, but there's no "magic bullet" to improve life for all human beings. How can we develop and share promising nanotechnologies in ways that are equitable and responsible?

Risks vs. Benefits

Can nanotechnology benefit *me*?

Well, we don't know. But imagine for a moment what it would be like if we had windows that cleaned themselves, affordable paint-on solar energy technologies, or drugs that targeted only the tumor and not the patient's healthy cells. Currently, the majority of nanotechnology products available are targeted to wealthy consumers in such things as stain-resistant dress pants, smoother cosmetics, and golf clubs and tennis rackets that are stronger and lighter. But nanotechnology can also be used to address many problems in developing countries. In addition to being used for fighting disease, nanotechnology has been employed to purify water, improve food preservation and develop new materials used for shelter.

Could nanotechnology be dangerous?

Yes. We already know that some nanotechnologies are dangerous and many others that we currently know less about could also be dangerous. But just because something is dangerous doesn't mean we shouldn't use it. We use a lot of dangerous things today in our everyday lives. Gasoline, for instance, is extremely toxic and flammable, but because its use is so prevalent and necessary, we take steps to use it safely. There are strict regulations about how gasoline can be produced, transported and sold. Of course, there is always a chance for accidents, but regulations help a great deal to make our use of gasoline safe. A similar approach should apply to nanotechnology. We should use it when it is most beneficial for our needs, but develop regulations to prevent nanotechnology from being mishandled or applied in dangerous ways.

The dangers posed by nanotechnology might be bigger than other technologies because they are impossible to see and difficult to detect, and the ultimate dangers might not be seen for a long time. Scientists, engineers, social scientists, lawyers and other specialists are already working to determine what the effects of some of the applications will be and their work is helping us to understand nanotechnology better. However, we can never know the full effect or dangers of a new technology until it is being regularly utilized. Nanotechnology is no exception.

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Would you use a dangerous technology?

Gasoline is toxic and flammable.

Gasoline can be dangerous, but because it's useful, we have regulations for producing, transporting and using it safely. It's part of our daily lives, so we rarely consider all the systems we have in place to make gasoline safe. But when emerging energy technologies hit the market, we'll need to create new regulations to ensure safety.

New applications of nanotechnology might provide clean, efficient sources of energy. If so, they'll have a profound effect on our society. After all, our reliance on gasoline-powered transportation affects our daily lives, the design of our communities and our natural environment.

As new technologies—including nanotechnologies—are developed, we'll reap new benefits but also face new risks. And our lives, relationships and ways of looking at the world will change in ways we can't always predict. How can we think ahead and plan for these changes?

Risks vs. Benefits

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What's hidden in *your* sunblock?

Many sunblocks contain nanoparticles.

If your sunblock rubs in clear, it might contain nanoparticles. Nanosized particles of zinc oxide or titanium dioxide are too small to reflect light, so they don't leave a white film on skin. The label will tell you the ingredients in your sunblock, but it doesn't have to say what size the particles are.

Although studies suggest that the sunblocks are safe for humans, some people worry that the tiny nanoparticles may impact the environment when they wash off our skin.

Nanotechnologies are difficult to regulate because they're hard to detect and to define, and we don't really know how safe or dangerous they are. Do you think manufacturers should be required to let you know if their products contain nanotechnology? Would you use a sunblock with nanoparticles in it on your skin?

Personal Health & Medicine

Nanoparticles are already in many personal care products

Nanoparticles could be used with MRIs

Under what conditions should nanotechnology applications in medicine and personal care products be made available to the public?

This is an extremely important question. But it is not a question that science alone can answer. It is a question you should ask yourself and discuss with your friends and even your political representatives. Science can help us to understand what risks might be involved, but research alone doesn't reveal every problem and, ultimately, choosing to accept risks is a value judgment. So we should address this question on a personal level as well as part of a broader community.

On a personal level, many people are willing to take more risks with medicine than with personal care products. For instance, iron oxide nanoparticles are considered a promising contrasting agent used in Magnetic Resonance Imaging (MRI) to detect the presence of tumors. Currently there are no approved nanotechnology-enabled contrast agents for humans, but recent research has discovered that these particles exhibit toxic effects on nerve cells in mice. If a nanotechnology-enhanced shampoo were to involve such dangers, few people would be willing to use it. But because cancer is such a deadly disease and the treatments we have for it already are so dangerous, those who suffer from cancer may be willing to expose themselves to potentially dangerous nanoparticles in seeking a cure.

Individual personal decisions about nanotechnology are incredibly important, but they are not enough. Every time we use a product enhanced by nanotechnology, our actions could affect other people. For instance, the nanoparticles used in cosmetics affect us directly by being absorbed by the skin, but ultimately the containers are disposed of and product residue could potentially end up elsewhere in the environment. Some people have decided that while it would be nice to have nanosilver socks that keep their feet from smelling bad, they won't purchase them because they don't know enough about the potential environmental consequences of nanosilver. So we have to make conscious and collective choices about how we want nanotechnology to be used.

It should also be noted that a great number of personal care products are enhanced through nanotechnology. Many cosmetics and sunscreens use nanoparticles of titanium dioxide to help block the sun's rays or to provide a smoother look when applied. Initially, a number of these companies proudly labeled their products as nanotechnology-enabled. As public concerns about nanotechnology rose, a number of these companies removed the label—but not the nanoparticles—to help limit public concern. There is currently a debate over whether companies that include nanoparticles in their products should be required to label them as such to help the public make an informed choice. Do you think these products should be labeled? If so, how much extra are you willing to pay to ensure that such labels exist?

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Are you being tracked?

New surveillance tags are so small, you might never know.

Radio Frequency Identification (RFID) is used for logging livestock, library books—and you. If you have a U.S. passport issued after 2006, it contains an RFID tag. You might also have a transponder in your car to pay road tolls. The human hands in this x-ray have RFID devices embedded in them, similar to identification chips used for pets.

Many people find that the convenience of tracking tags outweighs their concern for privacy. But in the future, tiny nanosized surveillance devices would be impossible to detect without special equipment. Some existing tags are already as small as dust! How do you feel about tracking now? Would you feel differently if the size of the sensors changed?

Amal Graafstra / www.amal.net

Currently, the ability to read these tags at a distance is limited to a few feet. Nanotechnology could help make smaller, more powerful tags and sensors. As these tags and sensors get smaller and the technology to read them improves, it may be more difficult to protect individual privacy. Would you use a tiny tag to watch a rebellious teen? What about an elderly parent with Alzheimer's?

Privacy

Our right to privacy

There are certain things that we justifiably don't want others to know about us. The right to privacy is an important cornerstone of our society and not necessarily because we want to be able to get away with doing illegal things. Rather, we would like some control over how others perceive us and believe that some level of privacy will help us to do that. Some people feel that new technologies will make privacy even more difficult to secure.

Traditionally, we've been able to make mistakes and move on. But the development of technologies like camera phones now make it increasingly difficult to keep embarrassing photos, for instance, from showing up on the Internet. Most people believe that the small errors in judgment they make in their personal life shouldn't prevent them from getting a job. However, applications like Facebook sometimes make it difficult for us to maintain privacy and keep our social life separate from our work life.

Two different types of RFID tags

How can nanotechnology affect someone's privacy?

Nanotechnology may compromise our privacy in two important ways: First, it will aid in producing sensors that are practically undetectable. And second, it may help to link different sensors so that vast amounts of information can be collected and assembled in one place.

Video surveillance technology has become a part of our everyday lives. When we walk into some stores, for instance, we can sometimes see that a camera is monitoring us and we may even see a television with our picture. Using nanotechnology, it may soon be possible to make sensors so small that they would be invisible to the naked eye and almost impossible to detect without special equipment. On the flip side, nanotechnology-enabled sensors could be used to detect chemicals in the air and prevent a terrorist attack in a crowded area such as a stadium. Or, they could be used to detect any trace of alcohol on a driver trying to start a car.

Where does the need for privacy outweigh the need for security? What amount of privacy would you exchange for convenience? The ways that nanotechnology can be used to secretly collect and share data prompts a lot of social, ethical and political questions. We as citizens will have to make these choices, so we should carefully consider what values are most important to us and find appropriate ways to support them.

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Does nanotechnology belong in toys?

Nanosilver is found in many consumer products.

Silver is naturally antibacterial, and tiny nanosized silver particles are especially effective at killing germs. Nanosilver is used in bandages, cutting boards and washing machines—and at one time, was even found in a stuffed teddy bear.

Nanosilver can help prevent infection, but widespread use of nanosilver could contaminate water supplies, kill fish, or lead to silver-resistant germs.

Any technology has risks and benefits. When one person or group benefits, others may be put at risk. Who should make decisions about whether to use certain nanotechnologies? Does it make sense to use nanosilver catheters to prevent infections in hospitals? What about using a nanosilver washing machine at home?

Regulatory Issues

Samsung's Silvercare washing machine "eliminates" bacteria

Who watches out for potential risks posed by nanotechnology?

There is no one regulatory agency that oversees nanotechnology, but the U.S. government's Food and Drug Administration (FDA) and the Environmental Protection Agency (EPA) are currently developing ways to monitor the effects of nanotechnology. Because nanotechnology is so difficult to identify, and is still an emerging science, we don't really know yet how safe or dangerous it is—for people or things. So far, the government hasn't regulated anything specifically because it was enhanced by nanotechnology, but it has weighed in on its use in some products.

Samsung's "SilverCare" washing machine, for instance, claimed that its product used silver ions to "kill" 99.9% of bacteria in clothes. This claim caught the attention of the EPA, which argued that because Samsung advertised that its washing machine "killed" bacteria, the product should be regulated under the Federal Insecticide Fungicide and Rodenticide Act (or FIFRA). The EPA required Samsung to substantiate the safety precautions the company had taken with SilverCare. Instead, Samsung decided simply to change its advertising to claim that the washer "eliminates" bacteria, which the EPA has chosen not to regulate.

Who else could help regulate nanotechnology?

Another major group that could regulate nanotechnology is you—the public. Recently, a company called Pure Plushy sold a teddy bear that was embedded with silver nanoparticles to prevent dust mites, bacteria and mold from growing on it. By eliminating these organisms, the bear—known as Benny the Bear—could be enjoyed by children with severe asthma and allergies. Benny became famous when Andrew Maynard of the Woodrow Wilson International Center asked publicly whether it was safe for a child to chew on a bear that had nanosilver embedded in it, which the company assured that it was.

Scientists know that nanosilver can be very dangerous for fish and other aquatic life, but there haven't been any studies showing that nanosilver can be bad for people. In fact, people have been using colloidal silver as an antibiotic treatment for many illnesses and infections for centuries. Pure Plushy took this to mean that its product was safe. But as Maynard and others wrote more articles questioning whether enough research had been done to be confident in its safety, Pure Plushy realized that their position on Benny's safety didn't matter as much as the public's perception. Without specific studies to support their claim, Pure Plushy decided to change their marketing to avoid potential lawsuits as well as public backlash against nanotechnology.

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