History of Islam

An encyclopedia of Islamic history

Nanotechnology

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Islam encourages the use of science and the scientific method. Acquiring knowledge is obligatory upon every Muslim, male and female. In Islam, science and technology should be used for moral ends and serve humanity's legitimate needs, and be considered as yet another means to understand and see God's Power and Glory.

In the 21st century, we are plunging forward into a new era of technological power — one that offers enormous promise and danger.

What is nanotechnology ?

In its most basic form, nanotechnology refers to the manipulation of materials at the atomic or molecular level. The name derives from the nanometer, a scientific measurement unit representing a billionth of a meter, three to four atoms wide. Scientists are learning how to connect atoms and molecules together to create nano-scale mechanisms that create switches or transistors, or even small machines that can perform complex tasks.

To use an oft-quoted comparison, a human hair is between 100,000 and 200,000 nanometers thick, while a typical virus can be just 100 nanometers wide. Atoms are typically between one-tenth and one-half of a nanometer wide. Due to the difficulties involved in working at this scale, manipulation of items as "large" as 100 nanometers is generally included in the concept of nanotechnology.

Nanotechnology enables scientists to create new materials atom by atom. With increasingly more powerful microscopes, scientists can see molecules that are mere nanometers (billionths of a meter) in size. To clarify this size, a pinhead is one million nanometers across. The field intertwines nearly all fields of science.

Most nanotechnology discussions deal with the futuristic concept of nanomachines or nanorobots: microscopic devices that carry out tasks at the atomic or subatomic level. Nanotechnology, also called molecular manufacturing, is "a branch of engineering that deals with the design and manufacture of extremely small electronic circuits and mechanical devices built at the molecular level of matter." The goal of nanotechnology is to manipulate materials at the atomic level to build the smallest possible electromechanical devices, given the physical limitations of matter. Many of the mechanical systems that we know how to build will be transferred to the molecular level as some atomic analogy.

A typical vision of the twenty-first century: "Nanotechnologists will be building our cars one molecule at a time, invading our bloodstream to declog our arteries, and replicating themselves thousands of times over."

Nanorobots (1)

A nanorobot is a computer-controlled robotic device constructed of nanometer-scale components to molecular precision, usually microscopic in size (often abbreviated as nanobot). This reminds one of the 1966 film Fantastic Voyage, in which a team of scientists are miniaturized, placed in a tiny submarine, and injected into a sick man's bloodstream. Nanotechnology invariably involves work on a much smaller scale than the average blood cell.

Producing commercially viable nanomachines will be more challenging, since atomic manipulation, while not theoretically contrary to the laws of physics, is still extremely slow and costly. The most widely discussed long-term solution is to make the nanomachines self-replicating. Control mechanisms for such systems, mainly how a machine "knows" to copy itself and when to stop doing so, are still in their very early stages. Once again, theory is far ahead of practical reality.

Many of nanotechnology's more recent practical applications have been in the area of material research. However, scientists believe that transistors eventually could be built in this way, paving the way for computational technologies that do not depend on silicon and that can pack even more circuitry into microscopic spaces.

Nanoshells (2)

Nanoshells, defined as tiny particles that can manipulate light, can be used to transform medical procedures, ranging from cancer therapy to medical testing and drug delivery. They are ideal for biotechnology applications because they are biocompatible, can be altered and modified, and absorb light easily in the near-infrared region, where human tissue is most transparent.

Nanoshells can be tagged and delivered specifically to tumor cells, thereby leaving healthy cells undamaged. In addition, they can reduce the amount of time needed to conduct medical tests from several days to a matter of seconds. When incorporated into temperature-sensitive polymers, nanoshells can be triggered to release a chemical using infrared light, thus enabling a patient to control the release of medicine that requires periodic dispensing.

A new bandage (3)

A new bandage that imitates natural healing process is used for injuries ranging from minor cuts to gunshot wounds. The bandage, a flannel-like material, stops bleeding immediately and eventually is absorbed by the body. This new material is developed by spinning a compound naturally found in the blood into a bandage that can minimize blood loss and be absorbed by the body, according to an article in the 12 Feb. 2003 issue of Nano Letters, a journal of the American Chemical Society. "We've taken an old technique — electrospinning — and applied it to natural fibers," says Gary Bowlin, associate professor of biomedical engineering at Virginia Commonwealth University.

When a person bleeds from a cut or a wound, a blood clot forms and netting made of a substance called fibrin develops over the clot. According to researchers, fibrinogen, the compound in blood that comprises the "natural" bandage, is a fibrin precursor that can come from human, bovine, or genetically engineered bacterial sources. The goal is to pack the bandage like gauze so that it can be used to treat trauma patients, according to Bowlin.

Science fiction into reality (4)

Imagine a world in which cars can be assembled molecule-by-molecule, garbage can be disassembled and turned into beef steaks, and people can be operated on and healed by cell-sized robots. Sounds like science fiction? Well, with current semiconductor chip manufacturing encroaching upon the nanometer scale and the ability to move individual atoms at the IBM Almaden laboratory, we are fast approaching the technological ability to fabricate productive machines and devices that can manipulate objects at the atomic level. With this ability, we will be able to develop molecular-sized computers and robots that will give us unprecedented control over matter and the ability to shape the physical world as we see fit.

Nanofabrication techniques with applications in fiber optics, biotechnology, microelectromechanical systems (MEMS), and "tiny mechanical devices such as sensors, valves, gears, mirrors, and actuators embedded in semiconductor chips," are of particular interest, as they are but a mere step away from the molecular machines envisioned by nanotechnology. MEMS are used in automobile airbag systems as accelerometers to detect collisions, and will become an increasing part of our everyday technology. In 1986, K. Eric Drexler, a researcher at MIT, foresaw the advent of molecular machines. In his Engines of Creation, he outlined the possibilities and consequences of this emerging field, which he called nanotechnology. Drexler has written numerous books on the subject, such as Unbounding the Future, and has founded the Foresight Institute, a nonprofit organization dedicated to the responsible development of nanotechnology. Today, nanotechnology research and development is widespread in numerous universities. The U.S. government has created an organization, the National Nanotechnology Initiative (NNI), to monitor and guide research and development in this field.

Potential benefits

It does not take much of a leap of imagination (to imagine) disassemblers dismantling garbage to be recycled at the molecular level, and then giving it to assemblers who will use it to build atomically perfect engines. Stretching this vision a bit, you can imagine a Star Trek type replicator that could reassemble matter in the form of a juicy steak, given the correct blueprints and organization of these nanomachines.

A laboratory-scale "in vivo nanoscope" could be capable of providing atomic resolution, real-time movies of happenings inside living cells in intact living animals. This nanoscope, a hybrid of conventional technology and early (pre-assembler) nanotechnology, is an enormous leap in the ability of biologists to understand the workings of cells and develop medical therapies.

Some of the more prominent benefits of nanotechnology would be precision manufacturing, material reuse, and miniaturization. Medical applications are pharmaceutical creation, disease treatment, and nanomachine-assisted surgery. Environmental applications lie in toxin cleanup, recycling, and resource consumption reduction.

Nanomedicine deals with the comprehensive monitoring, control, construction, repair, defense, and improvement of all human biological systems by working at the molecular level with engineered nanodevices and nanostructures; the science and technology of diagnosing, treating, and preventing disease and traumatic injury, as well as relieving pain and preserving and improving human health through the use of molecular tools and molecular knowledge of the human body; and the use of molecular machine systems to address medical problems and using molecular knowledge to maintain and improve human health at the molecular scale. Cosmetic nanosurgery carried out with simple nanomachines (no on-board computers, for example) could change hair color, cause hair to grow or not to grow in specific locations, keep teeth clean and skin smooth, and so on, all far more effectively than current treatments.

Looking somewhat further in the future at more radical modifications of the human body through nanotechnology, Edward Reifman describes dentistry with assembly-fabricated teeth, and even with the teeth and jaws being made of diamonds. "In the long term, we hope to be able to build small nanorobots which can search out and destroy cancerous tumors when they comprise just one or two cells" or "small drilling machines which dissolve clots."

Viruses, which are natural nanomachines, could be fought more effectively, as the body's own immune system has some handicaps: it tends to forget the shape of its enemies, cannot always successfully identify malignant cells, and suffers from a certain delay until the immune reaction is fully developed. Therefore, nanomachines could support the immune system. Nanomachines could rout bacteria, excise tumors, reconstruct damaged tissue, and even make a huge contribution to treating the process of aging.

Along with the obvious manufacturing benefits, there are many potential medical and environmental benefits. With nanomachines, we could better design and synthesize pharmaceuticals, directly treat such diseased cells as cancer, better monitor a patient's life signs, and make microscopic repairs in hard-to-operate-on bodily areas. With regard to the environment, we could use nanomachines to clean up toxins or oil spills, recycle garbage, and eliminate landfills, thus reducing our natural resource consumption.

Potential dangers

The downside to these benefits is the possibility of using assemblers and disassemblers to create weapons, to be used as weapons themselves, or the possibility that they may run wild and wreak havoc. Other less invasive but equally perilous uses would be in electronic surveillance.

However, with nanotechnology, armies could develop disassemblers to attack physical structures or biological organisms at the molecular level. A similar hazard would be if general-purpose disassemblers escaped into the environment and started disassembling every molecule they encountered, the so-called "gray goo scenario." Furthermore, if nanomachines were created to be self-replicating and, for some reason, had a problem with their limiting mechanism, they would multiply endlessly, like viruses.

Even without considering such extreme disaster scenarios, we can find plenty of potentially harmful uses for nanotechnology, such as the erosion of our freedom and privacy. For example, people could use molecular-sized microphones, cameras, and homing beacons to monitor and track others.

Ethical issues and analysis

Given the awesome potential dangers inherent in nanotechnology, we must analyze its potential consequences. Nanotechnology may never become as powerful and prolific as envisioned by its evangelists, but as with any potential near-horizon technology, we should formulate solutions to potential ethical issues before the technology is irreversibly adopted. We must examine the ethics of developing nanotechnology and create policies designed to assist its development while eliminating, or at least minimizing, its damaging effects.

Nanosensors(5)

A nanosensor is defined as a chemical or physical sensor constructed by using nanoscale components, usually microscopic or submicroscopic in size.

Nanotechnology brings science fiction into everyday life6 Nanotechnology's more immediate future lies in its application in such sensors as electronic "noses" that can detect, for example, the presence of individual protein molecules in a blood sample. This involves a fingernail-sized chip with thousands of sensors, each set to detect a specific substance. It might even be possible to make these noses so small that they could fit on a needle. Then, there would be no need for a blood test, for a finger prick would be sufficient to allow a full blood analysis.

Nanosensors also will be of great value in producing new medicines, for they can effectively find active substances. So far, it has been possible to build this type of sensor one by one; the difficulty lies in integrating perhaps 100,000 of them on one chip.

Aging can be delayed by repairing human cells one by one. Unlimited computer power can be obtained by improved microchip performance. Global warming can be reduced by cleaning greenhouse gases out of the atmosphere with nanoparticles, and pesticides could kill insects without harmful byproducts. Creating artificial muscles and sensors, as well as nanocoating for metal, could increase power plant efficiency and potentially save millions of dollars a year for electricity generators. For example, we now have self-washing windows that repel dirt, thanks to their nanostructured surface.

Nanofluids (7)

On the medical front, researchers at Virginia Polytechnic Institute are developing magnetic nanofluids. They posit that magnetic particles attached to medicines, like those used in chemotherapy, can be concentrated on one part of the body by using external magnets on patients.

Always clean clothing (8,9)

Imagine textiles that cannot be stained or wrinkled, that always maintain the look and feel of fabrics made from natural fibers. Imagine materials that are 100 times stronger than steel, but weigh only one-sixth as much. Nanofibers could be used in astronauts' suits, moving with them as they work to give them greater flexibility in space, or to allow the disabled greater mobility by acting as extra muscles.

Imagine batteries that take up less than one cubic millimeter, but supply a medical implant with power. Imagine sensors, smaller than a pinpoint, that detect anything in extremely low concentrations, from specific antibodies to toxic chemicals.

A big splash of coffee leaves an unmistakable stain on an ordinary pair of trousers; on a pair of nanotextile trousers, it can be brushed off without leaving a trace. A titanium frying pan and the laser in a fairly modern CD player are both based on nanotechnology. By using nanotechnology, wall paint could automatically sterilize an operating theatre, filters could be used in water purifiers to automatically kill undesirable bacteria, and roofing tiles that convert solar light into household electricity could give way to reinforced self-repairing houses immune to all natural disasters "short of a large incoming meteor.(10)

Hence nano-technology is and will continue to become part of our everyday lives … sometimes without us even noticing.

Michael Crichton (11)

Crichton says "These organisms [self-reproducing tiny computers] will be created by nanotechnology, perhaps the most radical technology in human history: the quest to build man-made machines of extremely small size, on the order of 100 nanometers, or 100/billionths of a meter. Such machines would be 1,000 times smaller than the diameter of a human hair. Experts predict that these tiny machines will provide everything from miniaturized computer components to new medical treatments to new military weapons. In the 21st century, they will change our world totally.

"The potential benefits are spectacular: Tiny robots may crawl through your arteries, cutting away atherosclerotic plaque; powerful drugs will be delivered to individual cancer cells, leaving other cells undamaged; teeth will be self-repairing. Cosmetically, you will change your hair color with an injection of nanomachines that circulate through the body, moving melanocytes in hair follicles. Other nanomachines will lighten or darken skin color at will, removing blemishes, birthmarks and liver spots in the process; still others could cleanse the mouth and eliminate bad breath. Nonsurgical nanoprocesses could even perform liposuction and body reshaping. They will also repair knees and spines.

Living spaces will be transformed with self-cleaning dishes and carpets and permanently clean bathrooms. Windows will lighten or darken at will; programmable paint will change color. You can walk through the walls of your house, since they are composed of particle clouds. Your personal computer and your watch will be painted on your arm. Temperature-sensitive clothing will loosen when it gets hot, insulate when it gets cold."

In the future, roving nanomachines will convert trash dumps to energy, solar nanomachines will be coated on the houses to generate electricity, and flexible nanomachines will provide earthquake protection. It may even be possible to move a house across the lawn on the backs of millions of nanomachines.

At this time, nanotechnology is still very much in its infancy. However, such major corporations as IBM, Fujitsu, and Intel are funding this research. U.S. government investment has gone from virtually nothing only a few years ago to hundreds of millions of dollars as of this writing. .

At present, nonotechniques are being used to make sunscreens, stain-resistant fabrics, and composite materials for cars; soon, they will be used to make extremely small computers and storage devices. Pittsburgh based PPG Industries, Inc. is making self-cleaning window glass; the Westaim Corporation of Toronto is making nanocrystal wound dressings with antibiotic and anti-inflammatory properties. Currently, nanotechnology is principally a material technology.

Most experts predict that self-reproducing machines are only a decade away. Man-made, self-reproducing entities already have been released into the environment. The first of these, of course, were computer viruses. The first viruses were created as a game ("core wars"), a 1960s battle between mainframe programmers, each releasing a program into the other's mainframe computer. Originally limited to specialists, hackers soon joined in. The growth of computer networking made rapid worldwide transmission possible. Computer viruses, worms on the Internet, have become an international threat to information and global business.

Scientists are witnessing some of the problems of self-replicating biotechnology agents. For example, a recent report indicates that modified maize genes are appearing in native maize in Mexico, despite laws against it and efforts to prevent it. This is only the start of probably a long journey to control this new technology. Laws have been passed to put hackers in jail; delinquent biotechnologists will soon join them. We need international controls to deal with self-reproducing technologies right now, whereas now there are essentially none.

Footnotes

(1) http://www.zdnet.com.au/newstech/enterprise/story/0,2000048640,20267134-2,00.htm (http://www.zdnet.com.au/newstech/enterprise/story/0,2000048640,20267134-2,00.htm)

(2)www.rice.edu/projects/reno/Newsrel/2001/20010402_nanotechnology.shtml.

(3) http://www.smalltimes.com/document_display.cfm?document_id=5481 (http://www.smalltimes.com/document_display.cfm?document_id=5481).

4http://cseserv.engr.scu.edu/StudentWebPages/AChen/ResearchPaper.htm.

(5)www.nansosensors.com.

(6) Nino Simic, "Nano into Everyday Life." http://www.oresundit.com/composite (http://www.oresundit.com/composite)(1610).htm.

(7) Ryan Randazzo, Reno Gazette-Journal, 15 June 2002.

(8) http://www.agg.com/Practice/Nanotechnology_main.html (http://www.agg.com/Practice/Nanotechnology_main.html).

(9) http://www.oresundit.com/composite (http://www.oresundit.com/composite)(1610).htm.

(10) http://www.foresight.org (http://www.foresight.org).

(11) Michael Crichton, "Could Tiny Machines Rule the World?" Parade Magazine, 24 November 2002, pgs. 6-8.

Some nanotechnology links:

http://www.about.com/nanotechnology (http://www.about.com/nanotechnology) (A search engine that compiles various sources and articles).

http://www.jmtour.com (http://www.jmtour.com) (Professor Jim Tour's research home page).

www-ece.rice.edu/~halas (Professor Naomi Halas' research home page).

http://www.nano.gov (http://www.nano.gov) (The National Science and Technology Council's site for nanoscale technology, including information on federal initiatives).

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