Nanotechnology – The Science of the Very Small.
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You know the saying – 'when you're hot you're hot, and when you're not you're not'. Well, in the physical sciences at the moment if you're not into nanotechnology then you're not very hot. Nanotechnology simply means building useful devices of the smallest possible size. Huge monies are committed worldwide to fund research into nanotechnology. Enthusiasts claim that nanotechnology will revolutionise the world. Others warn that it could get out of control and precipitate a plague of biblical proportions.

The nano in nanotechnology refers to the nanometre. The unit of length in science is the familiar metre. In order to designate smaller lengths we use submultiples of the metre. A millimetre is one thousandth of a metre, a micrometer is one millionth of a metre, and a nanometre is one thousandth millionth of a metre. An atom is about one tenth of a nanometre in diameter. Nanotechnology means building at the nanometre level or a bit bigger. It is not possible to build structures any smaller than this. The great interest in nanostructures is because some of them possess very superior electrical, mechanical, chemical or optical properties.

The development of new tools that are able to image and manipulate single atoms or molecules has accelerated interest in nanotechnology. New types of scanning probe microscopes, for example, the scanning tunnelling electron microscope and the atomic force microscope, can not only see individual atoms but can move them about from place to place. We all know that more and more power is being packed into desktop computers by making circuits in the electronic chips at the heart of the computer smaller and smaller. The electronics in current computers are based on the element silicon. Improvements in silicon performance are being pushed ahead relentlessly but a limit will be reached sometime in the next 10 to 25 years. The shrinking size of circuits in electronic chips is driving much of the interest in nanotechnology because it is very likely that new nano electronic devices will replace conventional silicon electronics when it reaches its limit.

Intensive research is underway worldwide to develop methods to build nanodevices. However, Mother Nature has known how to build the most sophisticated and successful nanodevices for billions of years. Every cell in your body is full of nanomachines. Some of these are molecular motors that power movement – for example, every time you move a muscle. Others are analogous to conveyor belt assembly lines serviced by robots – for example, the ribosomes in your cells on which proteins are manufactured. To my naive eye it seems that the best bet for the physical and the chemical scientists who predominate in nanotechnology would be to study how nature has built its nanodevices and to copy them.

The field of nanotechnology has been both popularised and tainted by a number of futurists who predict that this technology is a pathway to Utopia. In 1986 K. Eric Drexler published a best-selling book called 'Engines of Creation' which predicted that a developed nanotechnology would allow us to assume ultimate control over matter. Drexler described nanomachines capable not only of making any material device, but also capable of replicating themselves. These nanomachines would also be capable of curing disease and of greatly extending human lifespans. Imagine one type of such machine, a nanoscale submarine. The futurists envisage that such submarines could be injected into the blood stream to travel throughout the circulatory system and into the tissues where they would search for diseased

cells and destroy them. At the moment in America there is a growing trend for people to have their bodies preserved in a frozen state after death in the hope that advances in technology will one day make it possible to thaw out the body and carry out molecular repairs to correct whatever faults caused them to die, and to bring the body back to life again in a rejuvenated form. Futurists such as Drexler predict that nanotechnolgy will one day produce nanosubmarines sophisticated enough to carry out the necessary repairs on cryopreserved bodies and to facilitate their resurrection.

A new type of nanomachine proposed by Drexler is called the assembler. This machine is a universal fabricator capable of making any structure, including itself, by picking up atoms and placing them in the correct positions. Such assemblers (nanorobots or 'nanobots') would transform society by allowing virtually anything to be made quickly and at little cost. However, there is also a problematic side. Machines capable of self-replication might mutate into a form where self-replication runs out of control, just as healthy self-replicating biological cells can mutate into a cancerous form where cell division accelerates out of control. If such a mutation occurred in assemblers, the entire earth would soon become covered in a thick layer of 'grey goo'.

Most nanotechnologists now shy away from predictions that development of this new technology will usher in paradise on earth. Time will tell how useful nanotechnology will be but it will probably play an important part in our future. But we must proceed with caution. We are a long way from the development of self-replicating nanorobot assemblers, but if this ever became feasible we might well have to take the 'grey goo' theory seriously. After all, the only self-replicating nanotechnology-based entity we are aware of, the living cell, fairly quickly spread all over the earth after it first arose, dominating it and covering it with innumerable copies of itself.

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