Nanomedicine
By
Professor William Reville, University College, Cork.

In 1874, Sir John Eric Erichsen, a noted British surgeon declared that 'the abdomen, the chest, and the brain will be forever shut from the intrusion of the wise and humane surgeon'. Today we have heart transplants and open heart surgery. Medical science, like all other branches of science marches ahead relentlessly. What new medical procedures will be possible in 50 years time? Perhaps the new field of nanomedicine will have developed tiny robots (nanobots), each the size of a bacterium, capable of coursing through the body and destroying or repairing diseased cells and rejuvenating ageing cells.

Nanomedicine is a branch of the new field of nanotechnology. Nano comes from the Greek word nanos [italics] or 'dwarf' and means one-billionth part. Nanotechnology builds useful devices at the nanometre level or a bit larger. A nanometre is one billionth of a metre. About 6 carbon atoms sitting side by side would span one nanometre. A micrometer is one millionth of a metre, and a typical bacterium will be one to two micrometers wide. A typical cell in your body is about 50 micrometers wide.

Nanomedicine is interested in designing drugs and building medical devices at the nanometre level. The field is now only in its earliest stages. No nanomedical devices have yet been built, and probably will not be built for some time. But one form of nanomedicine under active development at the present time is the engineering of 'smart' drugs. All drugs are composed of molecules and molecules are of nanometer dimensions. Most drugs that we ingest course indiscriminately around the body, interacting with all of our cells and not just with those cells on whom they exert beneficial effects. Smart drugs, on the other hand, are engineered to act selectively only on those specific cells, for example cancer cells, against whom they have been designed to act.

It is envisaged that as time goes on molecular biology will join forces fully with nanotechnology. This may enable the construction of nanorobots that can travel throughout the human body, transporting important biomolecules, manipulating microscopic objects and using tiny motors, sensors and nanocomputers to communicate with physicians. Advancing biochemical knowledge will indicate how such nanorobots should be designed. This might sound far fetched and strange, but we must remember that our own bodies employ natural nanorobot-like devices on whose effective action our well-being is dependent - the white blood cells that constantly move throughout the body removing foreign particles, repairing damaged tissue and destroying invading microorganisms.

These white blood cells are fairly large on the nano-scale, being about 11,000 nanometers in diameter. However, almost all the individual cells in our body are full of exquisitely designed nanomachines. The structure and function of all of our cells is dependent on the class of biomolecules called proteins. A protein is a fairly large molecule made of a limited number of types of small molecules called amino acids linked together in a long chain. The structure and function of the protein is determined by the sequence in which the amino acids are linked together. There are thousands of different proteins in each of our cells, each type having a unique sequence of amino acids. The information that determines amino acid sequence resides in a linear code of chemicals called nucleotides arranged in our genes. The code for a particular protein, in the form of a long string of nucleotides, sits on a nanodevice called a ribosome which reads off the information in the nucleotide string, translating it into a corresponding sequence of amino acids joined together in the correct sequence to form a particular protein.

Robert A. Freitas Junior is writing a three volume discussion of the potential medical applications of nanotechnology. Volume 1 was published in 1999 and Vol. 2A in 2003 by Landes Bioscience. He envisages a typical interaction between a patient and a GP in the year 2030. A young man arrives at the GP's office with a mild fever, a stuffy nose and a cough. The GP places a small probe in the young man's mouth containing billions of receptors for the chemical signatures of specific bacteria and viruses. The probe is connected to a hand-held device. After a few seconds this device reads out the distinctive signature of a specific bacterial pathogen. The GP has a stock of nanorobots in her office. She types the name of the young man's bacterium into a computer that programmes a stock of billions of nanorobots to find, recognise and wipe out that particular microbial strain. The nanorobots are suspended in an aerosol carrier which the patient inhales.

The nanorobots enter the body and move about through their own form of autonomous locomotion – perhaps flagellae or screwdrives. They find and destroy the pathogenic bacterium. After 5 or 10 minutes the GP redirects the nanorobots back into the patients mouth using an acoustic homing device. The nanorobots are now retrieved through a collection bay on the homing device.

Freitas and some other scientists are very optimistic about the future of nanorobot technology in medicine. They envisage being able to programme nanorobots with a capacity to manipulate cellular biochemistry in very sophisticated ways. Since biochemical abnormalities are at the root of disease and ageing the futurists envisage a time when nanomedicine will cure all diseases and greatly retard the ageing process. Time will tell.

Answers to last weeks questions: Item 8 – Custer's choice was a glass eye. Item 9 – the correct equation is VII-VI=√1 [square root of 1].

(This article first appeared in The Irish Times, July 10, 2003.)