Nanotechnologies in modern medicine

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In this report some important problems and developing ways of the nanotechnologies will be considered. We'll talk about interesting ideas and projects in this new sphere.

First of all, what the does the “nano” prefix mean? It stems from the ancient Greek for "dwarf". In science “nano” means one billionth (10 to the minus 9) of something, thus a nanometer (nm) is is one billionth of a meter, or 0.000000001 meters. A nanometer is about three to five atoms wide, or some 40,000 times smaller than the thickness of human hair. A virus is typically 100 nm in size.

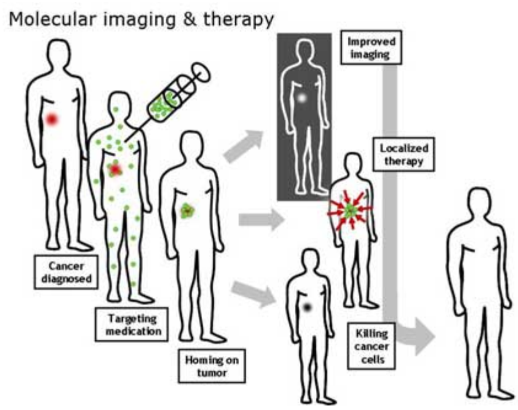
The ability to manipulate structures and properties at the nanoscale in medicine is like having a sub-microscopic lab bench on which you can handle cell components, viruses or pieces of DNA, using a range of tiny tools, robots and tubes. Imagine, for example, that you can stretch out a section of DNA like a strand of spaghetti, so you can operate on it, or build nanorobots that can "walk" and carry out tools inside cell components. Nanotechnology is bringing that scientific dream closer to reality. One highly sought goal in this field is the ability to tailor treatments according to the genetic make-up of individual patients. For instance, scientists at the Australian National University have managed to attach coated latex beads to the ends of modified DNA, and then using an "optical trap" comprising a focused beam of light to hold the beads in place, they have stretched out the DNA strand in order to study the interactions of specific binding proteins.

One of the researchers, Ned Seeman, says he envisages it will be possible to create a molecule-scale production line, where you move a molecule along till the right location is reached, and a nanobot does a bit chemisty on it, rather like "spot-welding" on a car assembly line. The work that Seeman and colleagues are doing is a good example of "biomimetics", where with nanotechnology they can imitate some of the biological processes in nature, such as the behavior of DNA, to engineer new methods and perhaps even to improve them.

DNA-based nanobots are also being created to target cancer cells. For instance, researchers at Harvard Medical School in the US reported recently in *Science* how they made an "origami nanorobot" out of DNA to transport a molecular payload. The barrel-shaped nanobot can carry molecules containing instructions that make cells behave in a particular way. In their study, the team successfully demonstrates how it delivers molecules that trigger cell suicide in leukemiaand lymphoma cells. Scientists say that protein-based drugs can be very useful because they're able to be programmed to deliver specific signals to cells. But the problem with conventional delivery of such drugs is that the body breaks most of them down before they reach their destination.

But what if it were possible to produce such drugs *in situ*, right at the target site? The Massachusetts Institute of Technology (MIT) team came up with the interesting idea while trying to find a way to attack metastatic tumors, those that grow from cancer cells that have migrated from the original site to other parts of the body. Over 90% of cancer deaths are due to metastatic cancer. They are now working on nanoparticles that can synthesize potential cancer drugs, and also on other ways to switch them on.

There's another nanotool caller “nanofiber”. Nanofibers are fibers with diameters of less than 1,000 nm. Medical applications include special materials for wound dressings and surgical textiles, materials used in implants, tissue engineering and artificial organ components. But there are huge challenges to overcome, one of the main ones being how to make them consistently of the correct size. Historically, this has been expensive and time-consuming. Researchers at the Polytechnic Institute of New York University (NYU-Poly) have recently demonstrated a new way to make nanofibers out of proteins. As it is written in the journal *Advanced Functional Materials*, the researchers say they approached their finding almost by chance: they were studying certain cylinder-shaped proteins derived from cartilage, when they noticed that in high concentrations, some of the proteins spontaneously came together and self-assembled into nanofibers.



They carried out further experiments, such as adding metal-recognizing amino acids and different metals, and found they could control fiber formation, alter its shape, and how it bound to small molecules. For instance, adding nickel transformed the fibers into clumped mats, which could be used to trigger releasing of an attached drug molecule.

This new method will greatly improve the delivery of drugs to treat cancer, heart disorders and Alzheimer's disease. There also are applications in regeneration of human tissue, bone and cartilage, and even a way to develop tinier and more powerfulmicroprocessors for their usage in computers and consumer electronics.

Recent years have seen an explosion in the number of studies showing the variety of medical applications of nanotechnology and nanomaterials. However, considerable challenges exist, the greatest of which appear to be how to scale up production of materials and tools, and how to bring down costs and timescales. Another challenge is how to quickly secure public confidence that this rapidly expanding technology is safe. And so far, it is not clear whether that is being done. It is perhaps more in the food sector that we have seen some of the greatest expansion of nanomaterials on a commercial level. Although the number of foods that contain nanomaterials is still small, it can possibly change over the next few years as the technology develops. Nanomaterials are already used to lower levels of fat and sugar without altering taste, or to improve packaging to keep food fresher for longer, or to tell consumers if the food is spoiled. They are also being used to increase the bioavailablity of nutrients (for instance in food supplements).

Some people say that Nano engineering can be dangerous for human health. It would appear, therefore, whether actual or perceived, the potential risk that nanotechnology poses on human health must be investigated, and be seen to be investigated. Most nanomaterials, as the NCI suggests, will likely prove to be harmless.

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