Editorial

Nanomedicine and nanopathology: two opposite aspects of nanotechnologies

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In Man's history there were ages called by the name of the new materials we had learned to use that contributed to the progress and development of human society in terms of knowledge and economy. Copper, bronze and iron are just three examples.

New materials mean new applications, progress and, of course, business, whose rules often prevail on the possible risks that new technologies can imply or hide, and nanotechnologies are no exception.

The century we are living in has opened with the discovery of the incredible, unexpected properties of matter at nanolevel, and that thanks to new instruments able to investigate at such a tiny dimension. Properties that allow scientists first, and then manufacturers, the former to invent new materials, the latter to manufacture new products with extraordinary characteristics. In the case of nanotechnologies, scientists discovered that laboratory-created nanoparticles show properties that bulk materials do not express. In less than 10 years, the business involving nanotechnological products or applications has grown exponentially all over the world. With the debut on the market of those novel products, new words were invented and are currently used also by common people: nanomaterial, nanoproduct, nanosilver, nano-something.

If on one hand nano-scientists were enthusiastically busy to synthesize new materials and to envisage new applications, some concern regarding their safety arose among consumers; concern shared also by some more prudent scientists. The concern was about the possible, much unexplored, toxicity and/or side effects that those materials could have on humans, animals and environment. It is no news that sometimes some inventions can have two opposite sides. Dynamite is one of the many examples and the difference between the two sides is only on its use. And there is the danger of misconception, of which the twice-Nobel-awarded Marie Curie is an example. Toying with radio-active materials killed her and nobody knows how many people on whom Medicine used unthinkingly radio-activity, the great novelty, without the necessary in-depth studies, a bad habit Medicine seems to be reluctant to get rid of. Actually it was only after Hiroshima and Nagasaki that we understood in full what a great exposure to radio-activity means, and it took still awhile for low, repeated doses. Finally now, after many decades (X-rays were discovered by Roentgen in 1895), we have learned to take the necessary precautions and use safely and beneficially that kind of energy.

Returning to nano, scientists were attracted at first to the possibility of a sort of small-scale imitation of God and create new matter suitable for probably never-even-fancied-before applications.

In the case of Medicine nanoparticles were coated with drugs and other chemical compounds, transforming them into "magic bullets" capable of hitting with extraordinary accuracy targets located in some organ or tissue and treat their pathologies. A novel field of research, another nano, had been opened: "nanomedicine". An attempt was made with iron-oxide particles. Once they had been driven to their target, in that case a cancerous tissue, they were heated up by a strong magnetic field at a temperature high enough to kill the diseased cells. Having not been reached by the particles, the healthy tissue remained undamaged. And iron-oxide particles can also be used for imaging purpose with excellent technical results. The problem is that those particles are not degradable by our organism which has no ways to get rid of them. And unfortunately, at least for the time being, no artificial technique exists for that purpose. So the question is: what is the fate of those materials, undoubtedly foreign bodies, in the long run? Impossible not to expect a reaction by the host tissue, and the obvious reaction is an inflammatory one. Marginally, we are not even completely sure that all the particles injected hit the target and that a few of them are not dispersed elsewhere.

A further source of concern among scientists is the interactions between nanoparticles and proteins, and between nanoparticles and DNA, phenomena they have already observed. After all, sizes are similar. If unwanted bio-interactions are something to be worried about, desired ones may offer very interesting possibilities to Medicine.

The invasivity of nanoparticles was already demonstrated years ago by Prof. Nemmar and his collaborators at the University of Leuven (Belgium) (Nemmar et al. Passage of 100nm sized particles in the blood and in the liver Circulation 2002, 105:411) when they verified that inhaled 100nm-sized carbon-technetium radio-labelled nanoparticles can cross the lung barrier in 60 seconds and can reach the liver in one hour. Nanoparticles can negotiate all barriers and are not recognized by the immune system and by cell sensors.

Thanks to this property, Nanoparticles are used in new drugs, particularly for neurodegenerative pathologies. In fact, unlike many substances, they can cross the blood-brain barrier. The right trick is to synthesize biodegradable nanosized polymers, soak them with the drug and inject them in the patient. Once they have entered the brain, they degrade releasing the drug. But at the same time, airborne nanoparticles incidentally generated by high-temperature combustion processes, once inhaled can reach the brain. In that case, very often they are not degradable and remain there forever. Invariably in all the brain cancers we have studied in our laboratory we found foreign bodies. One of the latest cases, a brain cancer of a baby, we found submicronic particles of stainless steel.

That is the risk represented by nanoparticles if not properly handled. They can cross the cell membrane invading the cytoplasm and, since they are not toxic in the classical sense, they do not kill the cell. In some cases, in in-vitro toxicological tests the engineered nanoparticles induce a cell over-proliferation as compared to control cultures. These foreign presences do not stop or hamper mitosis, so, when the nuclear membrane disappears, they can interact directly with the DNA. If this interaction is not strictly controlled as in the case of new investigations of gene therapy with nanoparticles as drivers of sequences of "right" DNA, the DNA can be damaged, inducing, for example, malformations in the offspring.

In conclusion, engineered and incidental nanoparticles behave in the same way and using them is a double-edged knife of which we must be conscious.

But can Man handle matter at nanolevel and dominate the mostly still unknown laws of nanoworld?

The 1996 Nobel laureate Richard Smalley discovered the properties of the form of carbon nanoparticles currently called buckyballs, and died in 2005 for leukemia and lung cancer simultaneously. He himself was convinced he was dying for the dust he had created and inhaled without any protection, since he did not know exactly what he was handling and what he was in the process of discovering.

Good or bad? Neither nor. It all depends on how we use them and on how patient we can be before starting to use them. No chance should be lost, but mistakes are painful and paid dear.

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Conflicts of interest

Author dcelares there are no conflicts of interest.