The emergence of nanomedicine: a field in the making

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'Our commitment is to attract the interest of the clinicians that eventually will be the end users of all the nanomedicine knowledge and technology generated.'

Most of us actively engaged in biomedical research came across the term 'nanomedicine' through the inspiring, yet overambitious, and at the time controversial writings of Robert Freitas and the Foresight Institute (CA, USA) [1,2]. In these early references to the term 'anomedicine, the focus lay with the role and function of the elusive 'nanorobots' and the potential benefit they could bring to medical practice both in diagnosis and therapy. The word nanomedicine is considered less controversial and more acceptable to the worldwide scientific community today [101,102], however, an accurate definition and conceptual framework of the term is still a matter of hot debate. A fundamental problem associated with the term nanomedicine, ironically enough, stems from those early proponents of nanomedicine, who define the term as 'More than just an extension of "molecular medicine", nanomedicine will employ molecular machine systems to address medical problems, and will use molecular knowledge to maintain and improve human health at the molecular scale' [103]. The problems with this definition are that:

- By including 'molecular machine' and 'molecular knowledge' into the definition of 'nanomedicine' or 'medical nanotechnology' the whole of chemistry, physics and molecular biology are essentially included, in this way contradicting the novel and new nature of nanomedicine;
- It is much broader than the now defined and widely accepted term of nanotechnology, which includes 'materials that at least one of their dimension that affects their function is in the scale range between 1–100 nm' [104,105];
- The close association of nanomedicine with non-realistic, futuristic and science-fiction-based imagery, such as nanorobots, can easily lead to negative perceptions about the term in the minds of the wider scientific and general public.

The result of the problematic definition and conceptual basis of nanomedicine leads to confusion and can also be responsible for undervaluing the credibility of this emerging field, which has been very recently highlighted in widely read science journals [3]. We, in this journal, adopt the definition of nanomedicine as 'the use of materials, of which at least one of their dimensions that affects their function is in the scale range 1–100 nm, for a specific diagnostic or therapeutic purpose'. Our strong belief is that nanomedicine should be led by the clinical purpose it is designed to achieve. Our commitment is to attract the interest of the clinicians that eventually will be the end users of all the nanomedicine knowledge and technology generated. We believe our journal can accomplish this task by educating, informing, updating and reviewing all aspects of nanomedicinal developments to clinicians of all disciplines.

Irrespective of terms, definitions and linguistics, it is now accepted that nanomedicine is a field that is emerging and rapidly gaining acceptance and recognition as an independent field of research and technology. As our knowledge of physical properties at the nanoscale becomes more profound and novel nanometer-sized materials are developed, their use in biomedical applications will exponentially increase. Similar to the rest of nanotechnology, the novelty and significance of nanomedicine is in the new perspective and focus that it offers: the utilization of nanometer-scale materials to monitor, diagnose and cure diseases. It can be argued that all drug molecules can be considered nanomedicines since they act at the molecular level. Nanomedicine researchers should respond that their discipline is focusing at the nanoscale, which is above the molecular level and within the 100 nm scale. Whatever the argument, the fact is that nanometer-sized self-assembled systems and devices, such as drug delivery systems, have been developed for a number of years, having an established role in clinical practice today. This does not mean that nanomedicine has no further potential to improve clinical practice. On the contrary, consolidation of previously acquired knowledge on

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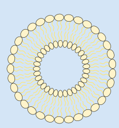
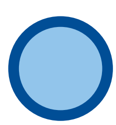
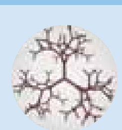
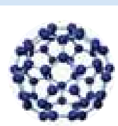
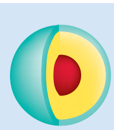
how nanoparticles act in the body with novel nanoscale materials (such as carbon nanostructures, quantum dots) and tools (e.g., sensors, high resolution imaging) give promise to a very exciting future for nanomedicine. In Figure 1, only a fraction of nanomedicines that have been developed into medicines found in the clinic today, or are currently under preclinical and clinical development, are shown as an example.

> 'The most dangerous shortcomings from which a promising field like nanomedicine can suffer are a detachment from reality and overhyped expectations.'

What about the shortcomings of nanomedicine? These lie in the 'eye of the beholder'. The most dangerous shortcomings from which a promising field like nanomedicine can suffer are a detachment from reality and overhyped expectations. Nanomedicine should be encouraged to develop as a discipline based on scientifically proven realities rather than alluring science-fiction-based prospects and illustrations. Safety considerations, public awareness of what is feasibly possible and very close contact with reality and the needs of the clinician who will ultimately use the nanomedicine tools and knowledge will guarantee valuable contributions and benefits to patients. Nanomedicine and the construction of a comprehensive delivery system for surveillance, monitoring, treatment and elimination of disease may be an elusive goal to achieve, but provides great motivation for a creative process that can serve and benefit medical practice.

The image of a miniscule-sized vessel navigating through the blood stream, moving through organs, surveying the whole body for unwanted pathogens or malignancies and obliterating them on-demand by use of a laser or tweezers is a truly fascinating concept that has become a cinematographic reality on numerous occasions since the 1950s. The close relationship between scientific paradigm and

Figure 1. Nanomedicines in the clinic.

Nanomaterial	Name & type	Pharmacological function	Disease
Nanomedicines in the clinic			
	Liposome 30–100 nm	Targeted drug delivery	Cancer
	Nanoparticle (iron oxide) 5–50 nm	Contrast agent for magnetic resonance imaging	Hepatic (liver)
Nanomedicines under development			
	Dendrimer 5–50 nm	Contrast agent for magnetic resonance imaging	Cardiovascular (Phase III clinical trial)
	Fullerene (carbon buckyball) 2–20 nm	Antioxidant	Neurodegenerative, cardiovascular (preclinical)
	Nanoshells (gold-coated silica) 60 nm	Hyperthermia	Cancer (preclinical)

science fiction illustrations has been tantalizing for both sides. What about reality though? Can nanotechnology assist with its tools and knowledge to achieve such a challenging goal for medicine? This is precisely the role of nanomedicine and all of us involved in this captivating, yet onerous, effort. We hope we will be able to assist you in navigating through the increasing, in both volume and interest, clinical applications of the myriad nanotechnologies developed. With a focus on what can be the clinically feasible and realistic nanomedicines of the future, *Nanomedicine* will help you to follow a field that is emerging at present.

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