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Nanobiosensors and molecular diagnostics: promising partnership

'The nanobiosensors-based diagnostic industry is expected to reach the billion-dollar mark by 2007–2008.'

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Nanobiosensing approaches to clinical and environmental testing is an emerging and already influential trend in the field of medical diagnostics. Imagine a near future, where nanoparticles of fluorophore-tagged dendrimers or nanoprobes of miniscule optical fibers enable the identification of a sign of infection or a pathological change within an individual cell (the smallest biological environment) and the signaling of these findings are directly possible through one's eyes or skin. And all this is not a pure fantasy; several academic and industrial research groups are presently involved in making such dreams a reality [1–5]. Moreover, the nanobiosensors-based diagnostic industry is expected to reach the billion-dollar mark by 2007–2008 [6–8].

Nanodimensions of new-generation biosensors will improve their spatial resolution down to molecular levels, reduce their detection volume to a few cubic micrometers and speed up their signal response to milliseconds. In turn, they will become simple, small and low-cost diagnostic tools. Good cell viability after testing with nanoprobes has recently been demonstrated, which opens the possibility of non-harmful continuous monitoring in real time. Are you impressed and inspired? As a potential consumer of these new exciting diagnostic technologies and particularly as an expert in nucleic acid-based molecular diagnostics, I certainly am.

Note that both molecular diagnostics and biosensors emerged essentially at the same time, during the late 1960s/early 1970s, as nucleic acid hybridization techniques,

enzyme-linked immunosorbent assay, electrochemical DNA detection and glucose monitoring, and then evolved in partnership [9–11]. The reason for this partnership is twofold. First, the majority of molecular diagnostics need some sensing unit for the most robust detection, whereas many biosensors need some kind of molecular diagnostic units in the form of bioreceptors and/or signal amplifiers to be incorporated. Second, different primary backgrounds are required for developing molecular diagnostics and biosensors. The former are based mostly on molecular-biological and biochemical knowledge, while the latter are grounded on solid physical-technical and engineering knowhow. Still, in both cases some experience from the other side is obviously also necessary.

As the size of diagnostic devices decreases to the nanometer scale (i.e., molecular size) and they become increasingly elaborate, this partnership will become even closer. Only a multidisciplinary collaboration of biologists, clinicians, physicists, engineers with computer and material scientists could now lead to further successful progress in the current health-related testing. Miniaturization of biosensors to nanodimensions will also lessen the difference between nanoprobes and molecular diagnostics. Molecular beacons, which are both nucleic acid hybridization probes and self-reporting optical transducers, can serve as an example, especially when they are combined with other nanotools, peptide nucleic acid openers and DNA nanostructure (also known as the PD-loop) [12].

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The Marriage of nanoprobes and molecular diagnostics might yield a new family of intelligent products, so-called smart biosensors, which are a type of nanorobot with positive feedback for therapeutic intervention and recurring check-up. As a result, not only will patient-specific medicine become possible, owing to forthcoming advances in pharmacogenomics, but smart biosensors will also permit assessment of health and drug responses of individual human cells. As a result, it will be possible to treat those cells that are sick.

The goal of this note is to express some personal excitement and share some thoughts which may stimulate the interest of others in future development of nanobiosensing technologies. Now is a very fortunate time to realize all their potentials and to overcome both technological and market challenges, given the increased funding for nanotechnology and generous investments in homeland security/defense applications. I will be happy even if only some of these exciting promises are realized!

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