Nanotechnology: Key To Advancing The Brain-Machine Interface And Medical Theranostics

Russell J Andrews

Nanotechnology & Smart Systems
NASA Ames Research Center, Moffett Field, CA, USA

Nanotechnology has been used for centuries – from the metallic nanoparticles that produced brilliant ceramic glazes and exquisite stained glass windows to the carbon nanotubes and cementite nanowires that gave the “Damascus saber” its legendary strength and resilience. However, it has only been the past 50 or so years – following Richard Feynman’s famous “There is Plenty of Room at the Bottom” lecture in 1959 – that nanotechnology has become a robust scientific field.

After an introduction to the nanorealm – both in size and in techniques involved in nanofabrication – several examples are presented of how nanotechniques and nanomaterials are enabling quantum leaps in medical diagnosis and treatment:
- The common MRI contrast agent gadolinium is in fact a nano-sized particle.
- From detecting toxins, bacteria, and nerve gases in air, soil, and water to providing disposable, paper-based point-of-care diagnostics, nanotechniques are enabling practical solutions to the threat of environmental contaminants and the need for laboratory tests that are inexpensive, robust, and simple to use.
- Various nanotechniques for cancer theranostics (combination of diagnostic and therapeutic agents) – including theranostics for malignant brain tumors – are considered.
- Nanomaterials for neurorepair and neuroregeneration can augment the nervous system’s reparative capabilities that were unrecognized until recently.
- Nanoelectrodes allow precise real-time monitoring and modulating of both electrical and chemical (neurotransmitter) brain activity. Such nanoelectrodes enhance the charge transfer between brain tissue and electrode by several orders of magnitude over noble metal (e.g. platinum) electrodes – increasing the efficacy and safety of deep brain stimulation. Nanoelectrodes will also permit the simultaneous monitoring of several neurotransmitters in close proximity – a capability essential for understanding disorders such as severe depression and epilepsy.

The boundaries between surgery (the discipline with a scalpel!) and other interventions have already been blurred by radiosurgery and interventional neuroradiology. As nanotechiques become more pervasive in neurosurgery, this boundary will become increasingly blurred - until the diagnosis and treatment of nervous system disorders is increasingly a multispecialty challenge. The intelligent neurosurgeon will evolve with evolving knowledge base!