Inorganic Nanoparticles for medical applications
Outline

- Overview
- Why inorganic Nanoparticles for medical applications?
  - Needs from the medical side
  - Potential from the material side
- Examples:
  - Silica
  - QD
  - SPION
- Interaction of nanoparticles with tissue, cells, proteins
The medicinal chemist looks at the vast landscape of nanomaterials.
The landscape of nanomaterials for medicines is rich with options, and innovative solutions will likely be found in the wise combination of different components.

The researchers who venture into this field should reach out to and partner with physicists, biologists, and clinicians to find creative solutions to these complex, multidisciplinary problems.

See also Marchesan ACS Med. Chem. Lett. 2013, 4, 147–149
Interactions in Nanoscience and Nanotechnology
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Bioanalysis and Diagnostics:

- New platforms include the use of nanoparticles (dots, bars, rods) as labels for biomolecules for separation and screening, as well as nanopore and nanoscale fluidic assay systems and self-assembling arrays of nanoparticles.

- For patient monitoring and diagnosis it needs more efficient and selective Nanoparticles for diagnostics at clinical level (MRI contrast agent).
Therapeutics:

- More efficient uptake of drugs using existing drugs which are reformulated as nanocrystals or encapsulated.
- Tissue-specific delivery with a strong localized dose-control a lower overall concentration of the drug, providing lower patient toxicity and side-effects.
- Triggered drug release by a secondary mechanism such as light, pH, heat or enzyme activation.
- Diagnose and treat neurodegenerative disease with particles having the ability to cross the BBB.
- Therapeutic treatment with heat (magn. hyperthermia) light (QD)
### Nanoparticles (NP)

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<tr>
<th><strong>Semiconductor NP</strong></th>
<th><strong>Properties of NP</strong></th>
<th><strong>Applications</strong></th>
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<tr>
<td>Electron-hole pair</td>
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<tr>
<th><strong>Metal NP</strong></th>
<th><strong>Surface plasmon resonance</strong></th>
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<tr>
<th><strong>Metal oxide NP</strong></th>
<th><strong>Magnetic resonance</strong></th>
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<th><strong>Lanthanide-doped NP</strong></th>
<th><strong>Upconversion</strong></th>
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Nam et al.  
Advanced Drug Delivery Reviews 65  
(2013) 622–648
Core and Surface properties

Nanoeffects
- Ferro- to superparamagnetism
- Band gap change (fluorescence)
- Surface plasmon

Scaling effects
- Increased reactivity per mass
- Solubility
- Colloidal stability
- Penetration through barriers
Nanoeffects

Energy

Atom

Molecule

Cluster

Nanoparticle

Forbidden bandgap

LUMO

HOMO

Semi-conductor

Metal

Nanoparticle

Single domain

Multidomain

2-10 nm

D_c

Particle Size

M

H

Licht

Metall Partikel

Elektronen
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Mesoporous silica nanoparticles

The in vivo studies using MSNs have to date mainly focused on the delivery of the approved cancer drug Doxorubicin using folate as the targeting ligand. This should be extended to include novel cancer drugs under development, in clinical trials or excluded from the market due to severe side effects. Generating a particle platform were the ligands and drugs are easily replaced in accordance with the patient profile could constitute a true advantage for personalized medicine.

Superparamagnetic Iron oxide nanoparticle

Quantum Dots