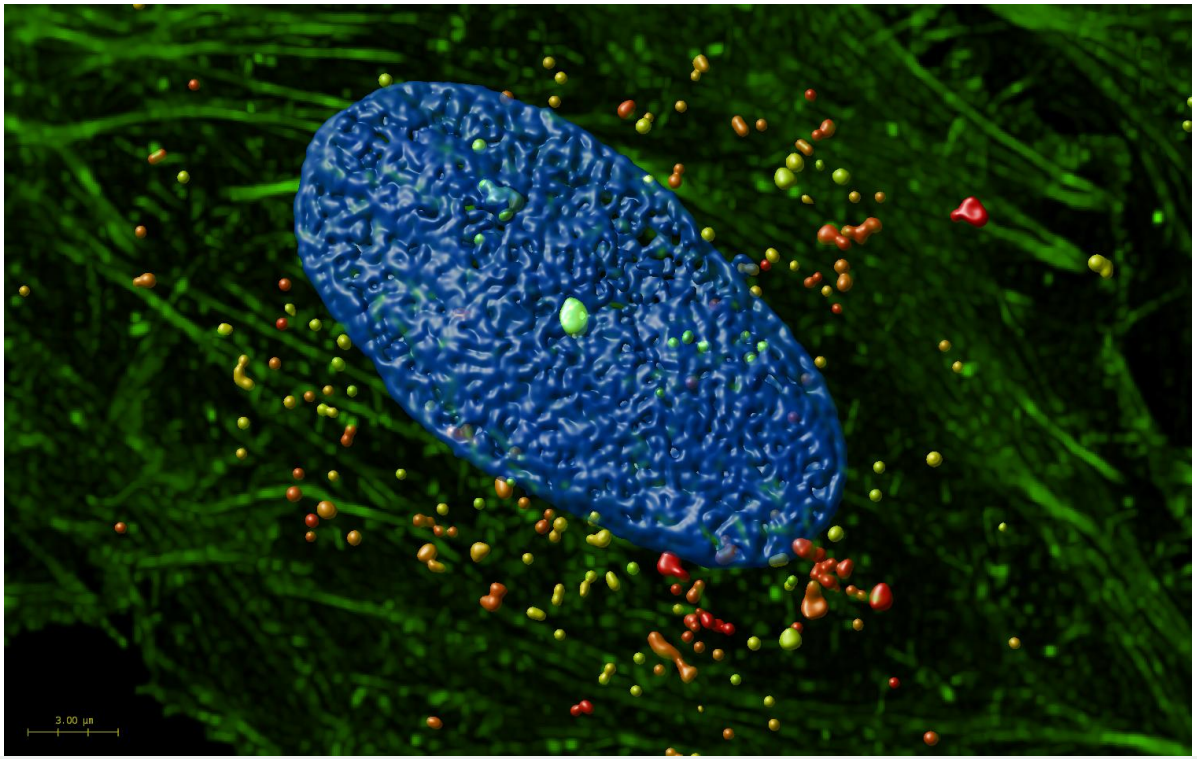
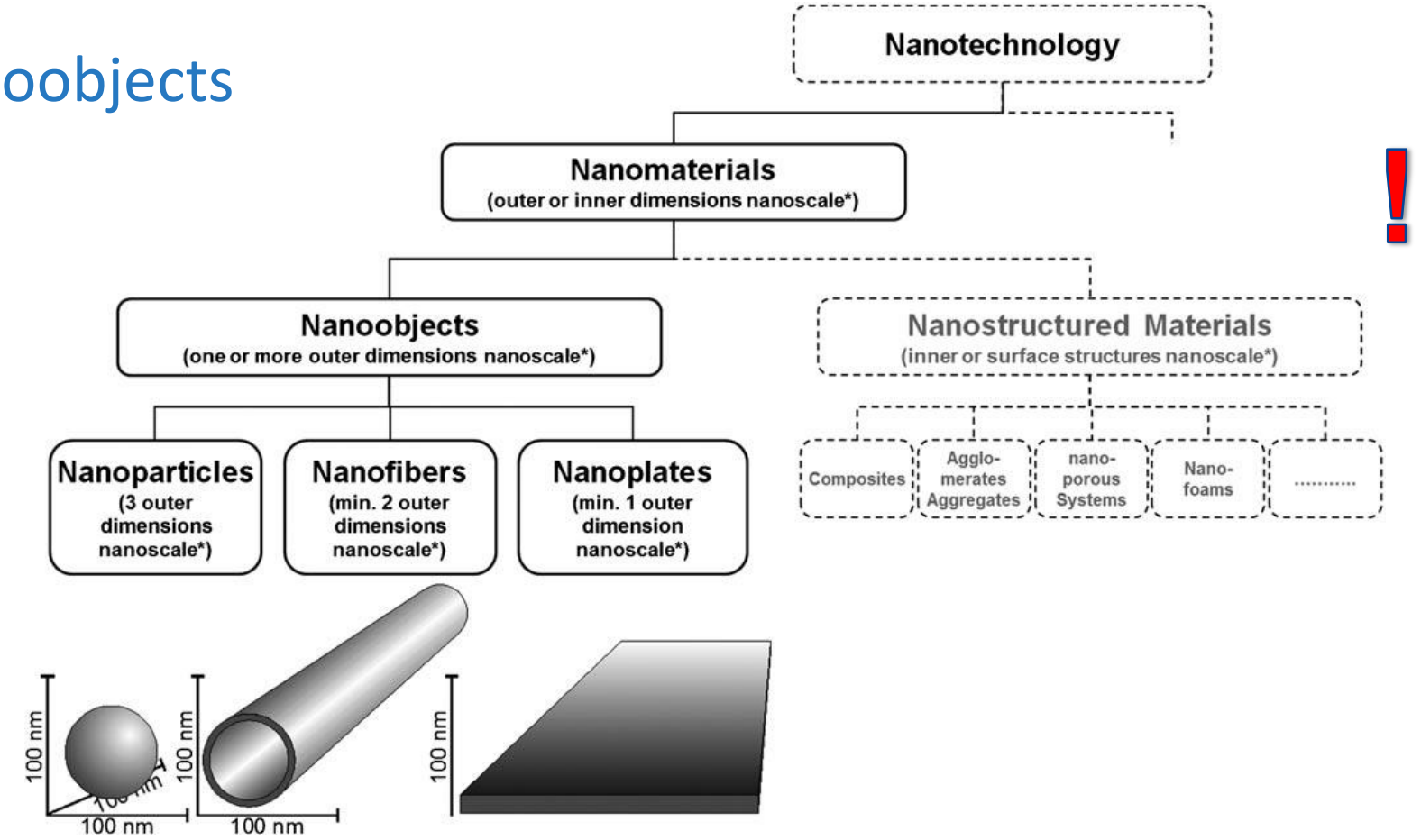
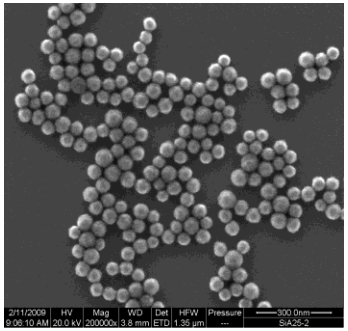


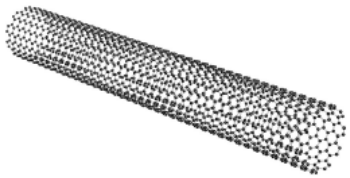
Biomedical Applications of Nanoobjects
July 05, 2019

Dr. Annette Kraegeloh
INM - Leibniz Institute for New Materials

Nanoobjects

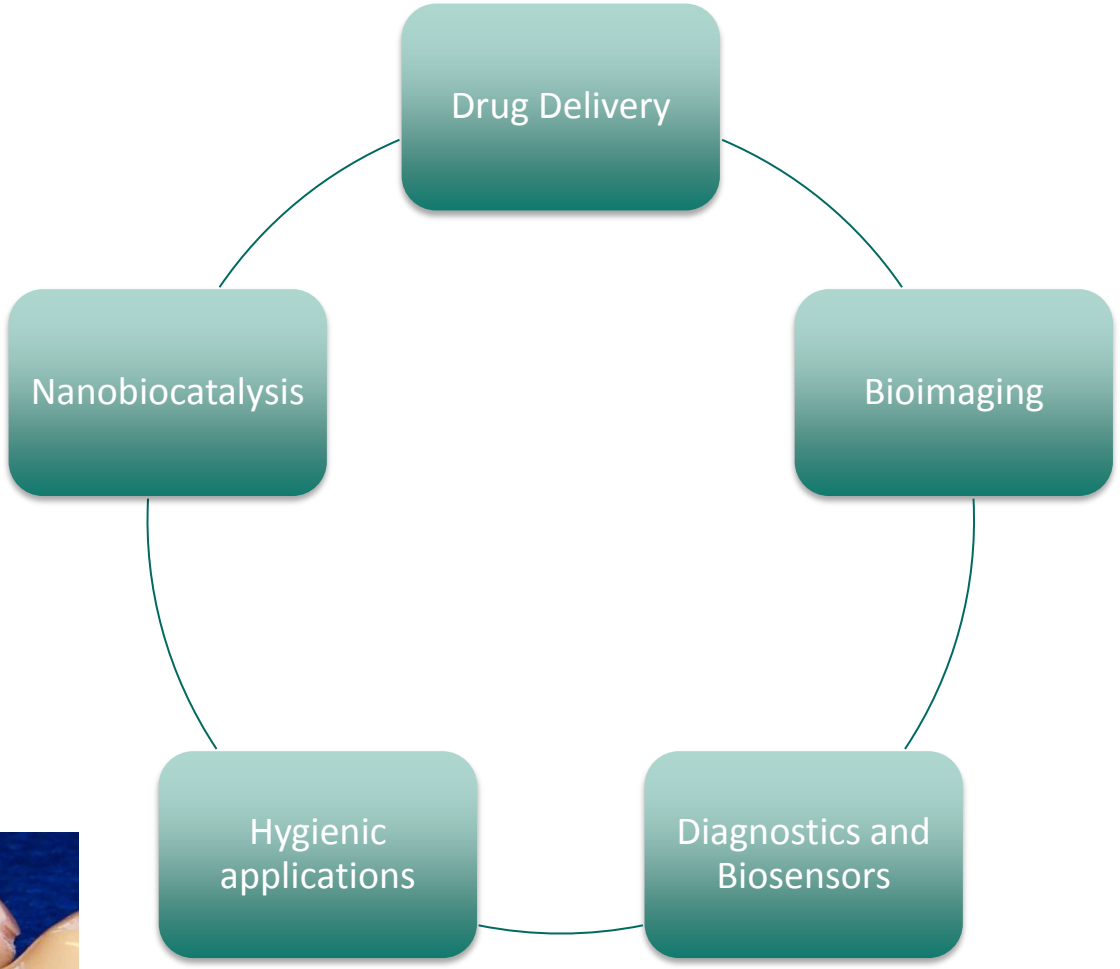




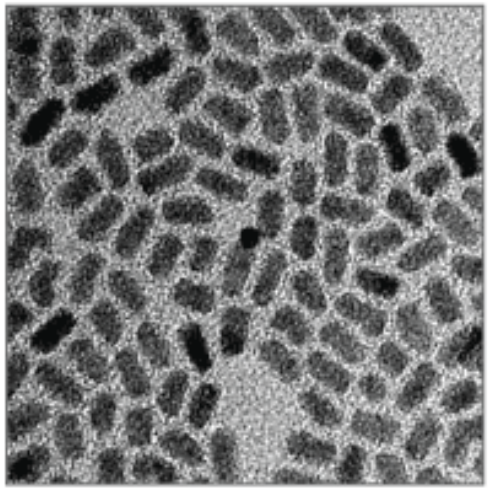


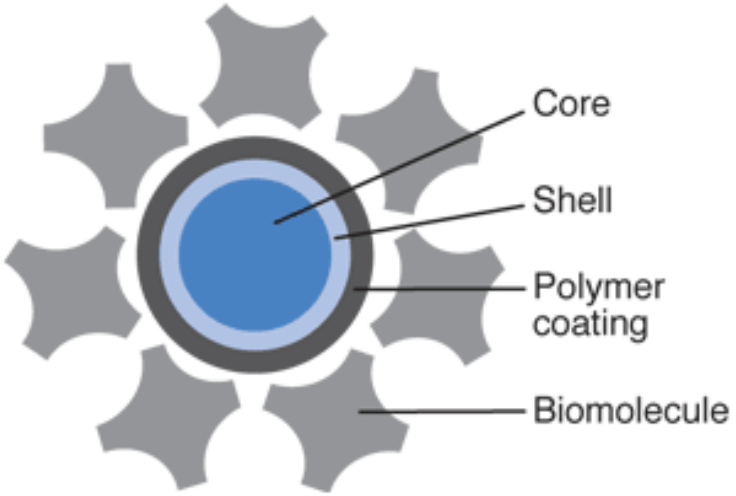
(Krug and Wick, 2011)

Biomedical Applications of Nanoobjects

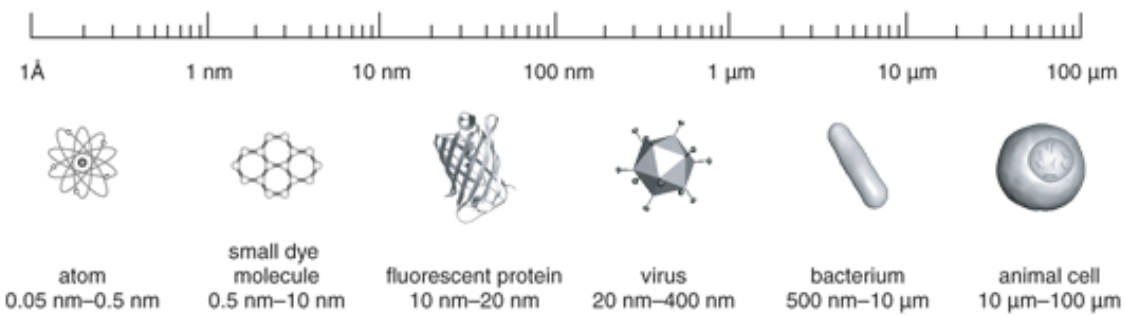


Quantum Dots for Biological Applications



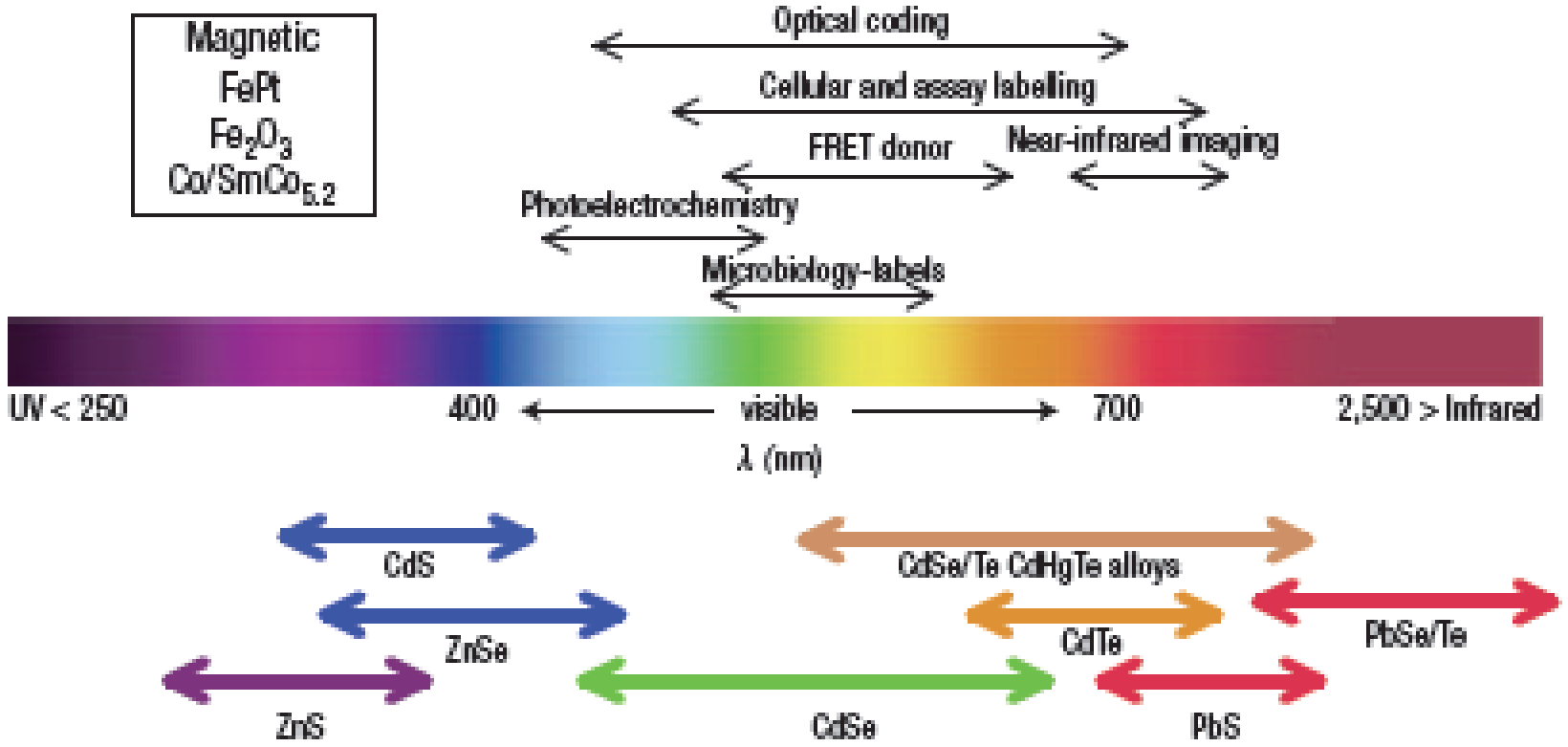


Qdot® nanocrystal
10 nm–20 nm



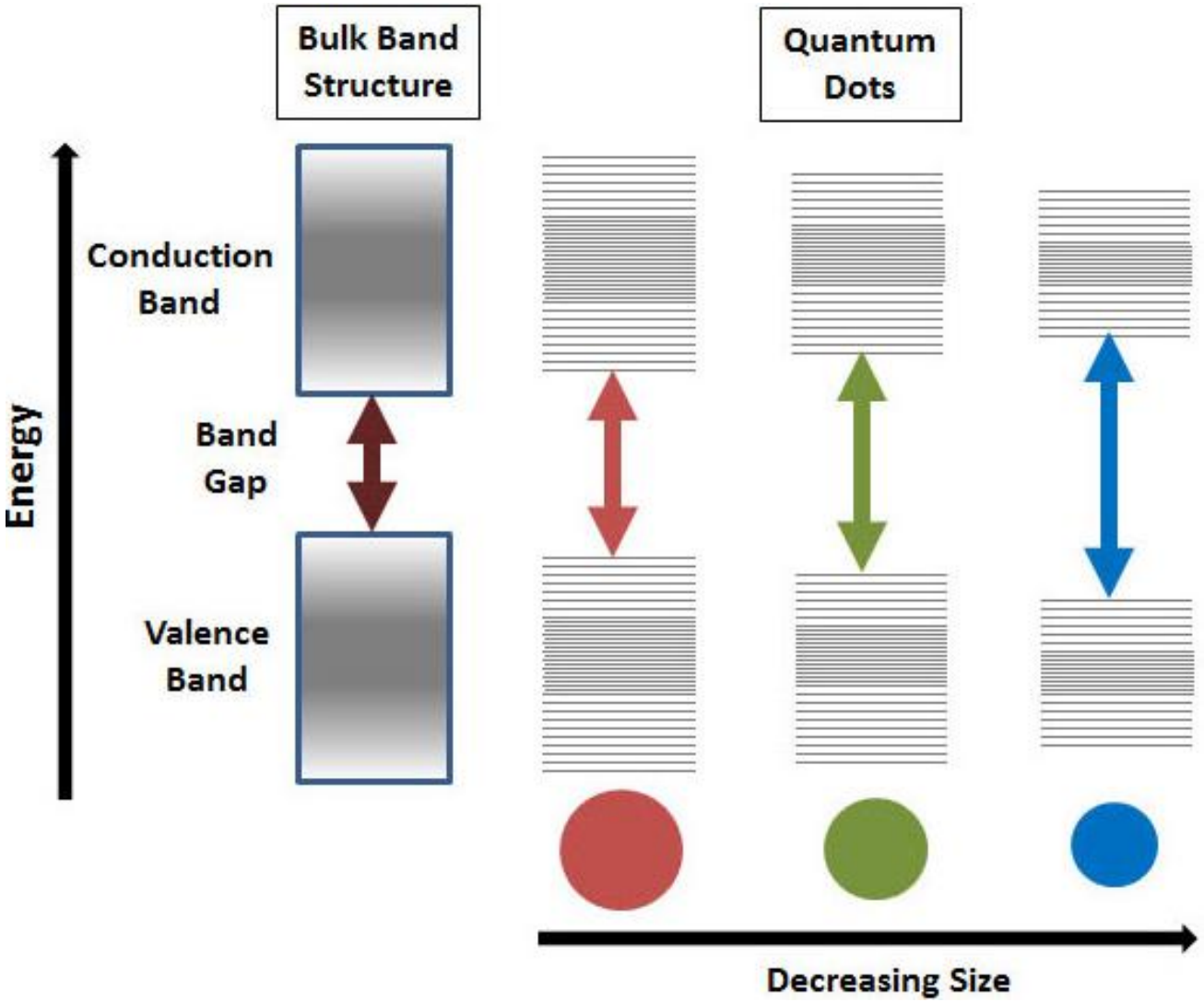
(thermofisher.com)

Quantum Dots Core Materials



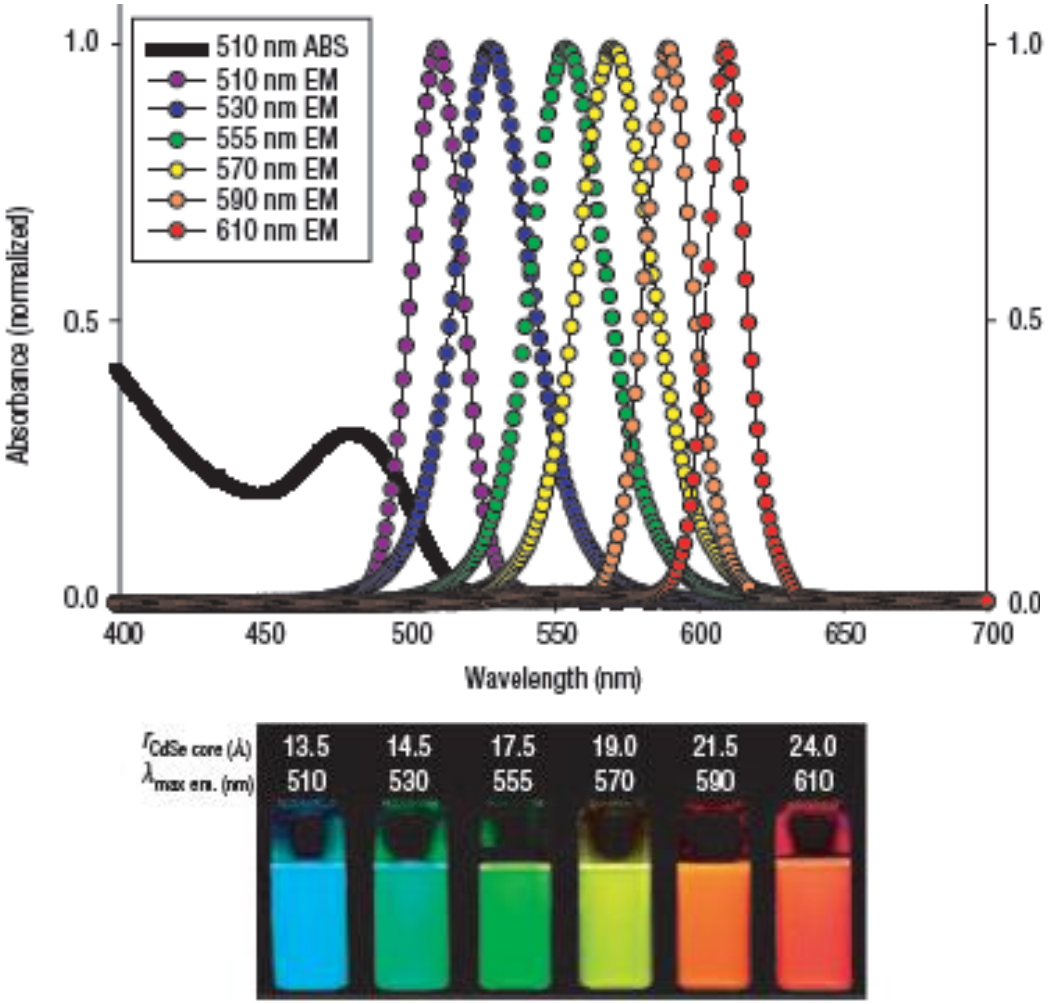
(Medintz et al., 2005)

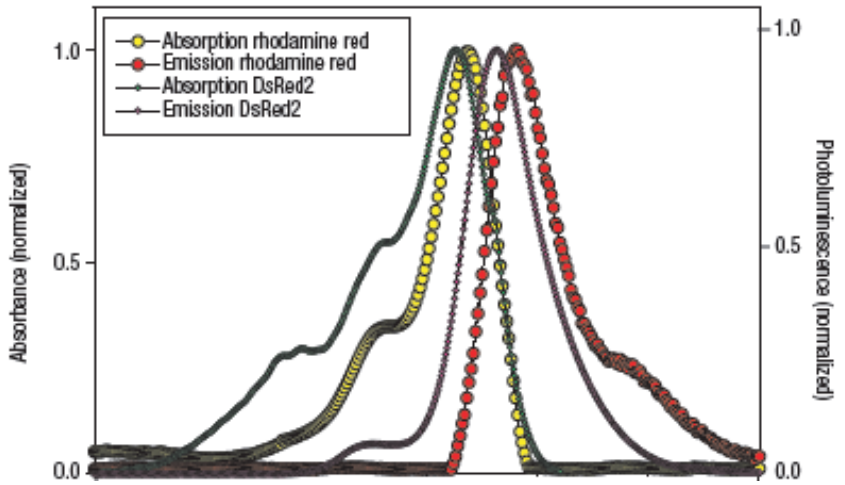
Quantum Dots Photophysics



(sigmaaldrich.com)

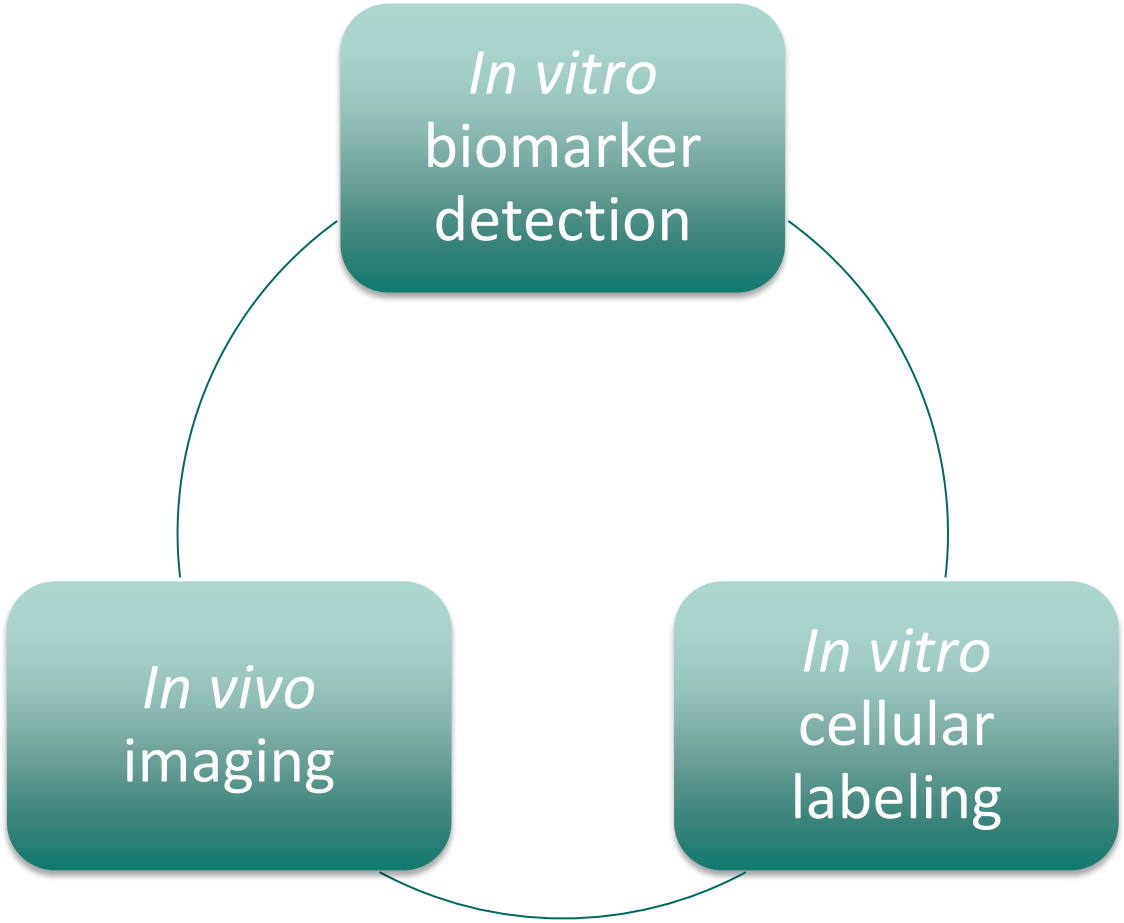
Quantum Dots Optical Properties



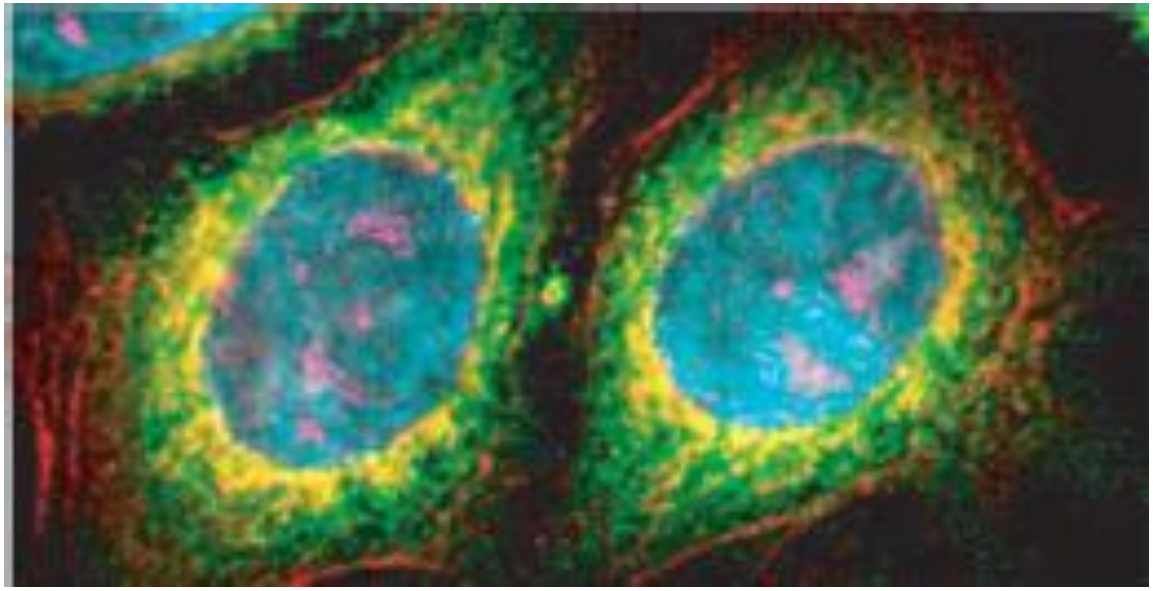


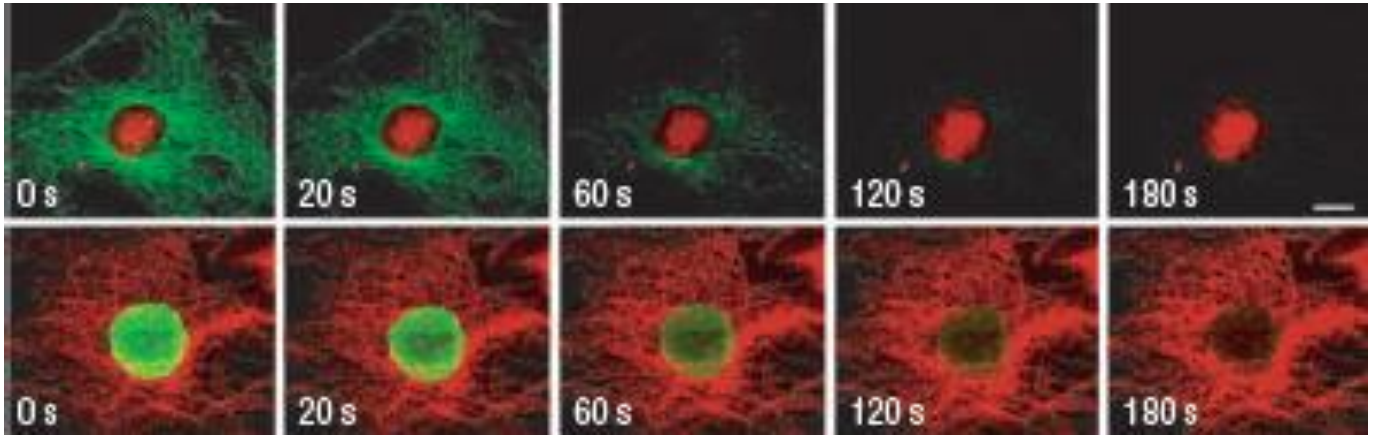
(Medintz et al., 2005)

Biomedical Applications of Quantum Dots



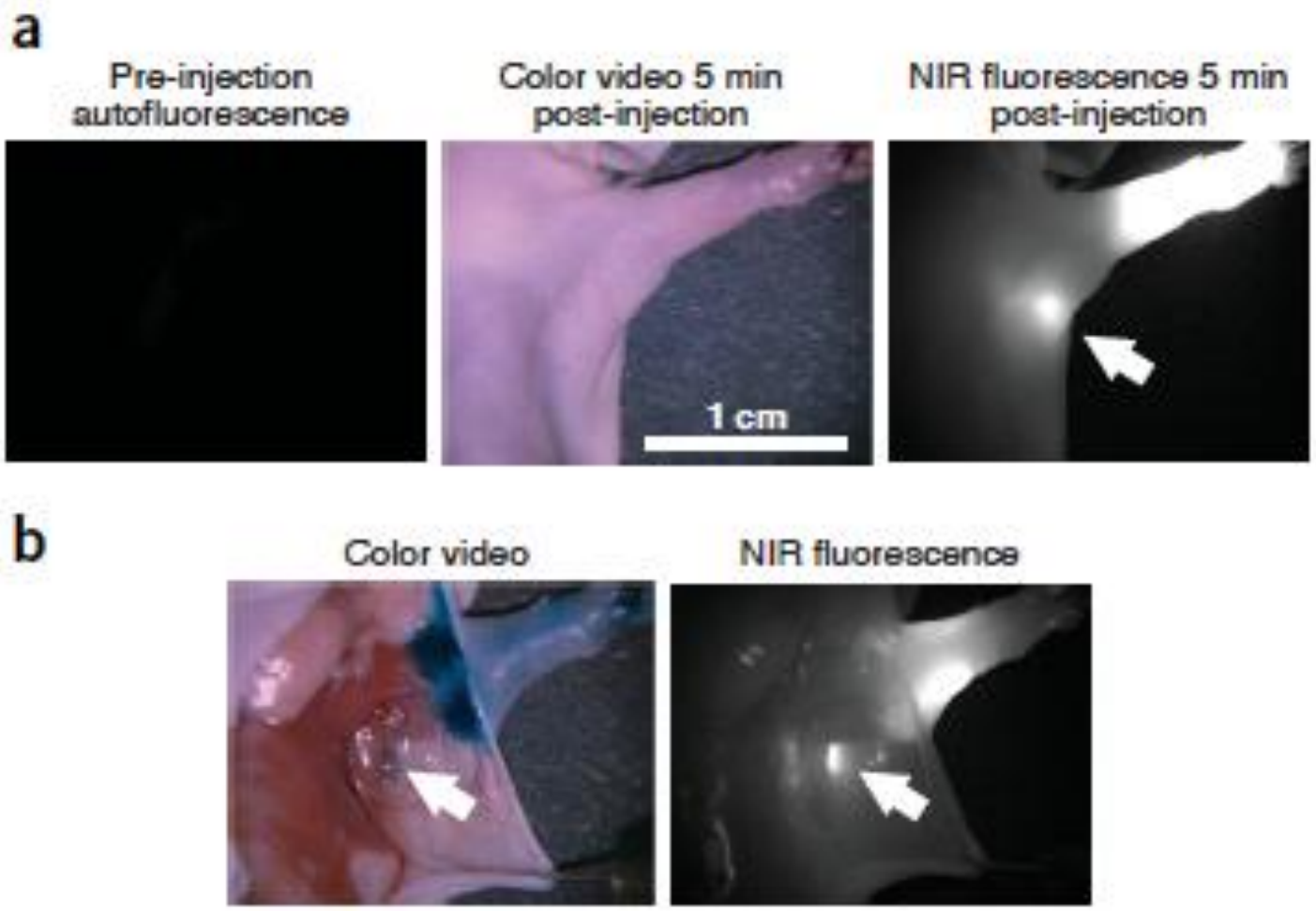
Cellular Labeling





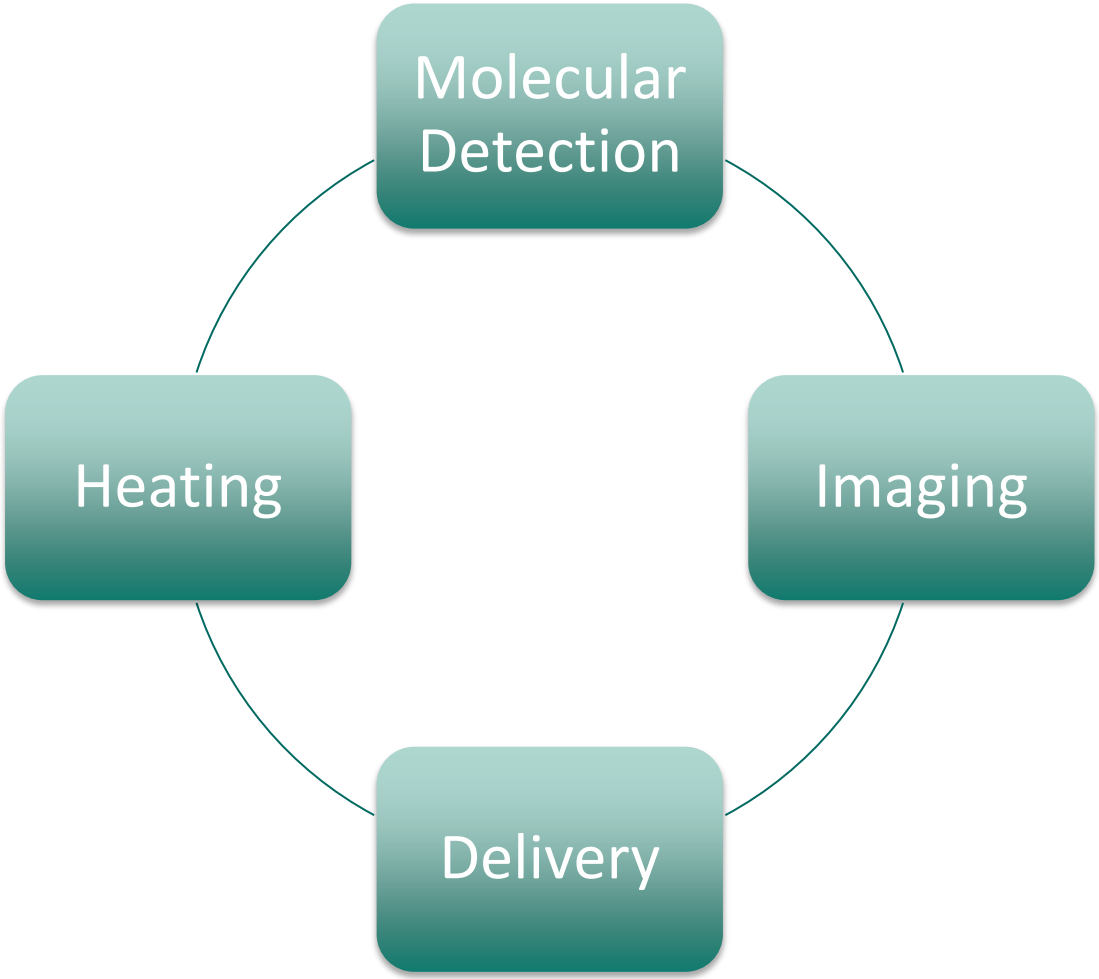
(Medintz et al., 2005)

In Vivo Imaging Using Quantum Dots

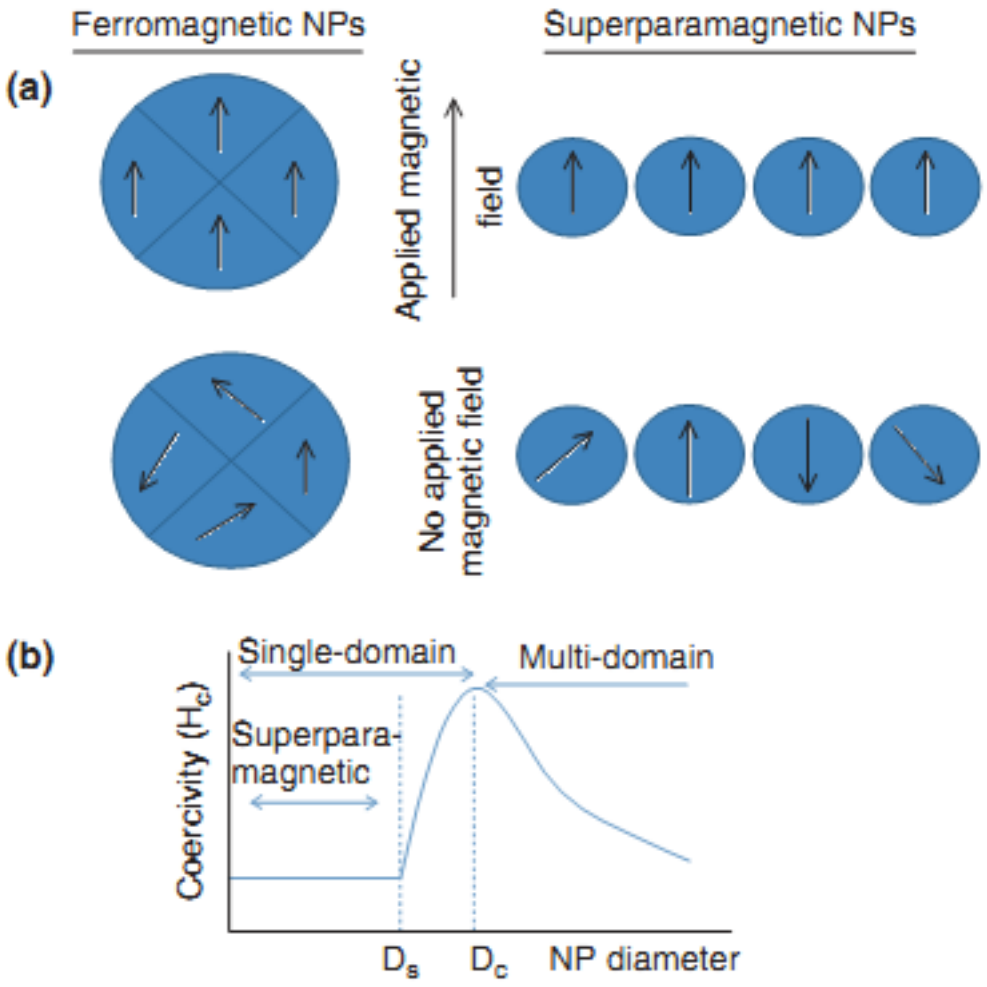


(Chan, 2007; Kim et al., 2004)

Biomedical Applications of Magnetic Nanoparticles

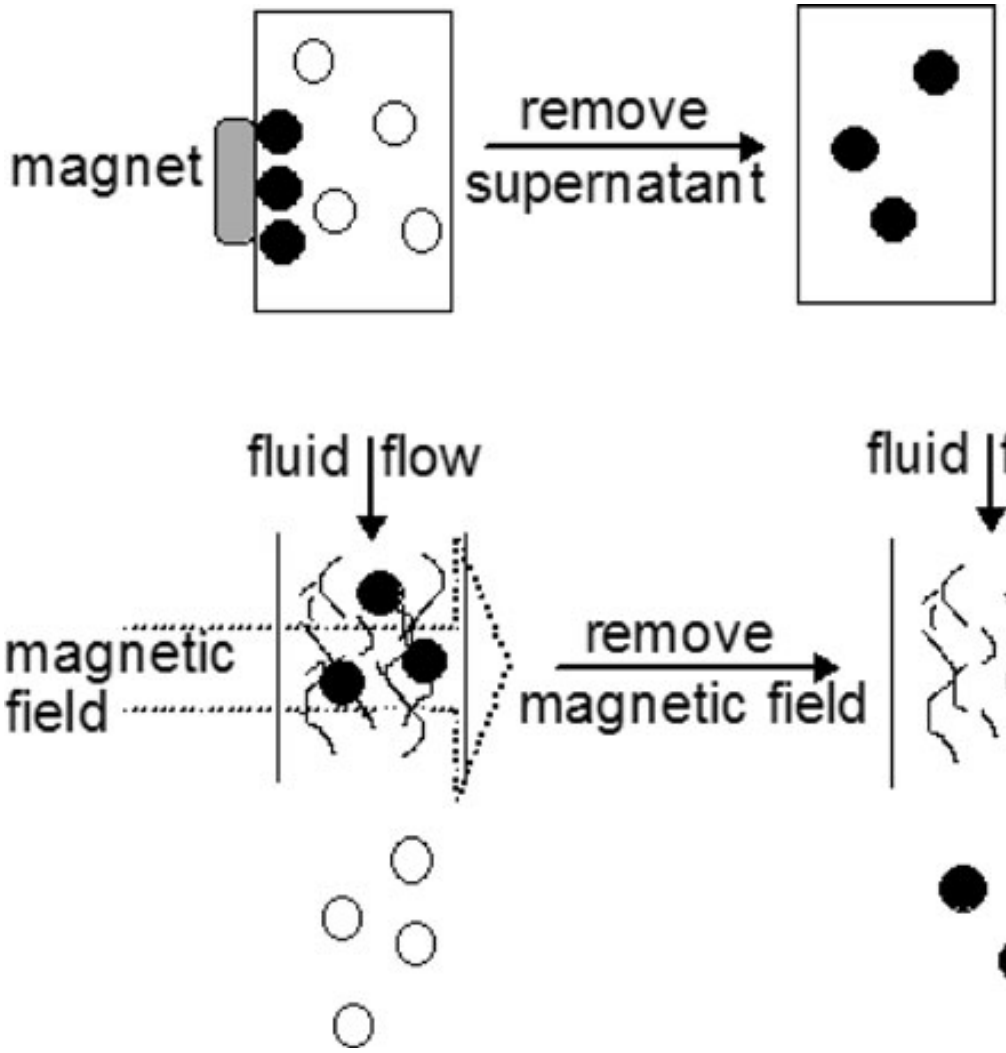


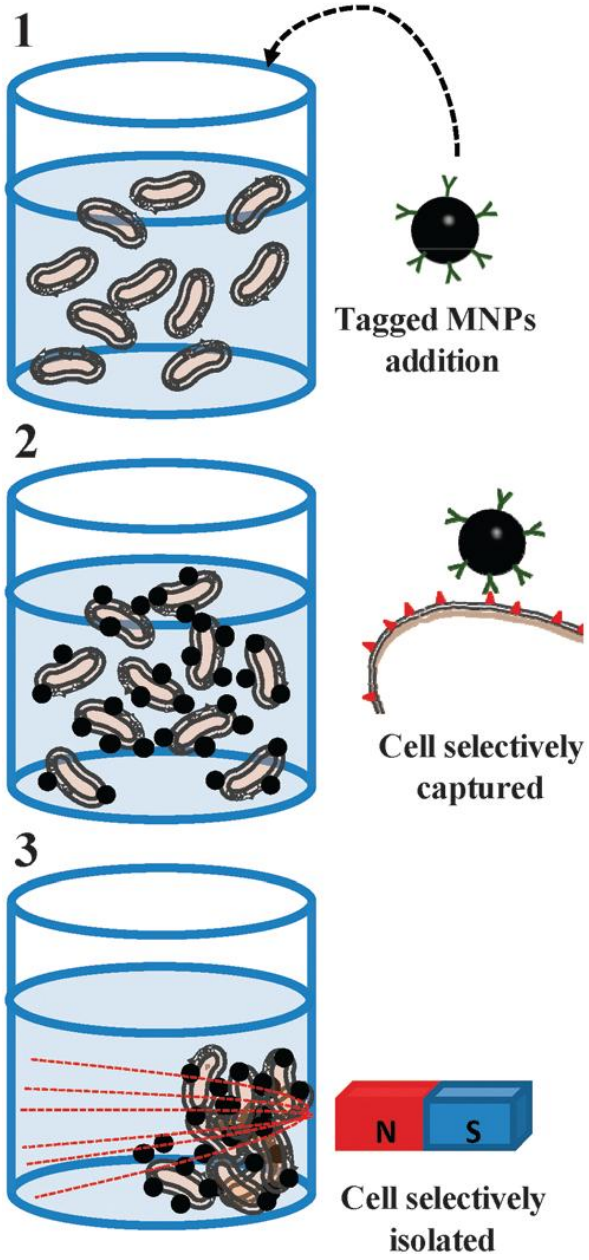
Physical Properties of Magnetic Nanoparticles



(Akbazardeh et al., 2012)

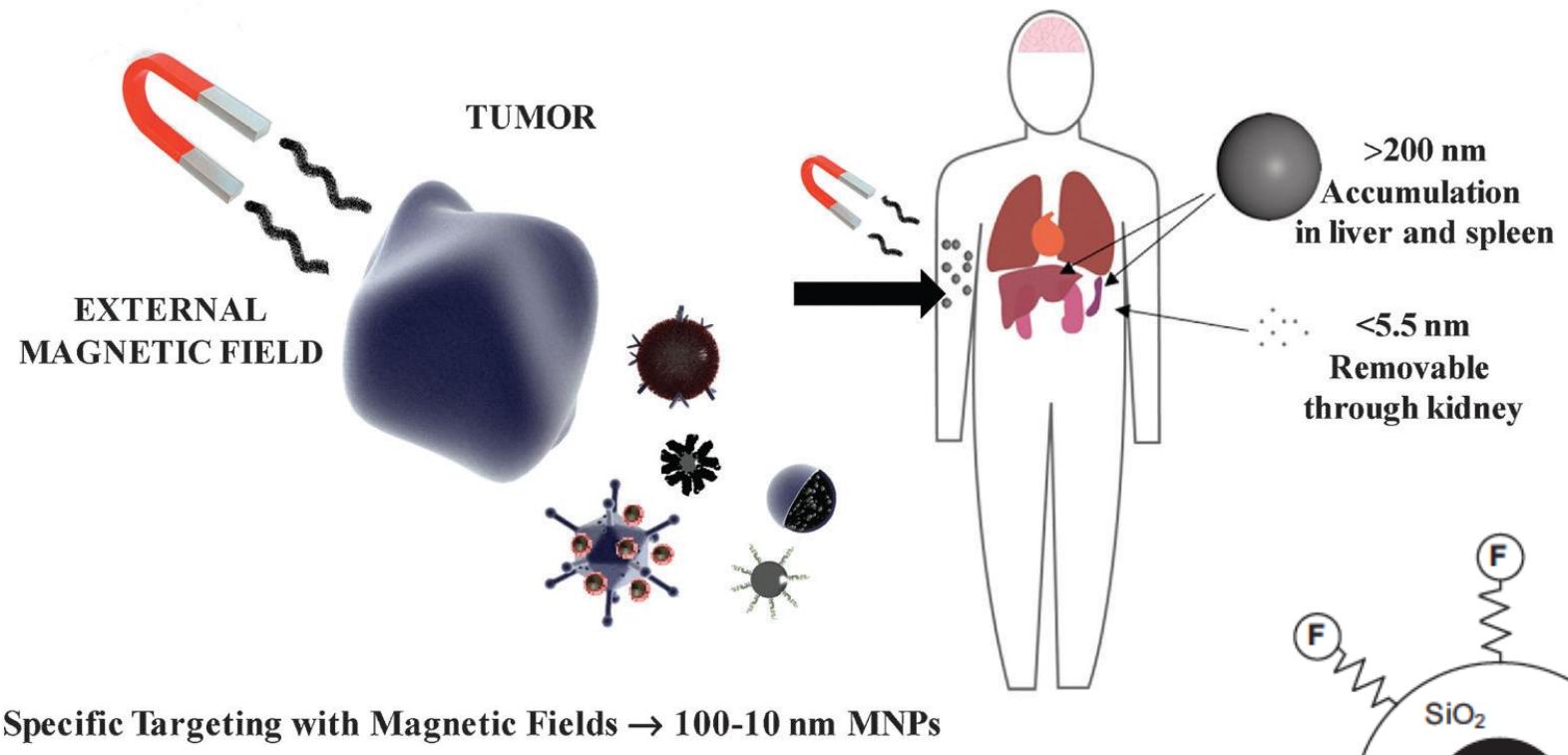
Magnetic Separation



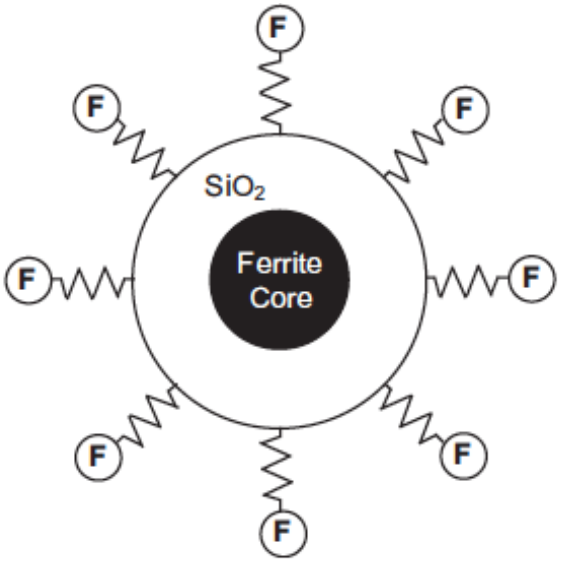


(Pankhurst et al., 2003; Colombo et al., 2012)

Magnetic Targeting and Drug Delivery

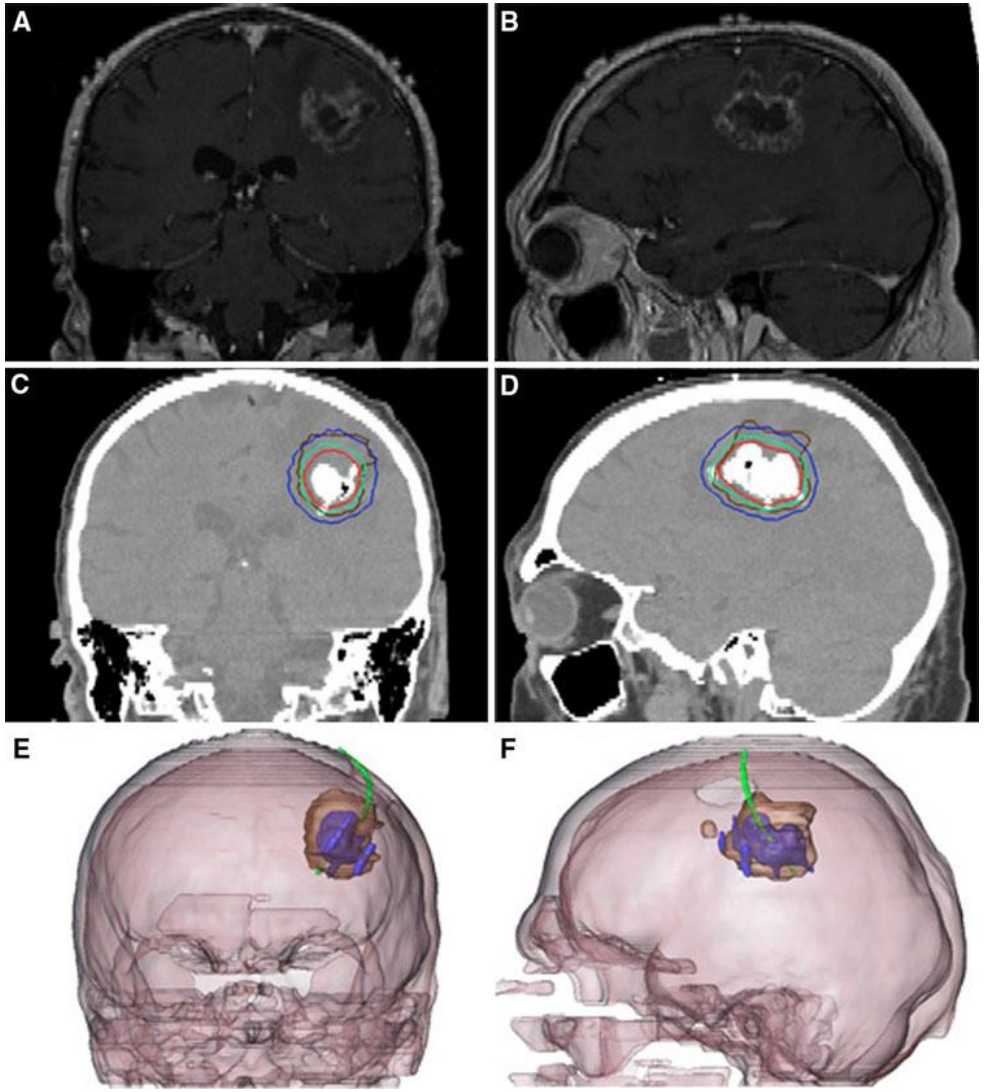


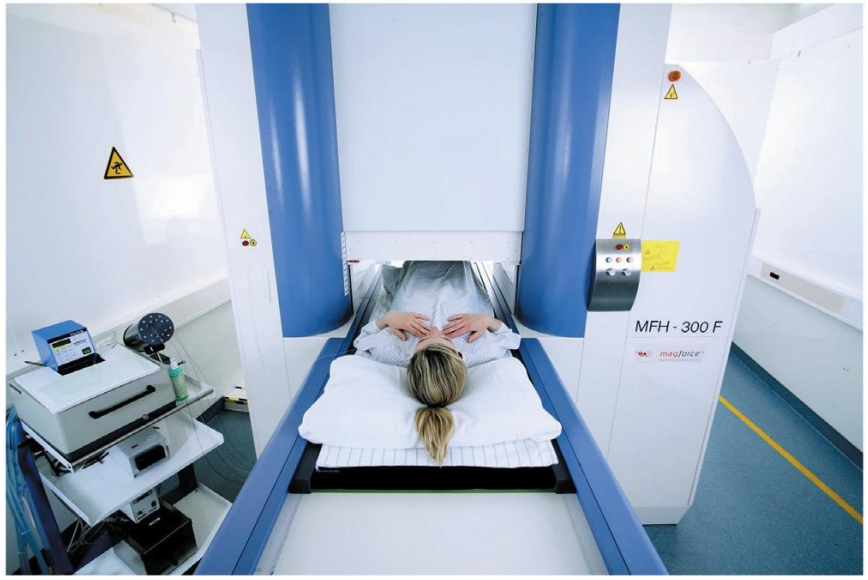
Specific Targeting with Magnetic Fields → 100-10 nm MNPs



(Colombo et al., 2012; Pankhurst et al., 2003)

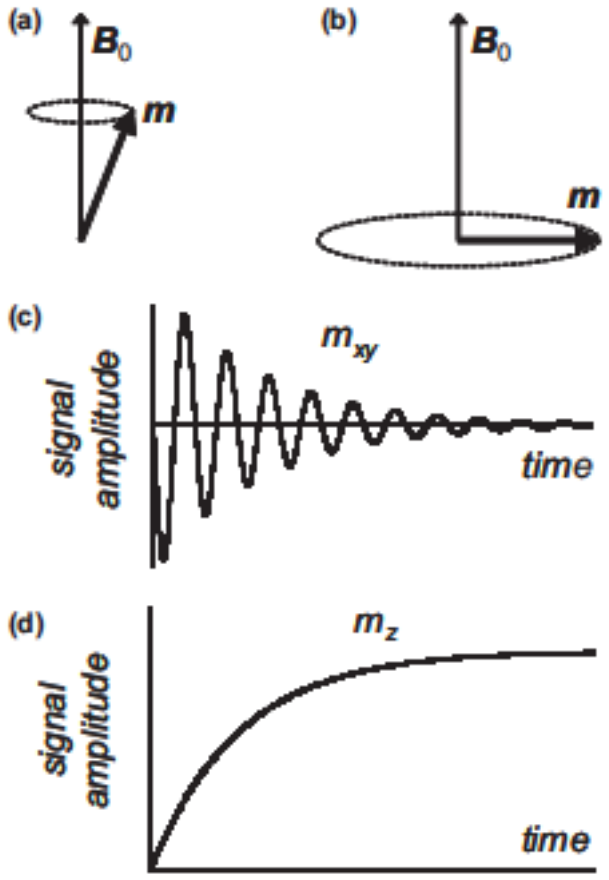
Hyperthermia

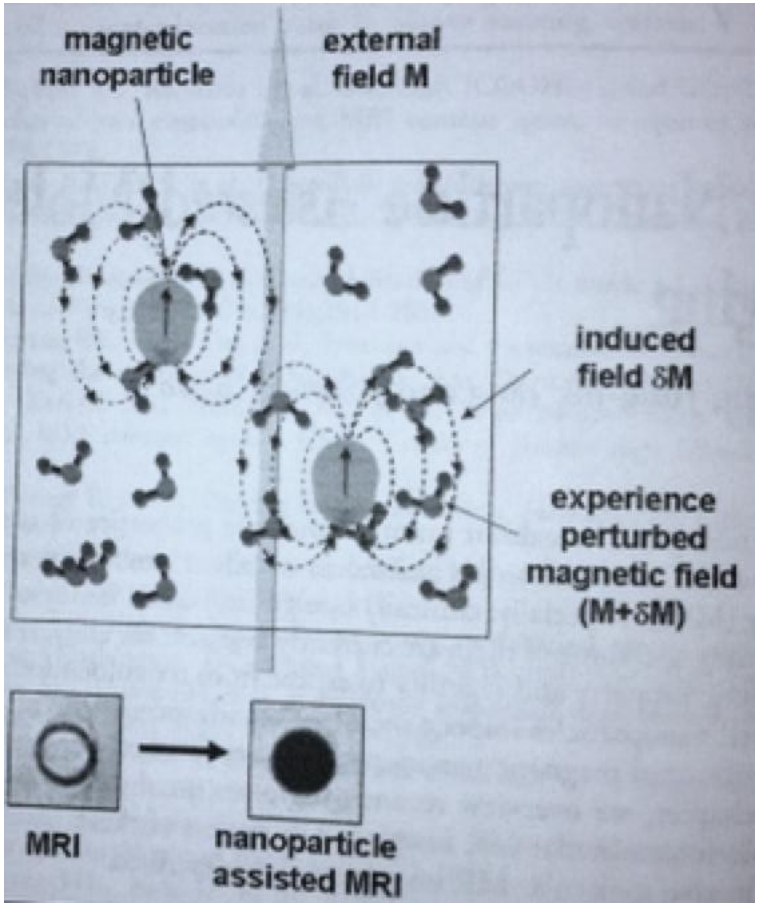




(Maier-Hauff et al., 2011; Thiesen and Jordan, 2008)

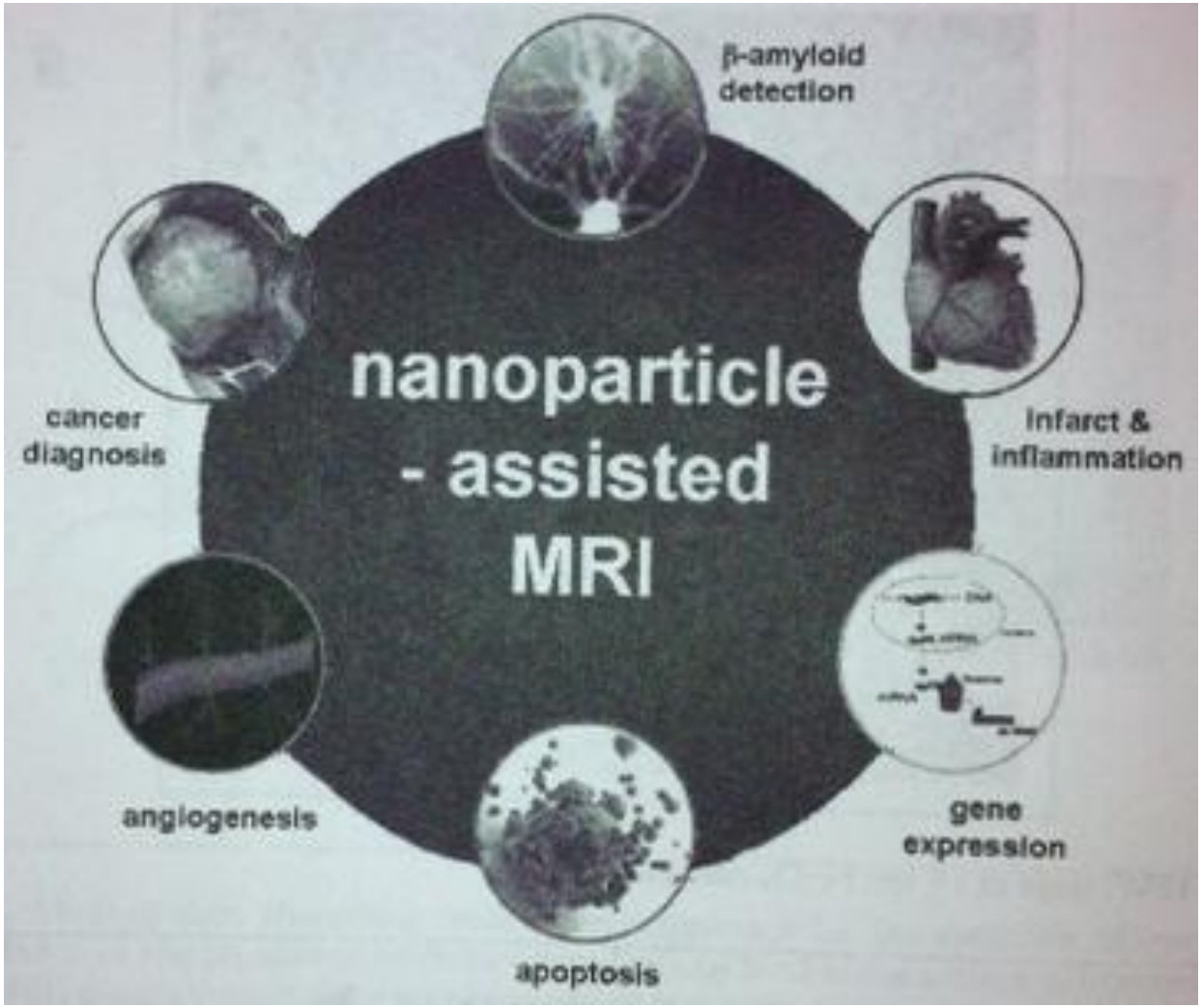
MRI Contrast Enhancement by Magnetic Nanoparticles





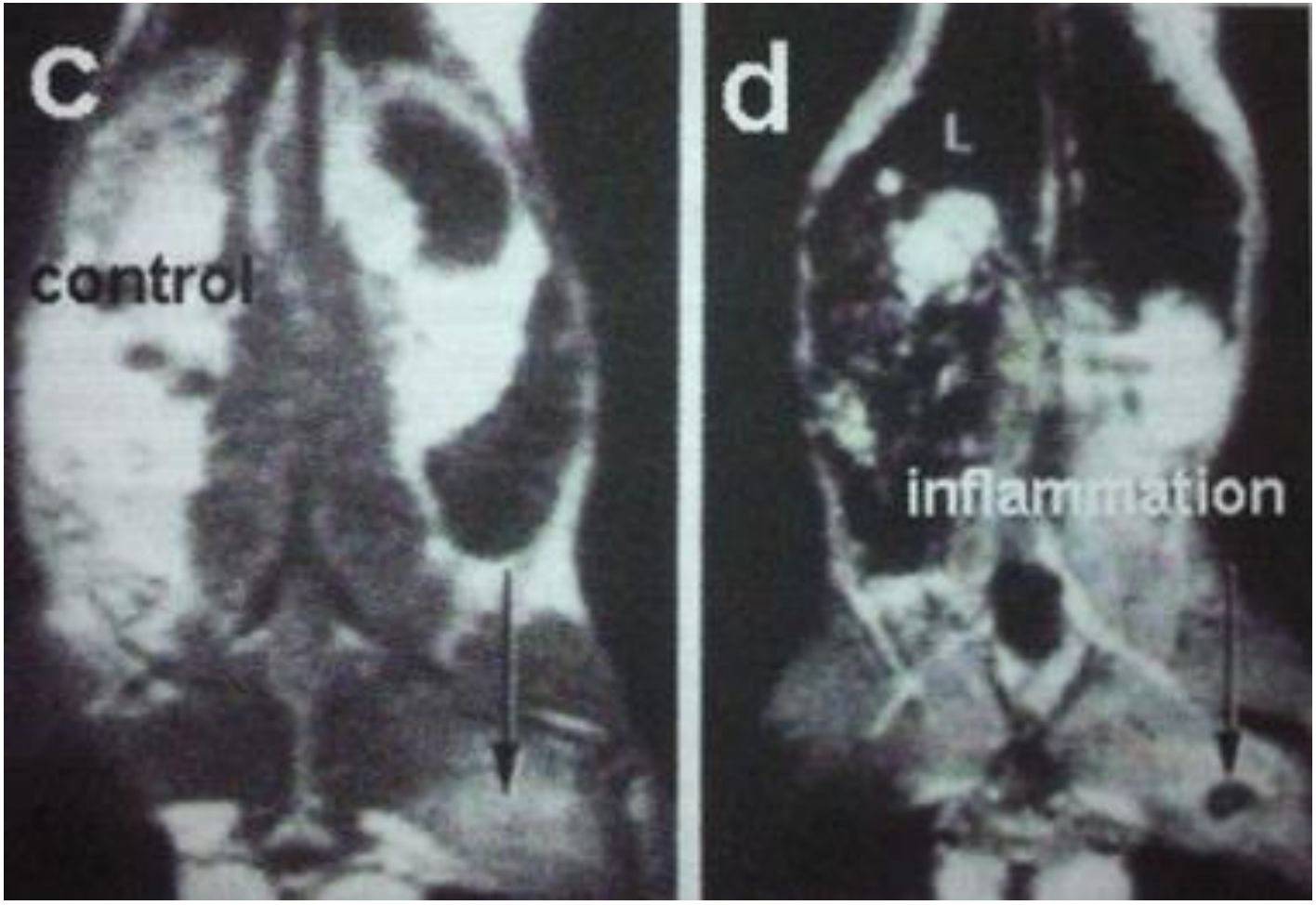
(Pankhurst et al., 2003; Chan 2007)

Applications of Magnetic Resonance Imaging



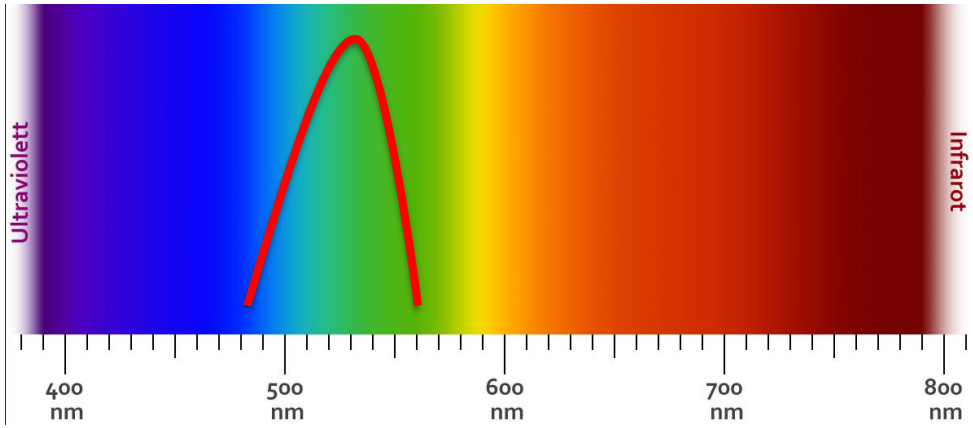
(Chan 2007)

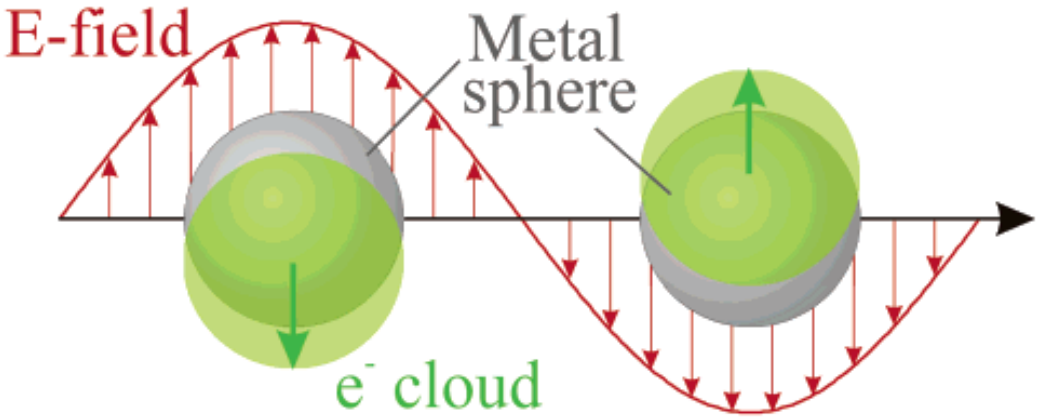
MRI for Detection of Inflammation



(Chan 2007)

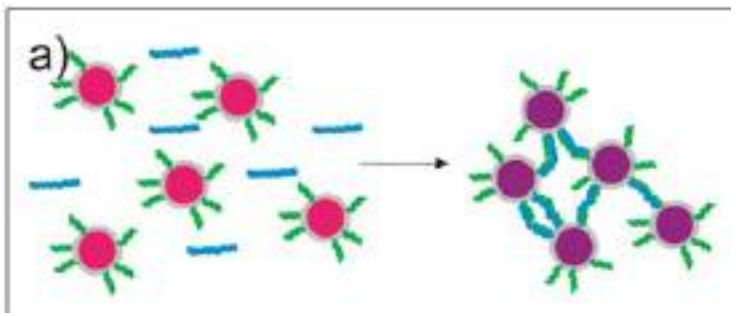
Optical Properties of Gold Nanoparticles



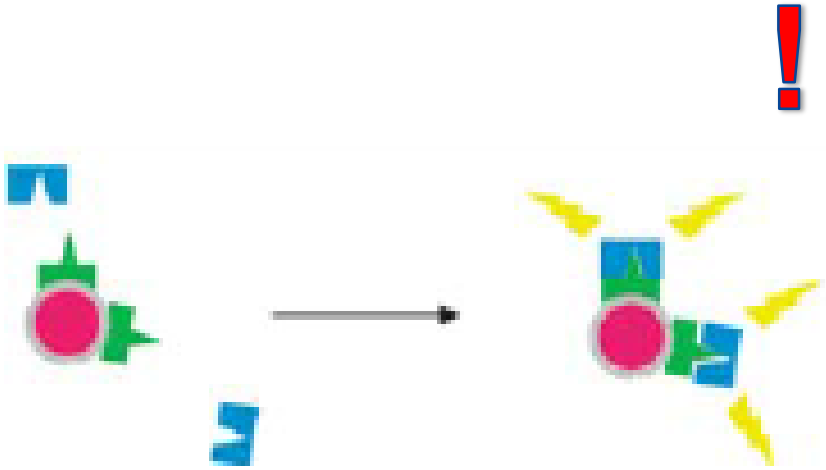


(Kelly et al., 2003; britishmuseum.org; Weintraub 2013)

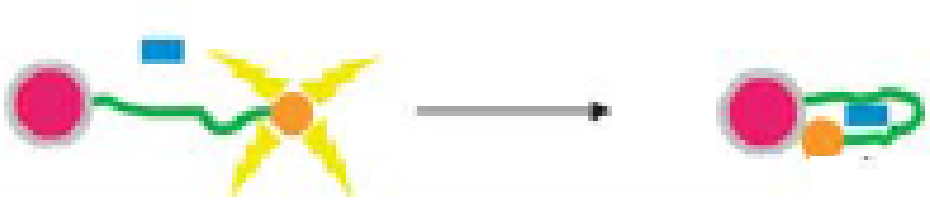
Sensor Applications of Gold Nanoparticles



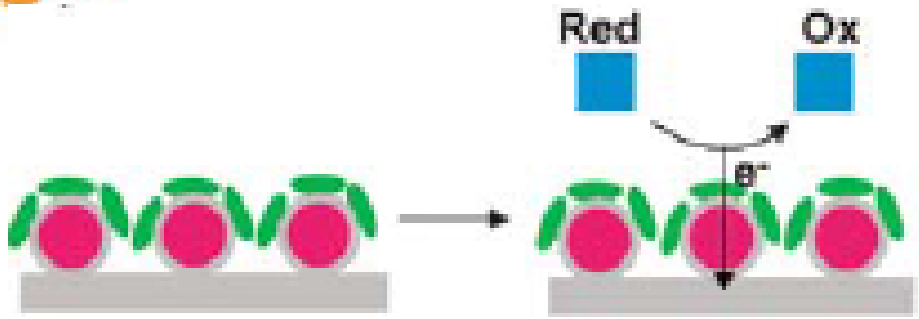
Colorimetric Assays



Surface Enhanced Raman Scattering



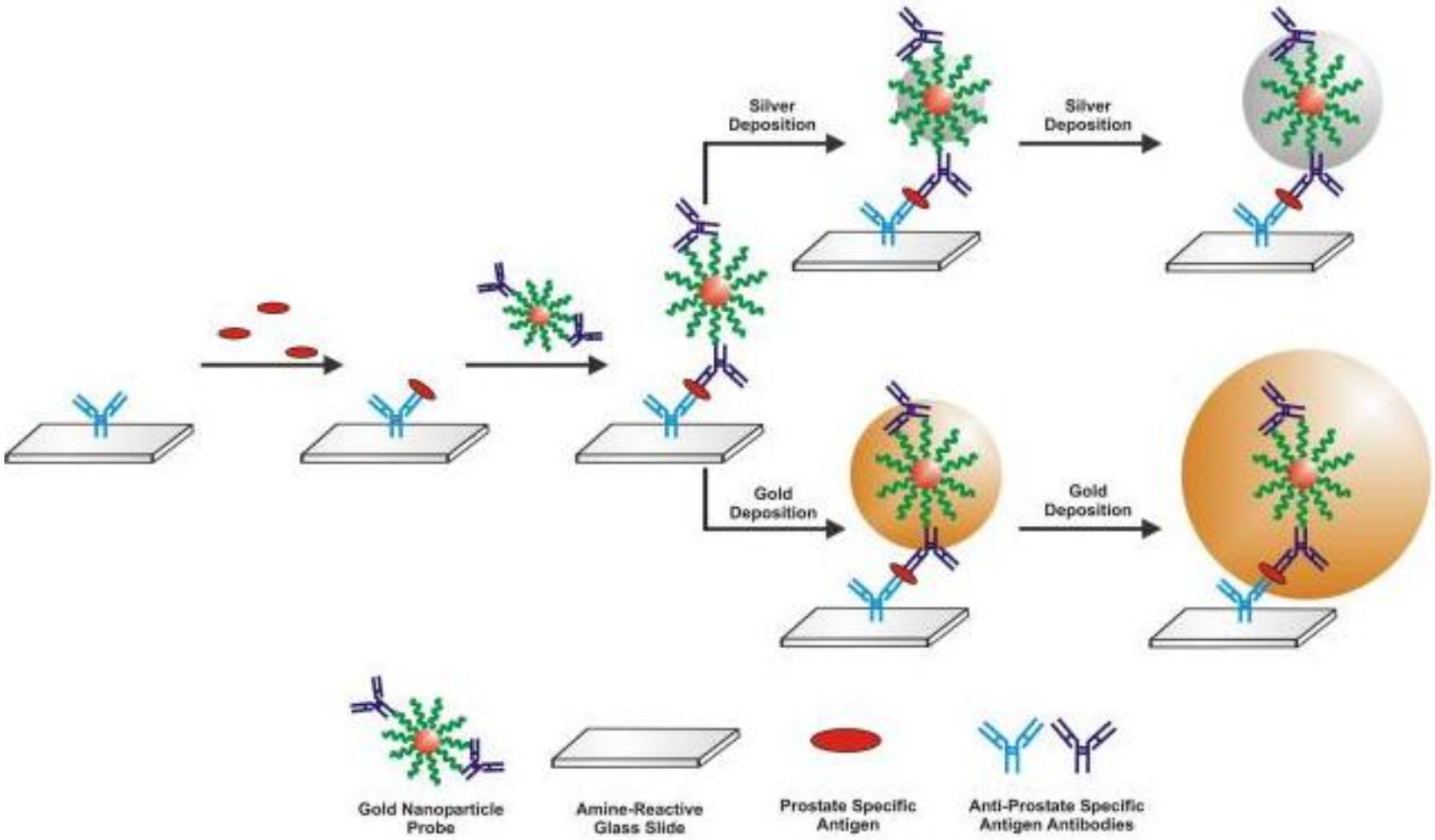
Fluorescence Quenching



Enzyme-Mediated Redox Reactions

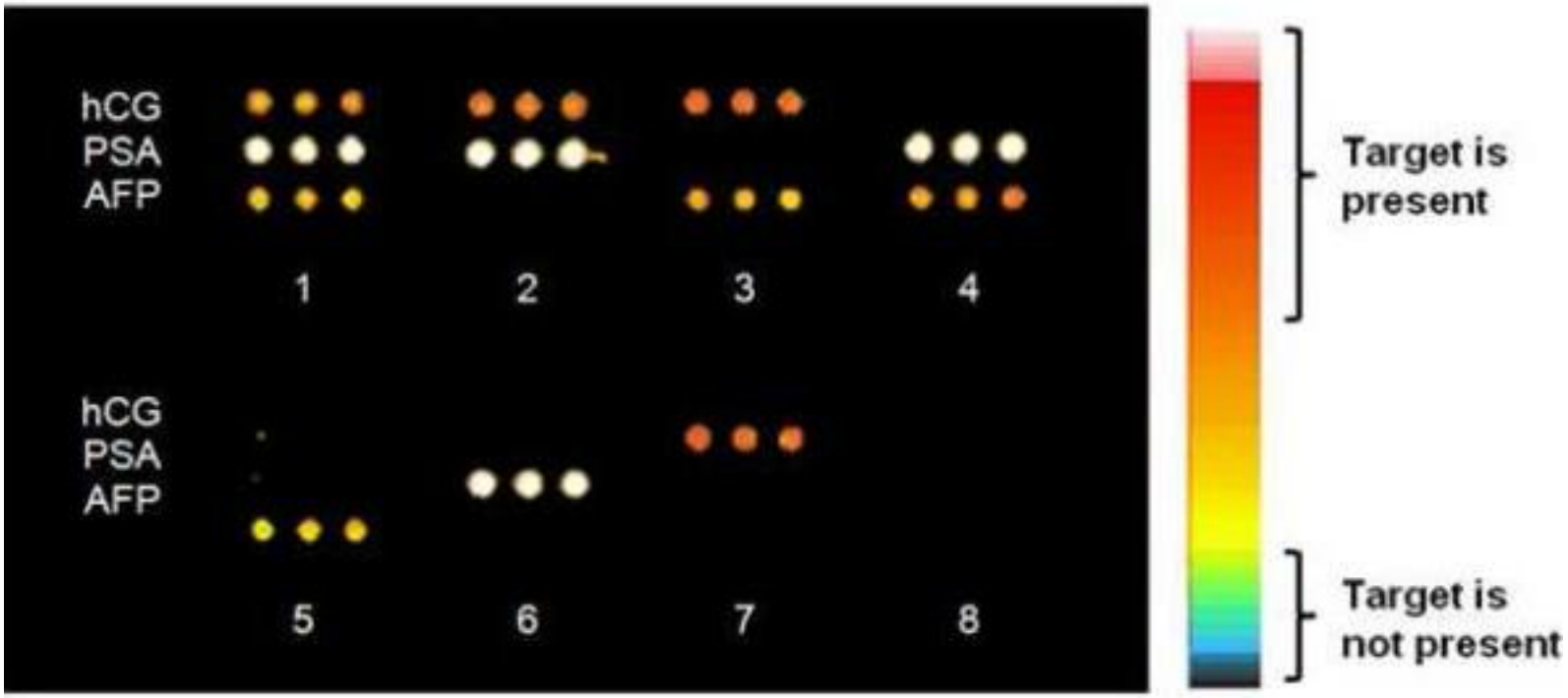
(Sperling and Parak., 2008)

Gold NP Microarray for Protein/DNA Detection



(Kim et al., 2009)

Gold NP Microarray for Protein/DNA Detection



PSA = prostate specific antigen = tumor marker
AFP = alpha fetoprotein = serum protein
hCG = human chorionic gonadotropin = hormon indicating pregnancy

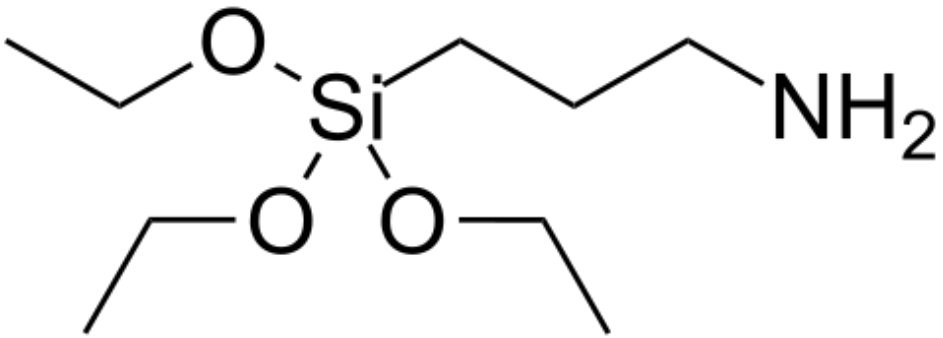
(Kim et al., 2009)

Synthesis of Silica Nanoparticles

Hydrolysis:

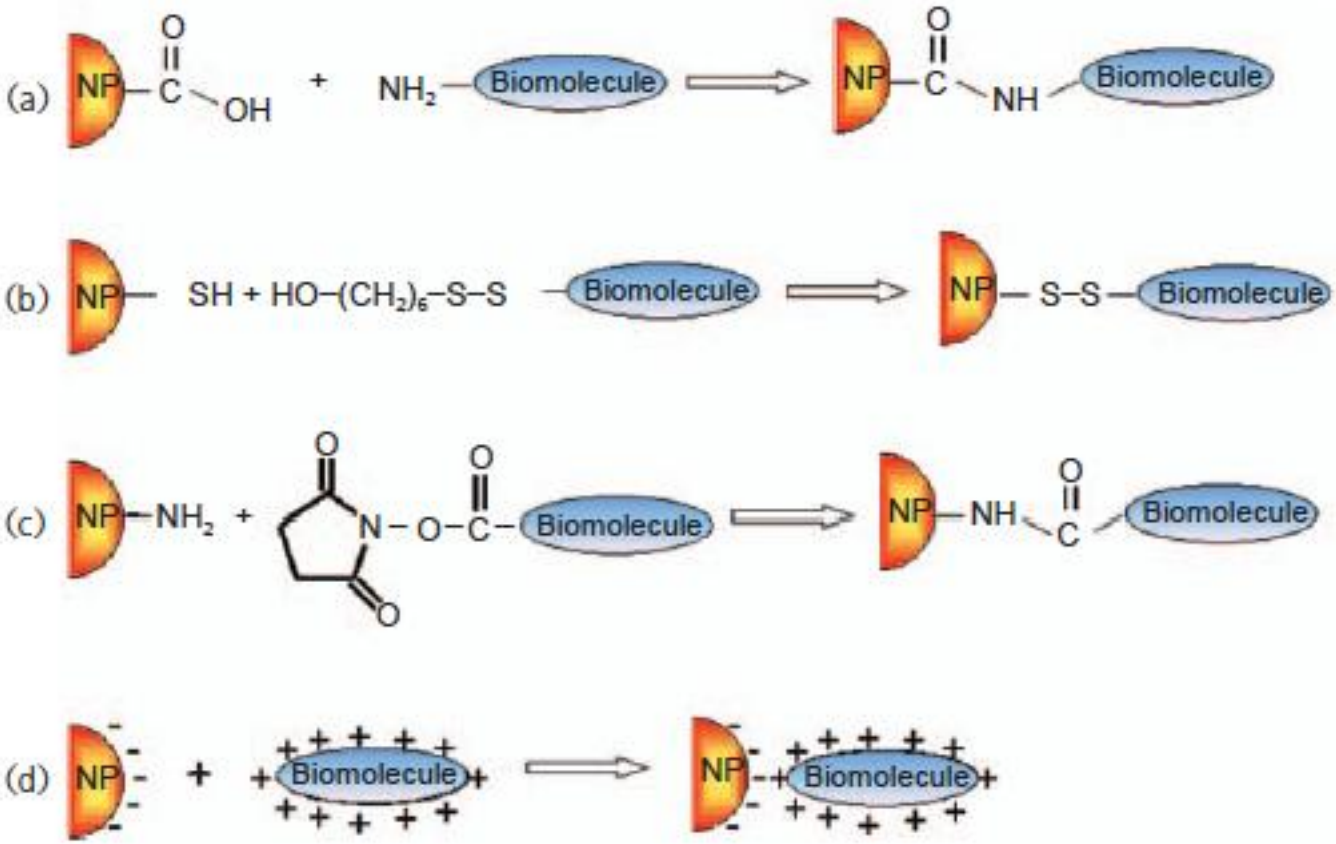
Condensation:

Synthesis of Fluorescent Silica Nanoparticles



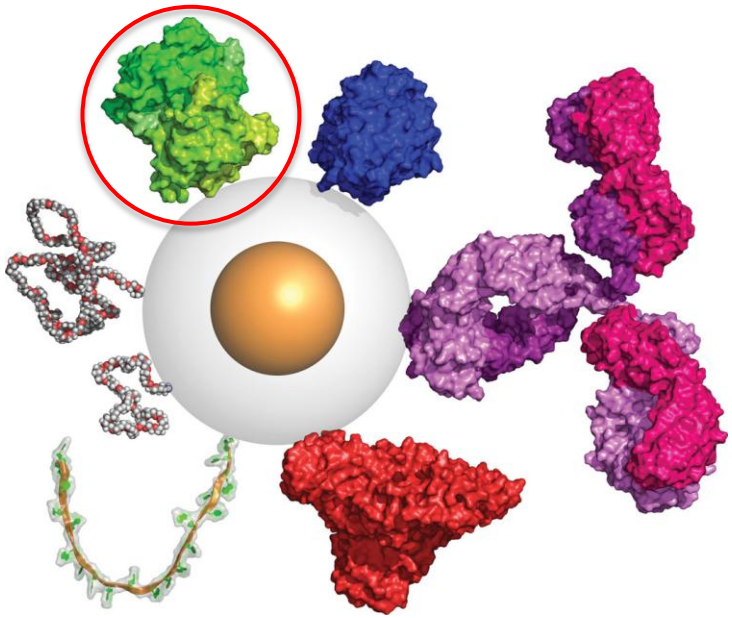
[Wang et al., 2008]

Bioconjugation of Silica Nanoparticles

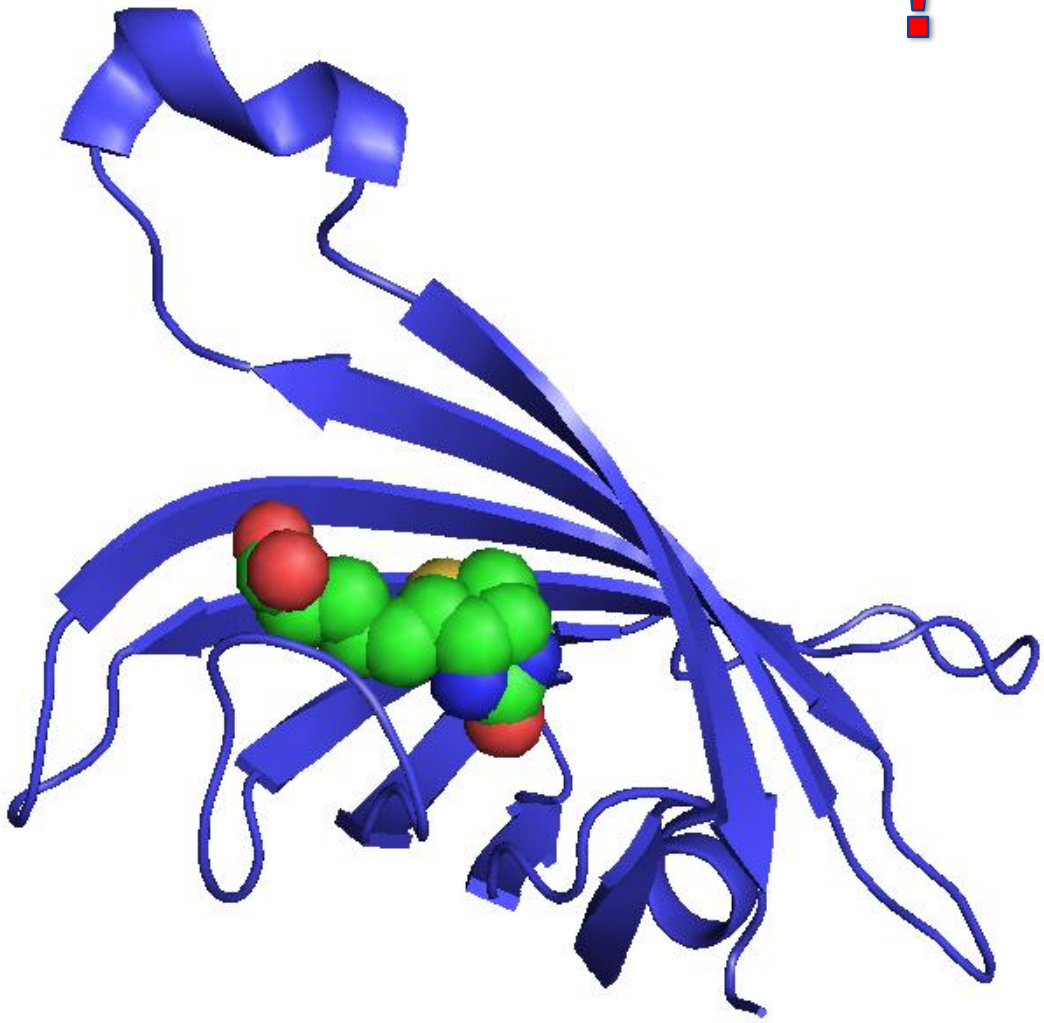


[Wang et al., 2008]

Bioconjugation of Silica Nanoparticles - Streptavidin Biotin



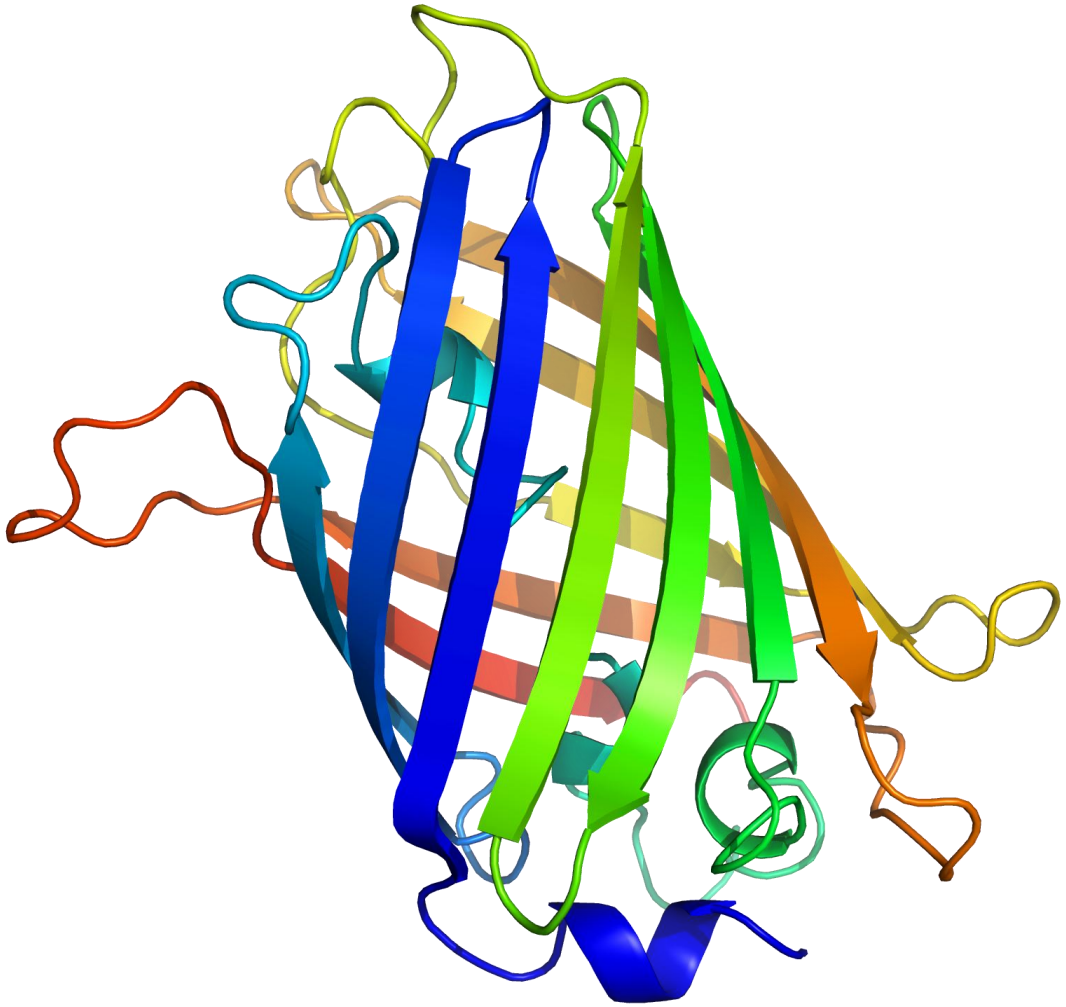
streptavidin (left green, right blue),
transferrin,
antibody,
albumin,
DNA,
PEG



!

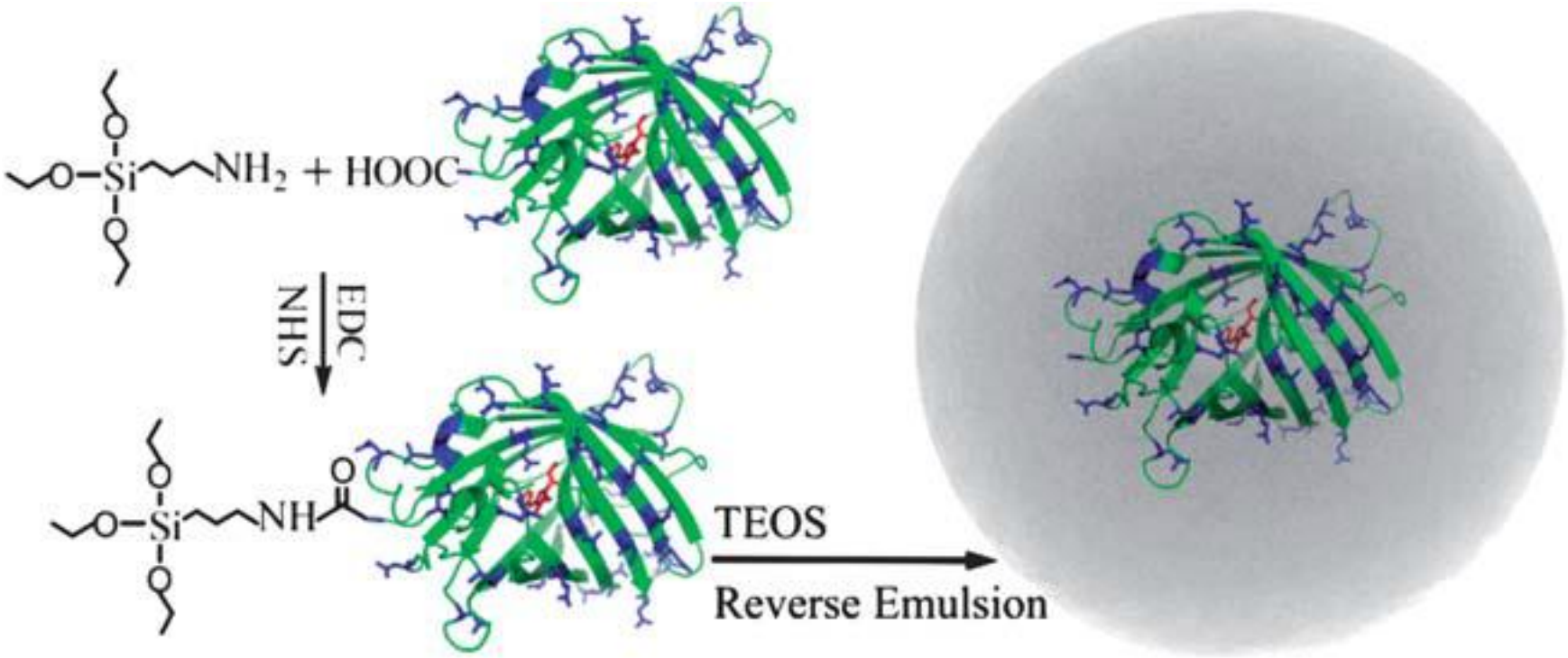
[Roo 2012, Sperling and Parak, 2010]

Fluorescent Proteins



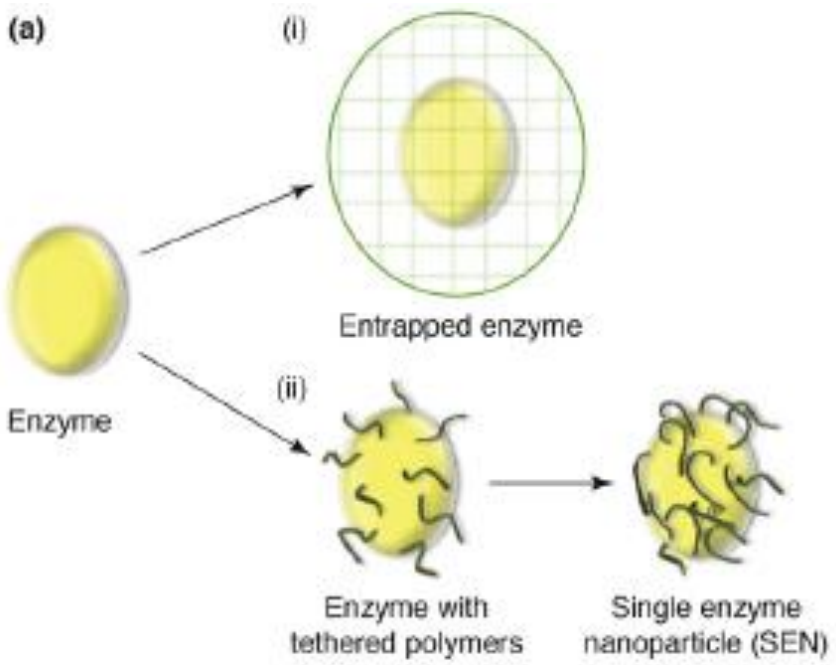
[Richard Wheeler]

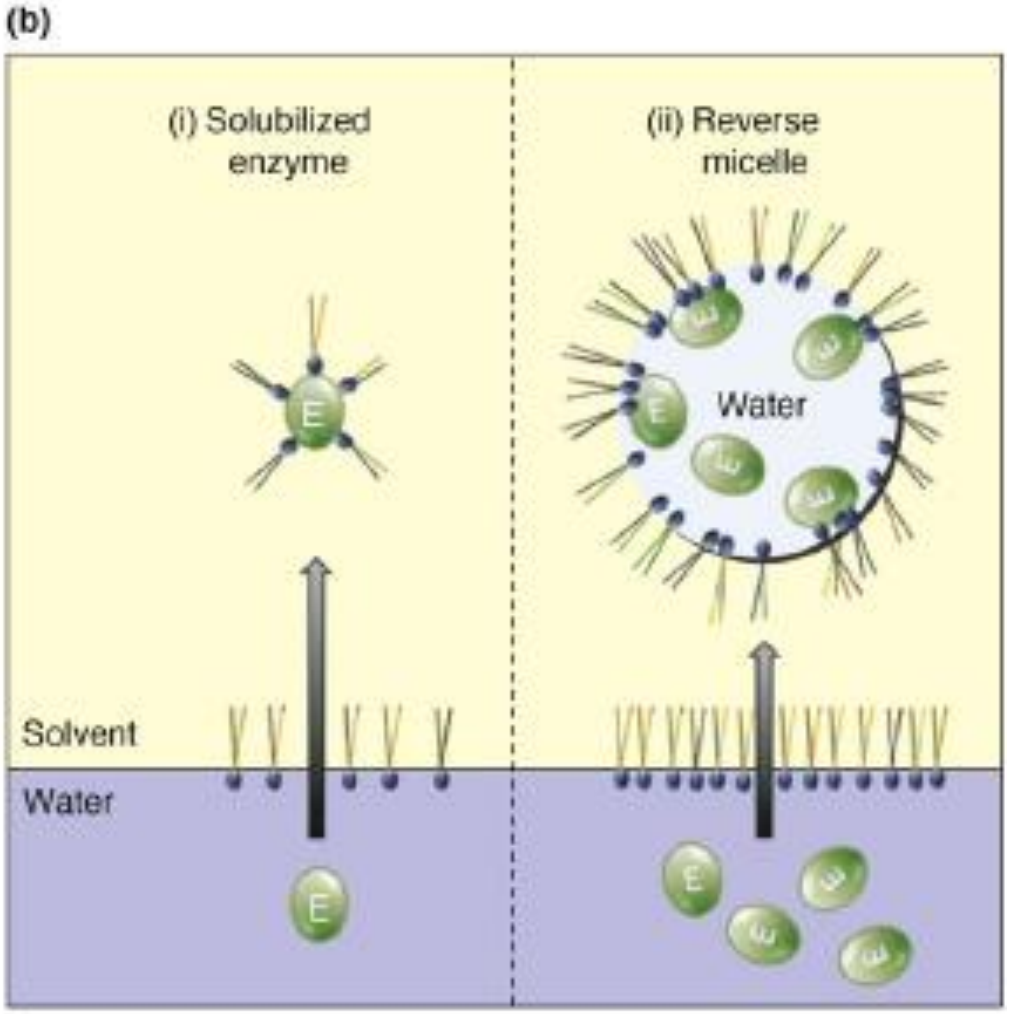
Encapsulation of Proteins within Silica Nanoparticles



[Cai et al., 2011]

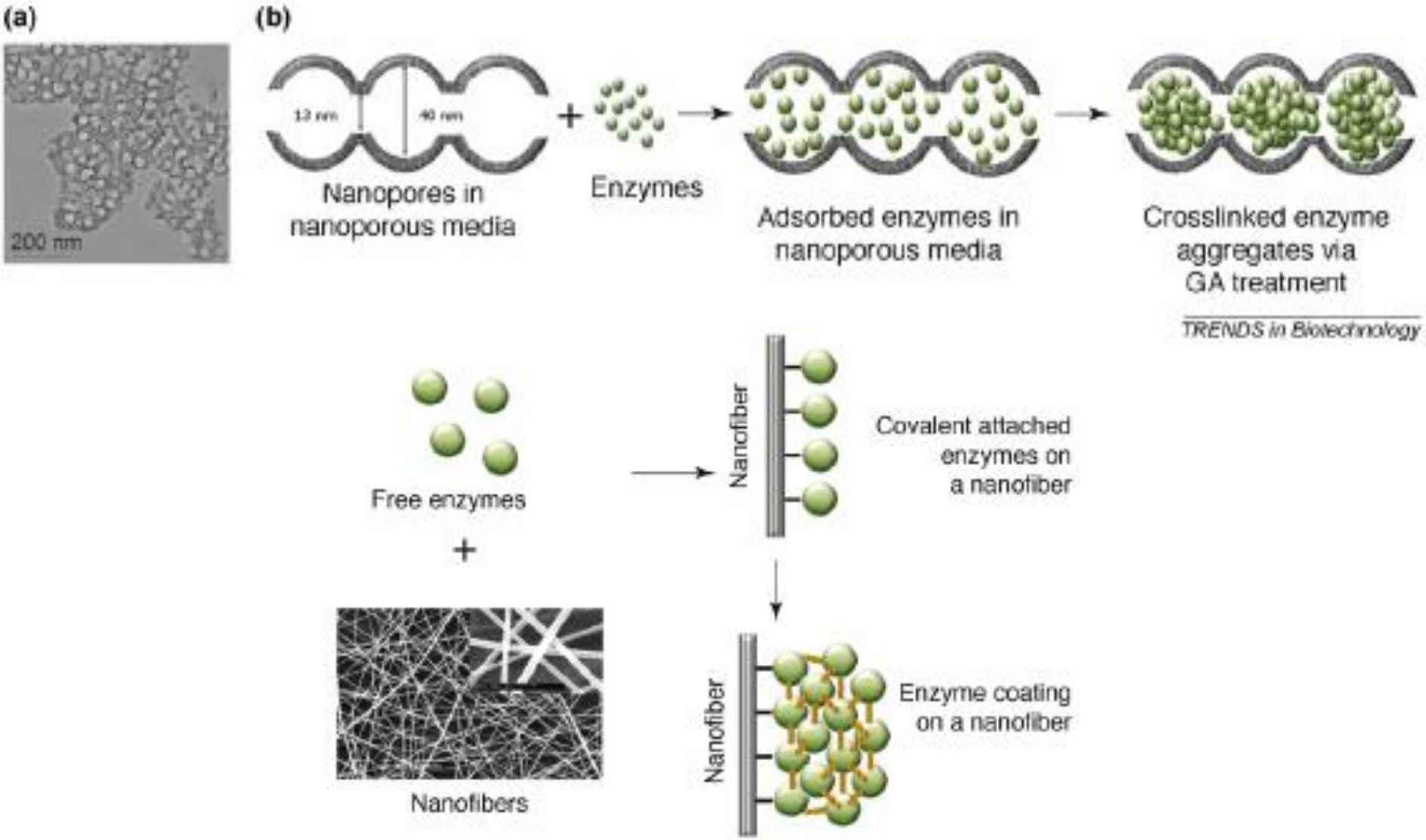
Enzyme Nanoentrapment





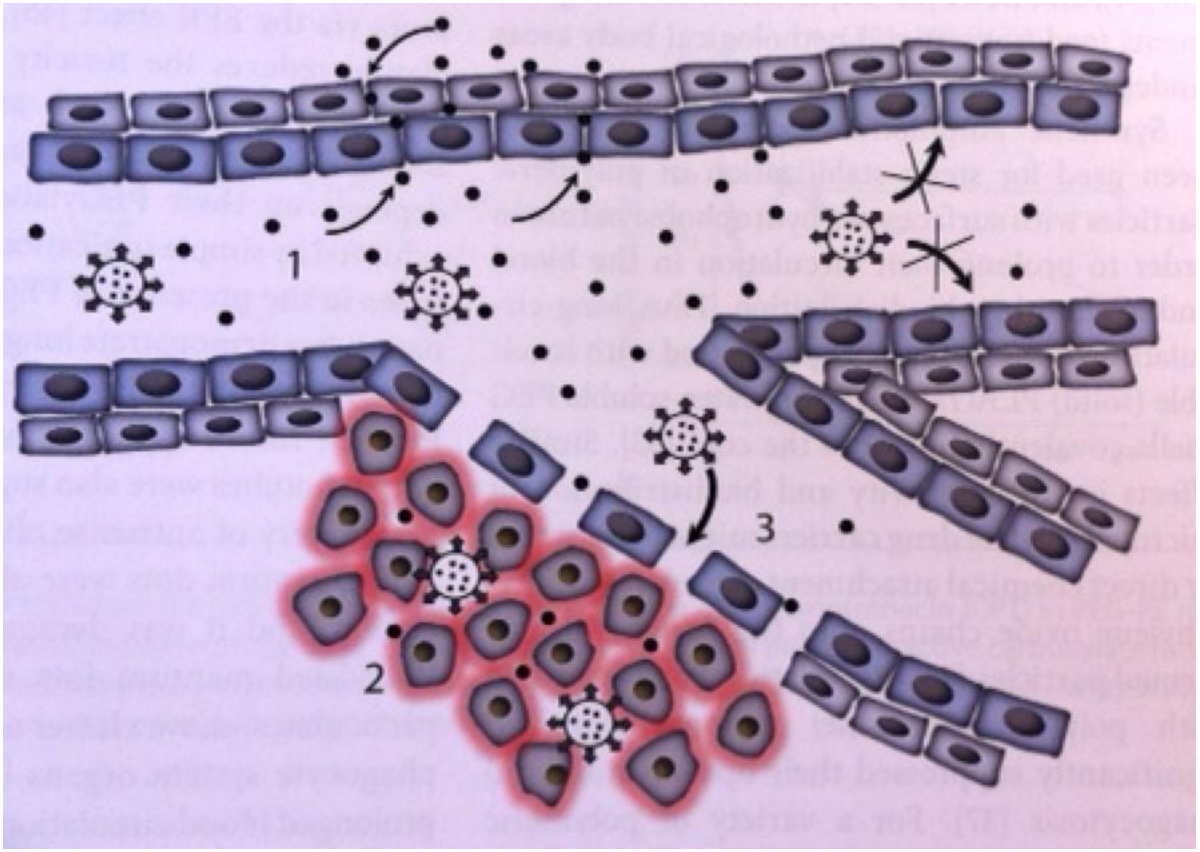
[Kim et al., 2008]

Entrapment of Enzymes in Nanopores and on Nanofibres



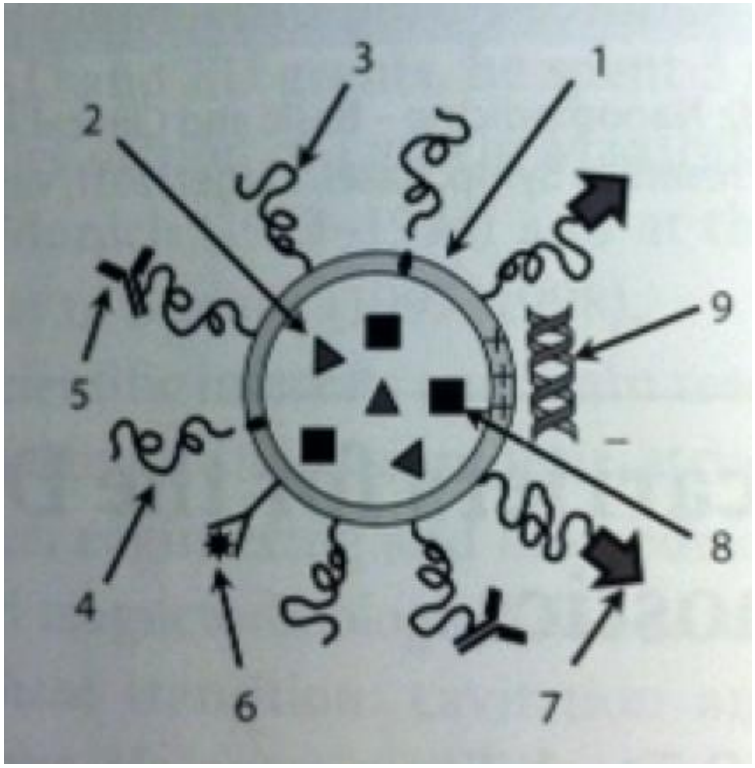
[Kim et al., 2008]

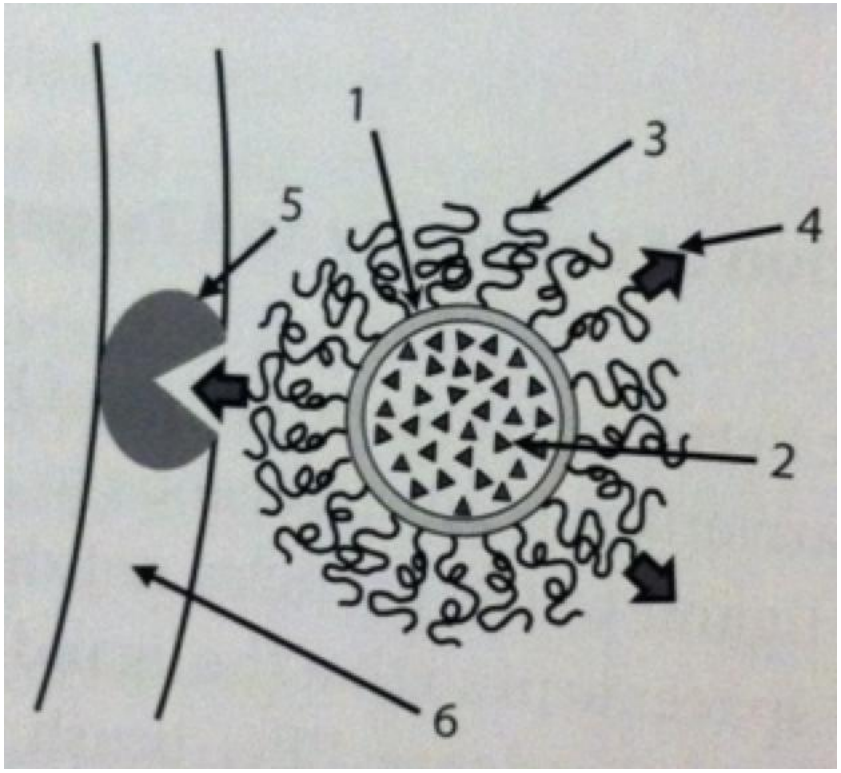
Passive Targeting via Enhanced Permeability and Retention



(Alexiou 2011)

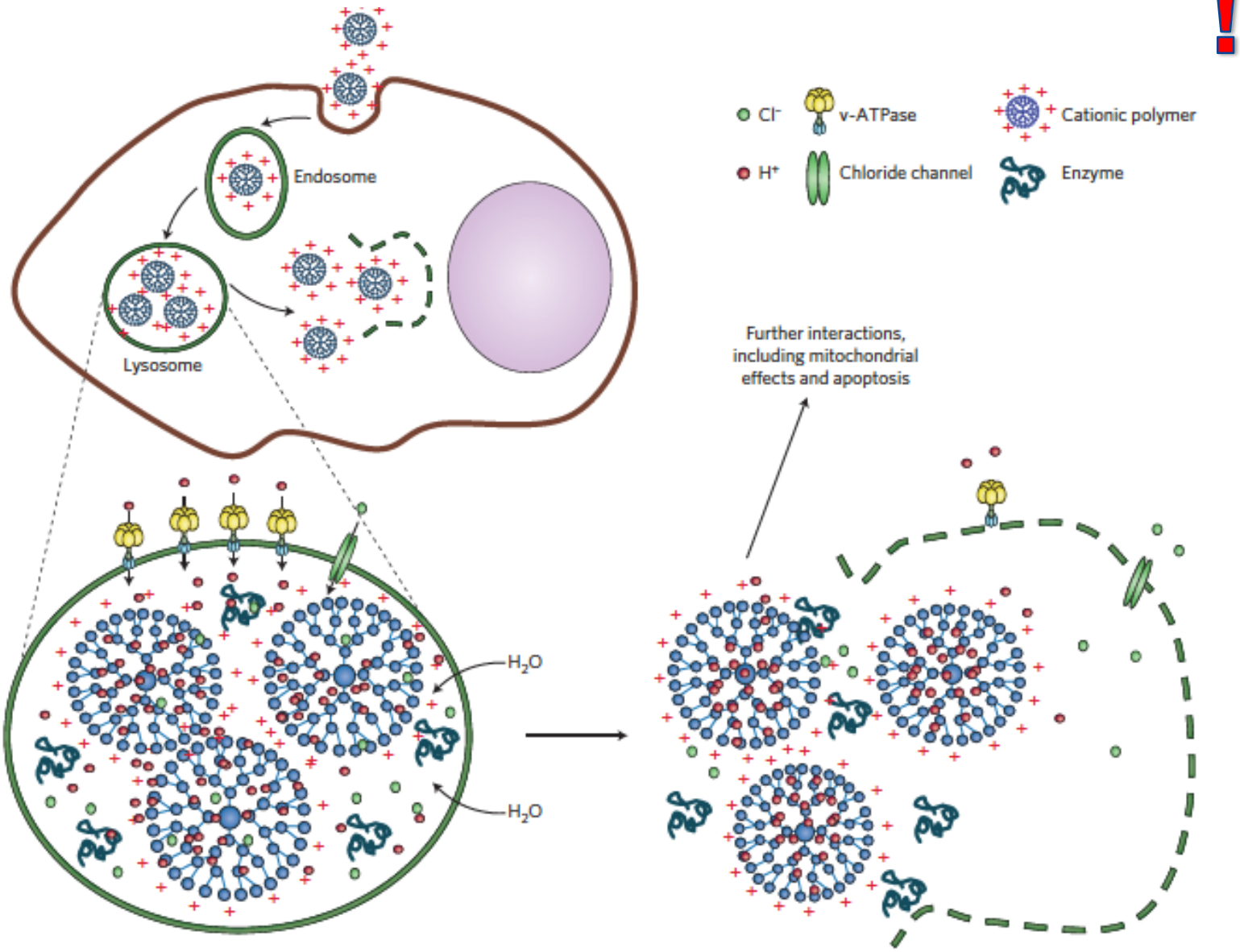
Drug Delivery via Active Targeting





(Alexiou, 2011)

Intracellular Targeting



(Nel, 2009)

Literature

Books:

- Chan (2007) Bio-Applications of Nanoparticles
- Alexiou (2011) Nanomedicine – Basic and Clinical Applications in Diagnostics and Therapy
- Williams (2014) Essential Biomaterials Science

Articles:

- Medintz et al. (2005) Quantum dot bioconjugates..., Nat Mater 4: 435
- Akbarzardeh et al. (2012) Magnetic nanoparticles, Nanoscale Res Lett 7:144
- Colombo (2012) Biological applications of magnetic nanoparticles, Chem Soc Rev 41: 4306
- Sperling and Parak (2008) Biological Applications of Gold Nanoparticles, Chem Soc Rev 37: 1745
- Kim et al. (2009) A Microarray-based ... Immunoassay...,Anal Chem 81: 9183
- Kim et al. (2008) Nanobiocatalysis and ist potential applications, Trends in Biotechnology 26: 639
- Wang et al. (2008) Bioconjugated Silica Nanoparticles: Development and Applications, Nano Res 1: 99

Questions

- ❑ What are nanoobjects?
- ❑ What are main application fields of nanoparticles in biomedicine? How do they work?
- ❑ What are quantum dots? What are they made of, what are their main properties and applications?
- ❑ What are important properties of gold nanoparticles? How are they used in biomedicine?
- ❑ What are main applications of magnetic nanoparticles?
- ❑ Silica nanoparticles: How are they prepared? How can biomolecules be coupled to silicon dioxide nanoparticles? How can proteins be encapsulated? What are fluorescently labeled silica nanoparticles?
- ❑ What is the EPR effect? What is this effect used for?, what is passive targeting of nanoobjects/drugs?
- ❑ How is active targeting of nanoobjects achieved?
- ❑ What is intracellular delivery of nanoobjects? How are nanoobjects released into the cytosol?
- ❑ Why drug delivery? Discuss

Next Lecture: July 12, 2019

Nanosafety

Written Exam (Klausur): July 19, 2019