Iron Oxide(Fe_3O_4) Nanoparticles for T2 MRI Contrast Agents

HoYoung Kim

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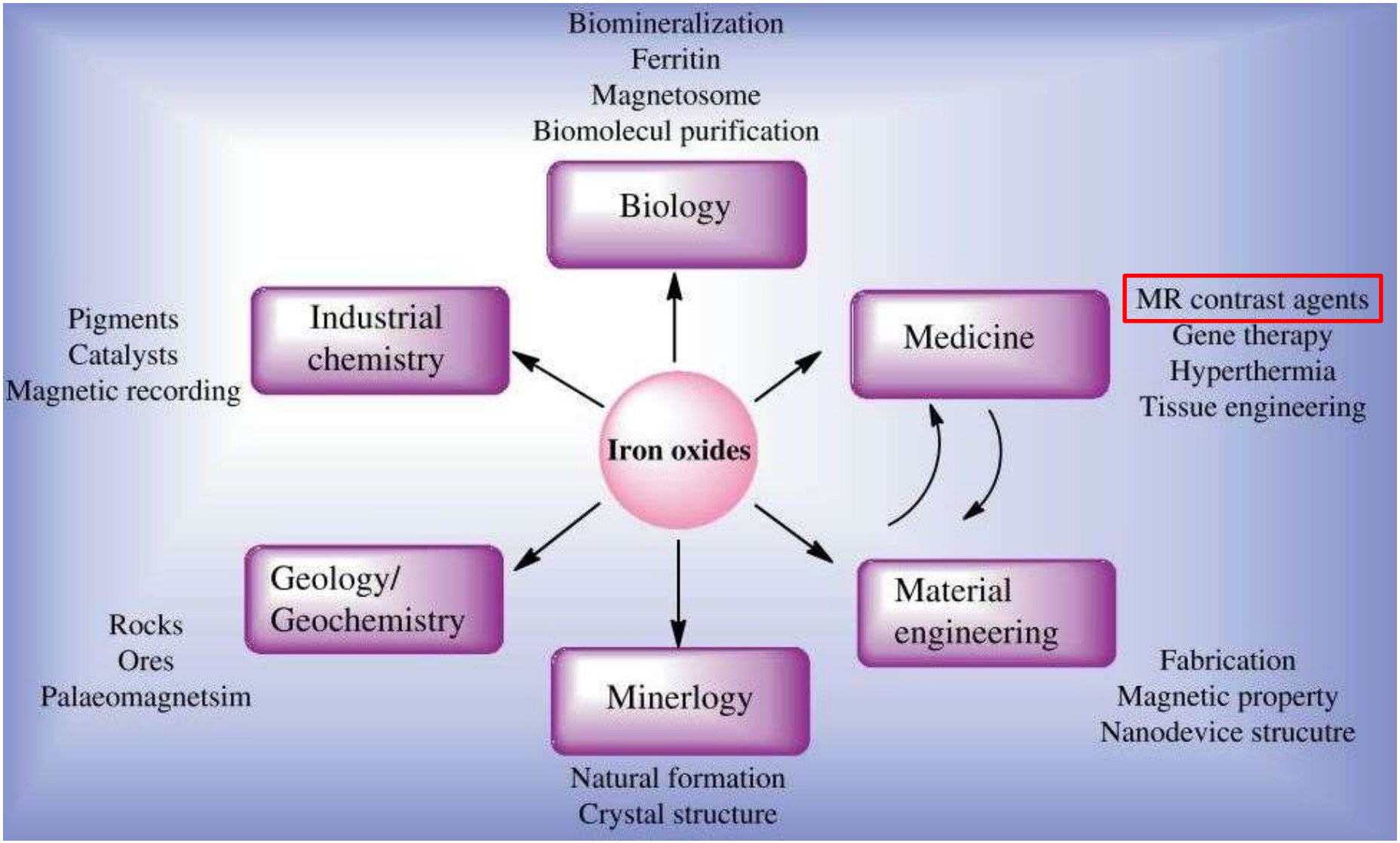
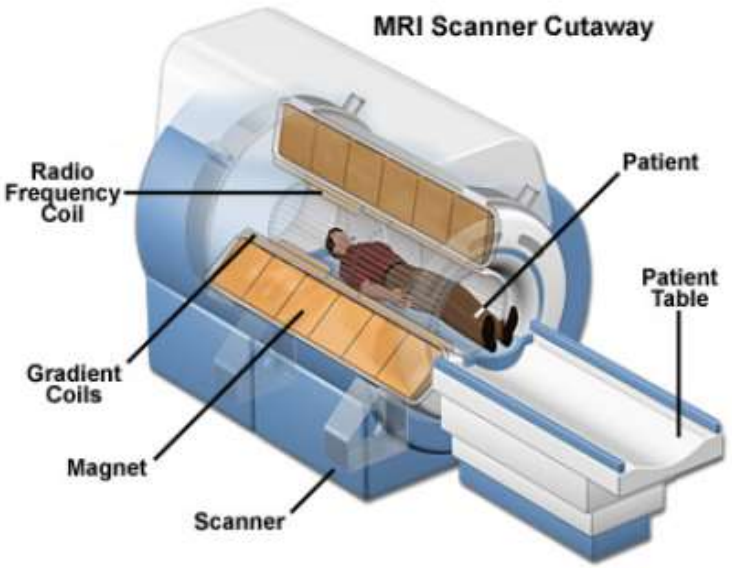
Center for Evolutionary Nanoparticles

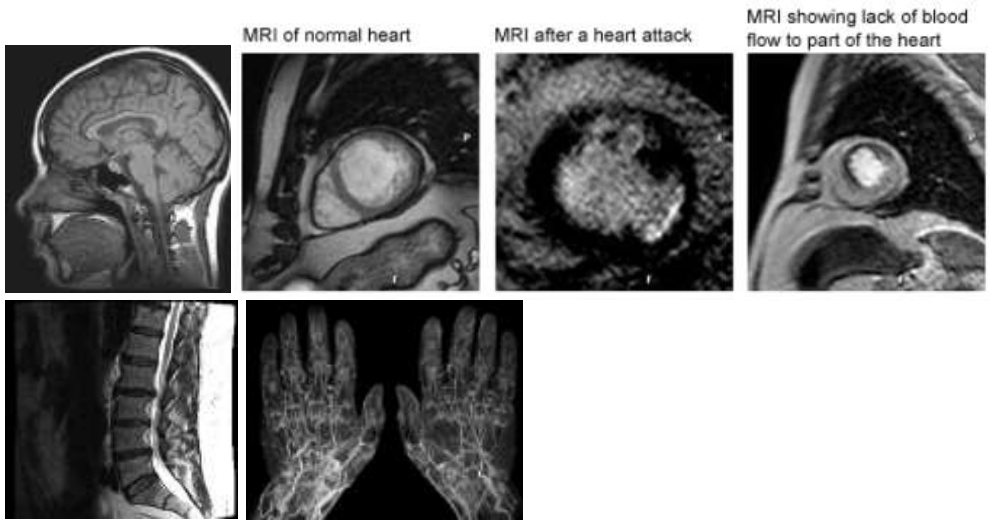
Recent research on iron oxide research



Magnetic Resonance Imaging (MRI)

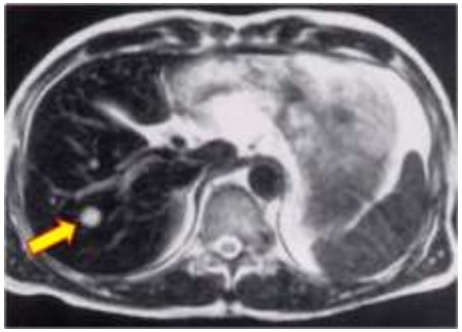


anatomic images of soft tissue



Powerful Diagnostic Technique!

- **Non-Invasive**
- **High Resolution**
- **Anatomical Details**



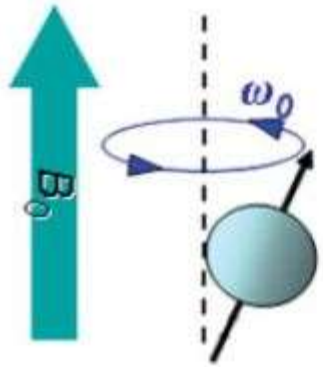
T2-weighted Image using iron oxide nanoparticle

TABLE 1. Comparison of Several Imaging Modalities[9]

imaging technique	source of imaging	spatial resolution	tissue penetrating depth	sensitivity[a]	types of probe
magnetic resonance imaging (MRI)	radiowave	25–100 μm	no limit	mM to μM (low)	para- (Gd^{3+}) or superparamagnetic (Fe_3O_4,) materials
positron emission tomography (PET)	γ-ray	1–2 mm	no limit	pM (high)	radionuclides (^{18}F, ^{11}C, ^{13}N, ^{15}O, ^{124}I, ^{64}Cu)
computed tomography (CT)	X-ray	50–200 μm	no limit	not well characterized	high atomic number atoms (iodine, barium sulfate)
optical fluorescence imaging	visible or near-infrared light	*in vivo*, 2–3 mm; *in vitro*, sub-μm	<1 cm	nM to pM (medium)	fluorescent dyes, quantum dots

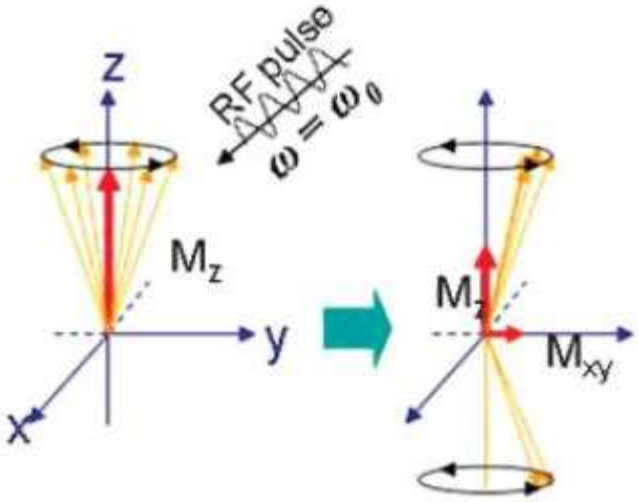
[a] Sensitivity of detecting probe is relative to background.

How Magnetic Material Enhance Contrast in MRI?

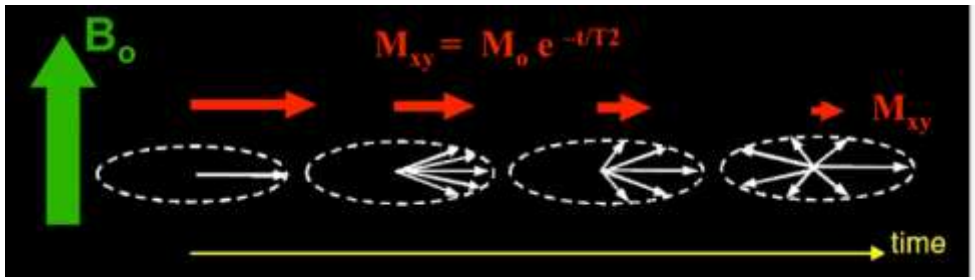


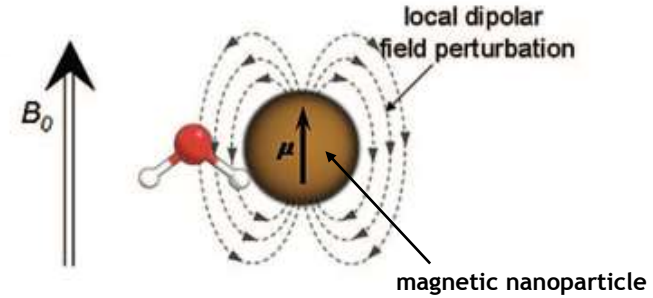
$$\omega_0 = \gamma B_0$$

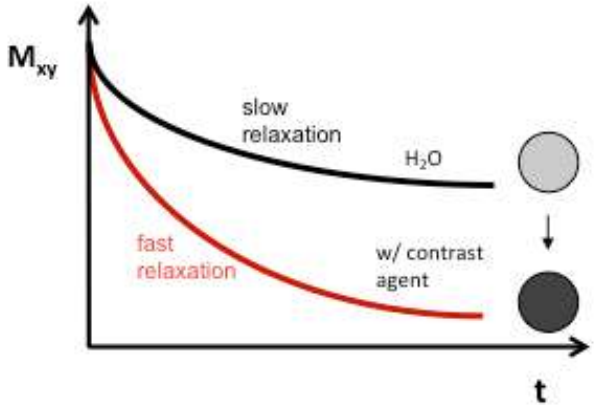
ω_0:Larmor frequency
γ: gyromagnetic ratio
B_0:Magnetic field



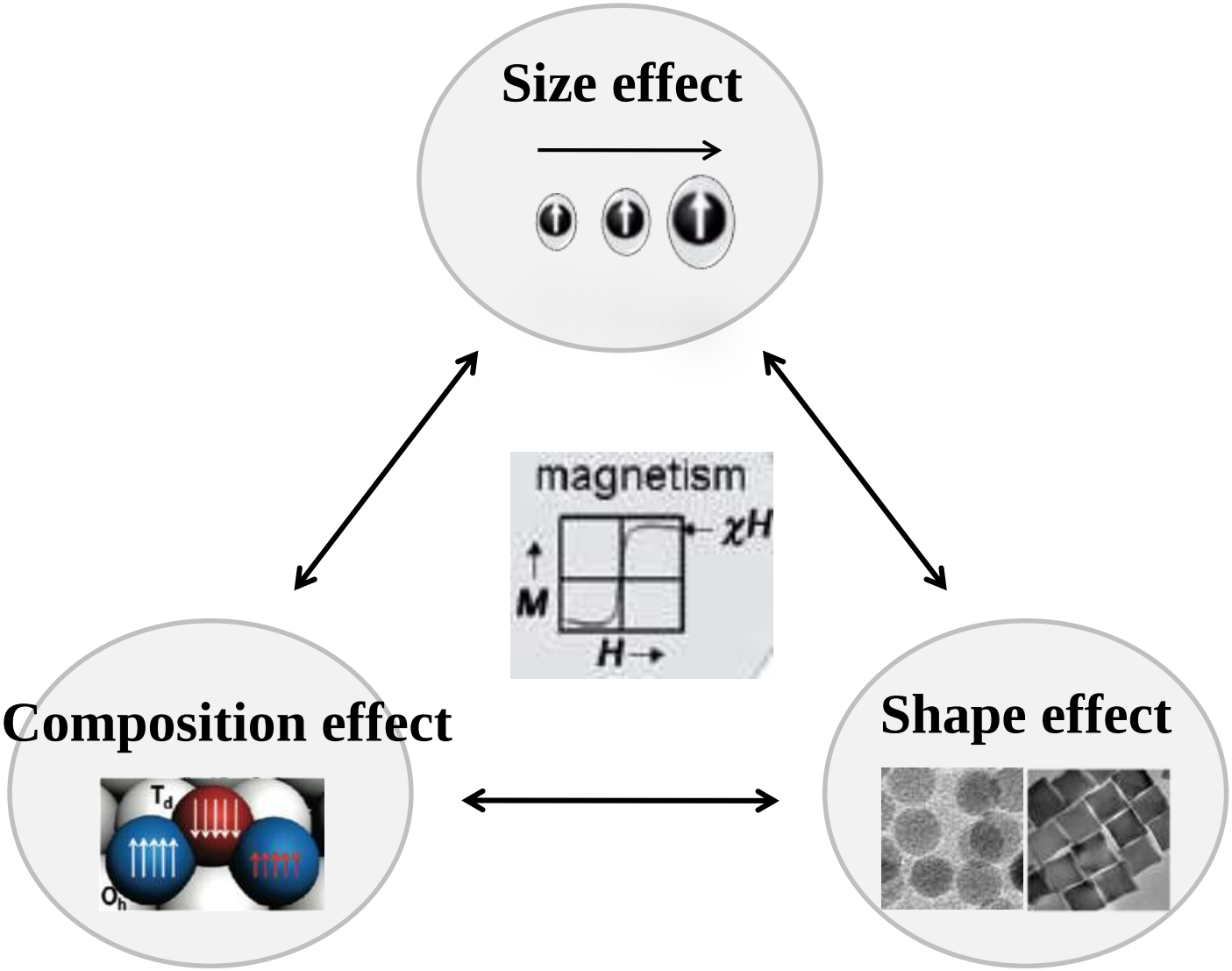
T2 mode





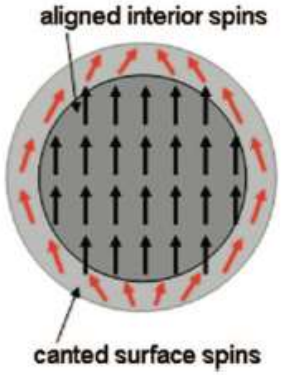


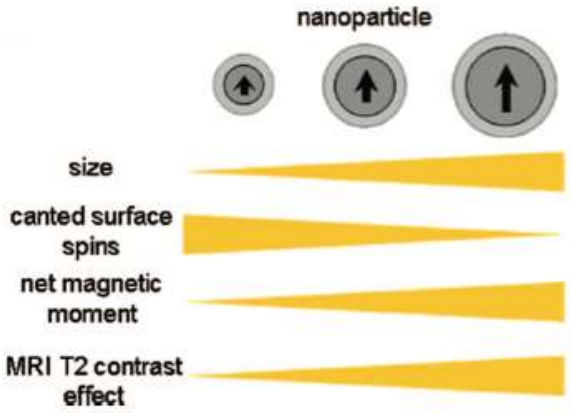
Size, shape, and composition effect on M_s of Nanoparticles

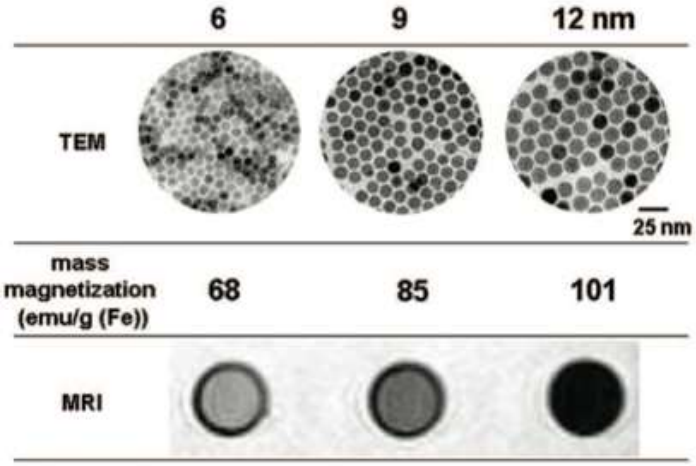


Size, shape, and composition effect on M_s of Nanoparticles

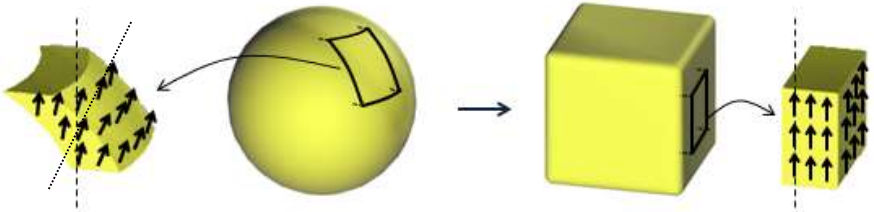
Size effect





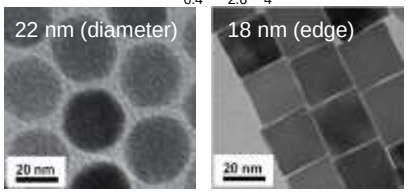


Shape effect

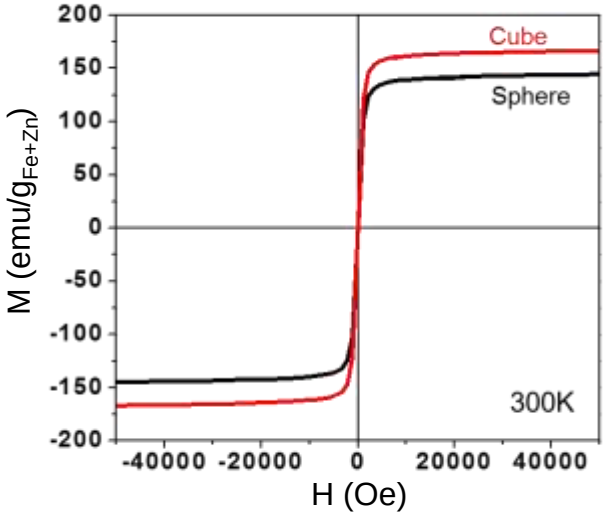


sphere nanoparticle **cube nanoparticle**

$Zn_{0.4}Fe_{2.6}O_4$



same magnetic atoms (Fe): 2.3×10^5 atoms

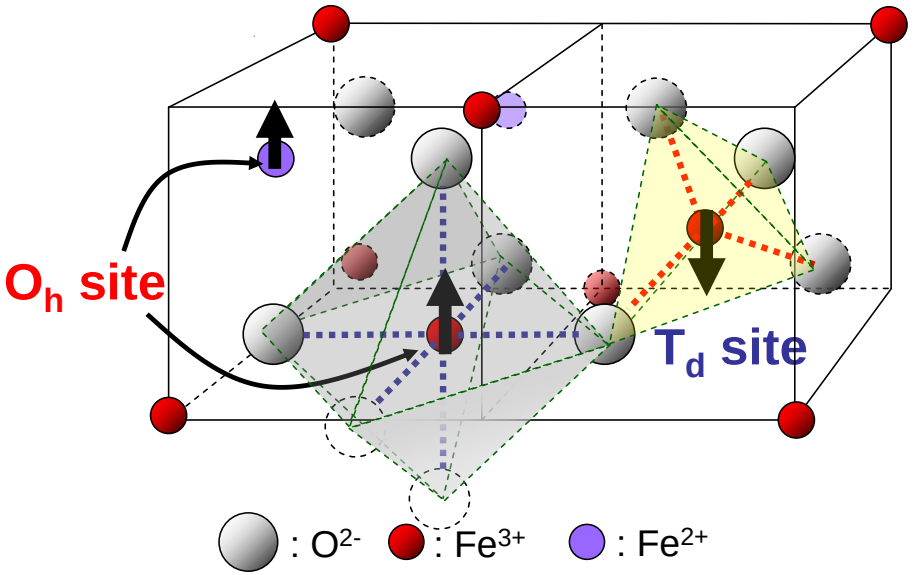


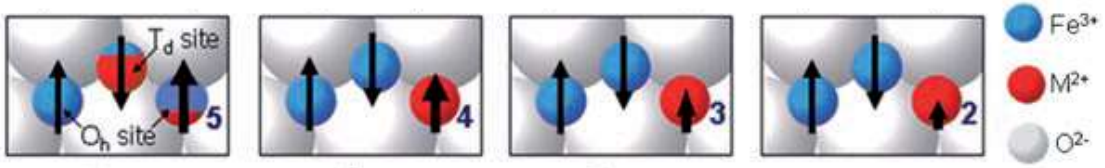
165

145

Size, shape, and composition effect on M_s of Nanoparticles

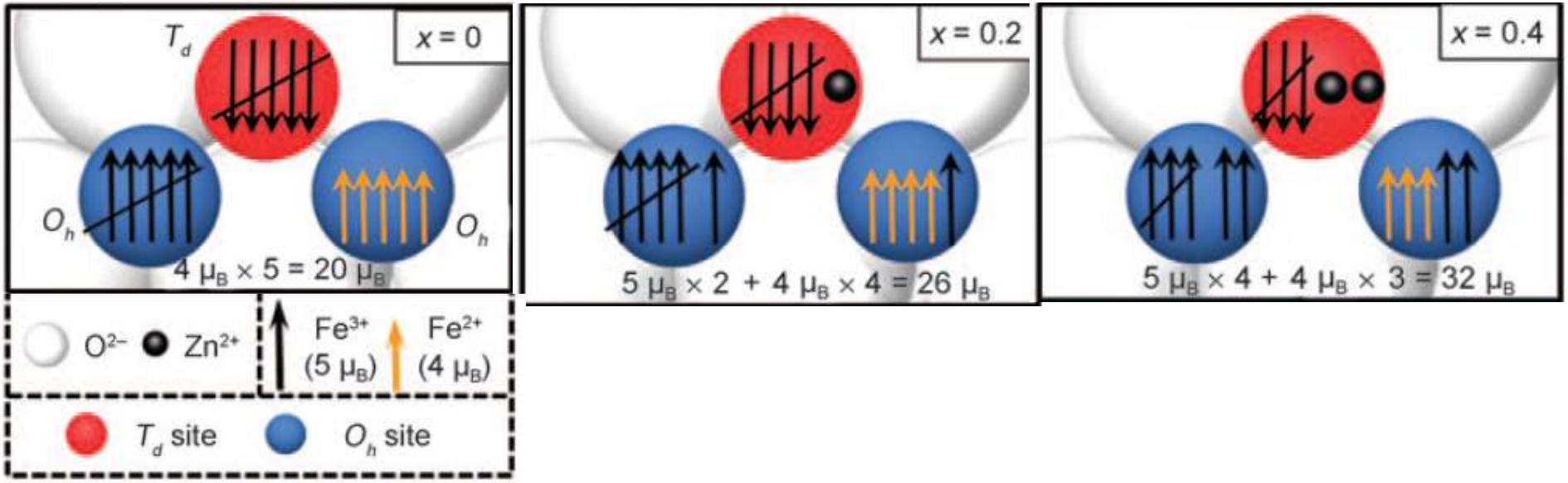
Compositon effect

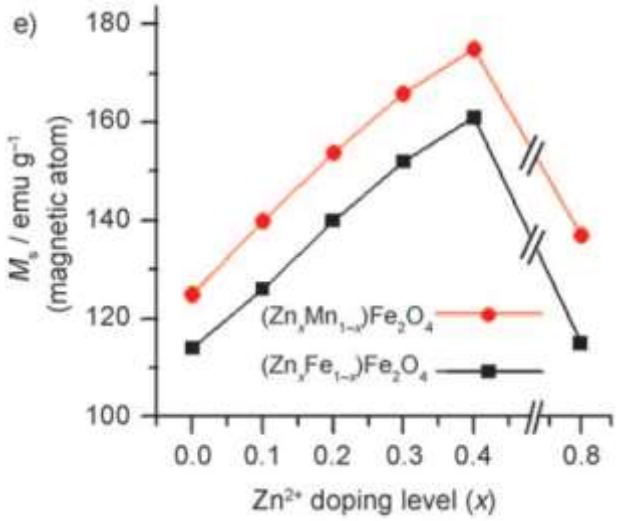


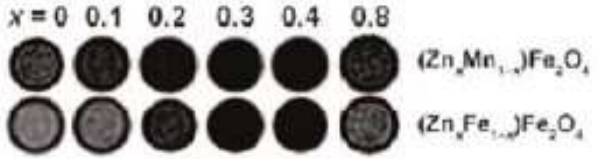
	$MnFe_2O_4$	$FeFe_2O_4$	$CoFe_2O_4$	$NiFe_2O_4$
magnetic spin structure				
magnetic moment	5 m_B	4 m_B	3 m_B	2 m_B
mass magnetization (emu/g)	110	101	99	85
MRI T2 relaxivity ($mM^{-1}s^{-1}$)				
	358	218	172	152

Size, shape, and composition effect on M_s of Nanoparticles

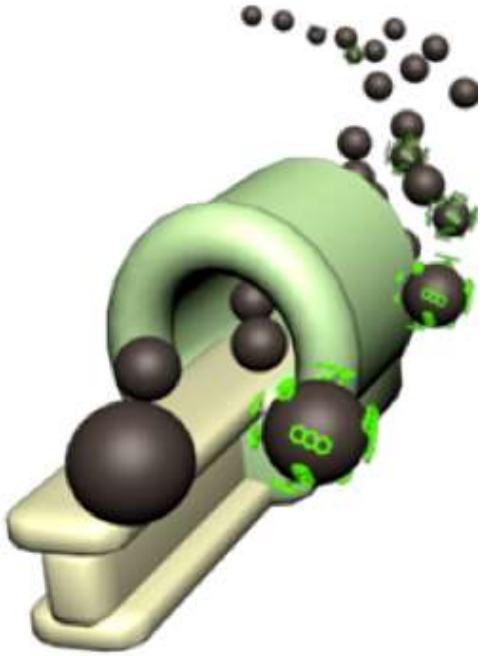
Compositon effect



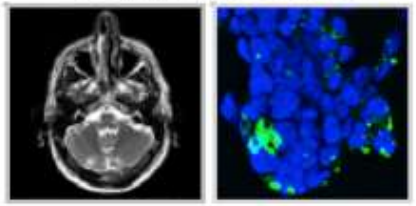


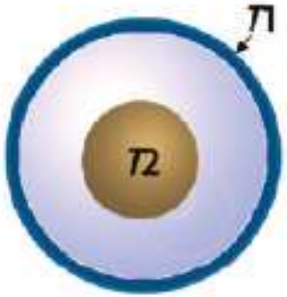


Recent studies of iron oxide nanoparticles for T2 mri contrast agent

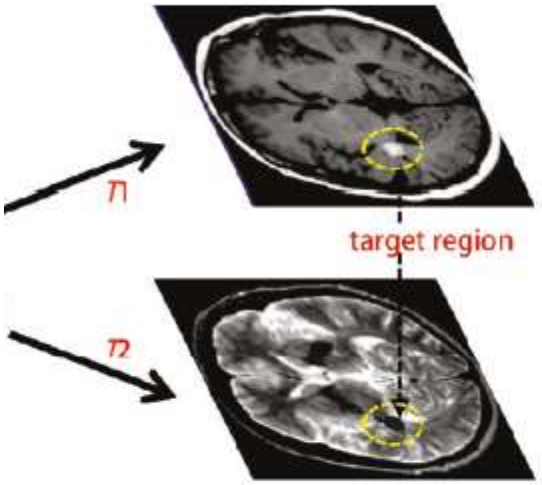


Imaging
- MRI
- Fluorescence



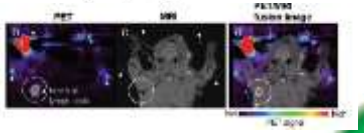


core-shell structure

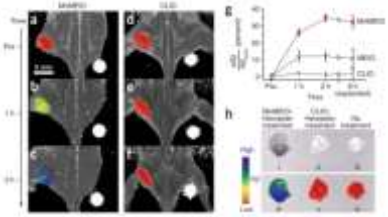


- self confirmation
- high accuracy

radionuclide
- positron emission tomography (PET) tracer (^{18}F, ^{11}C)



targeting moiety
- antibody, peptide, DNA, RNA
- molecular imaging



magnetic nanoparticle
- magnetic resonance imaging (MRI)

optical tag
- visible or near infrared (NIR) fluorescence (optical dye, quantum dots)

Thank You!