SmartState Center for Environmental Nanoscience and Risk

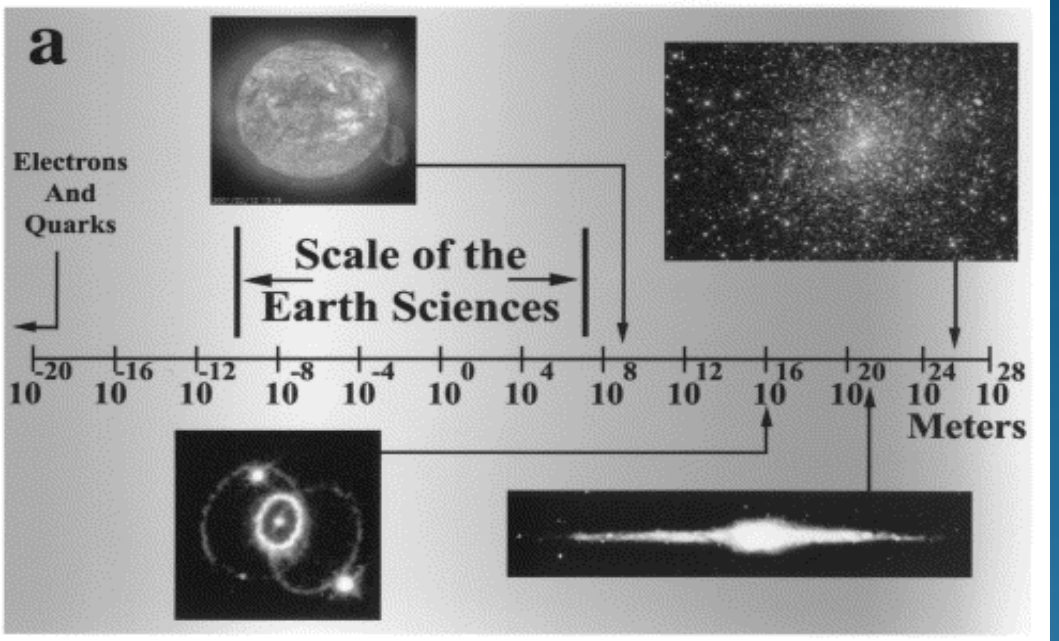
Nanoparticle Fate, Behaviour and Transformations in the Environment

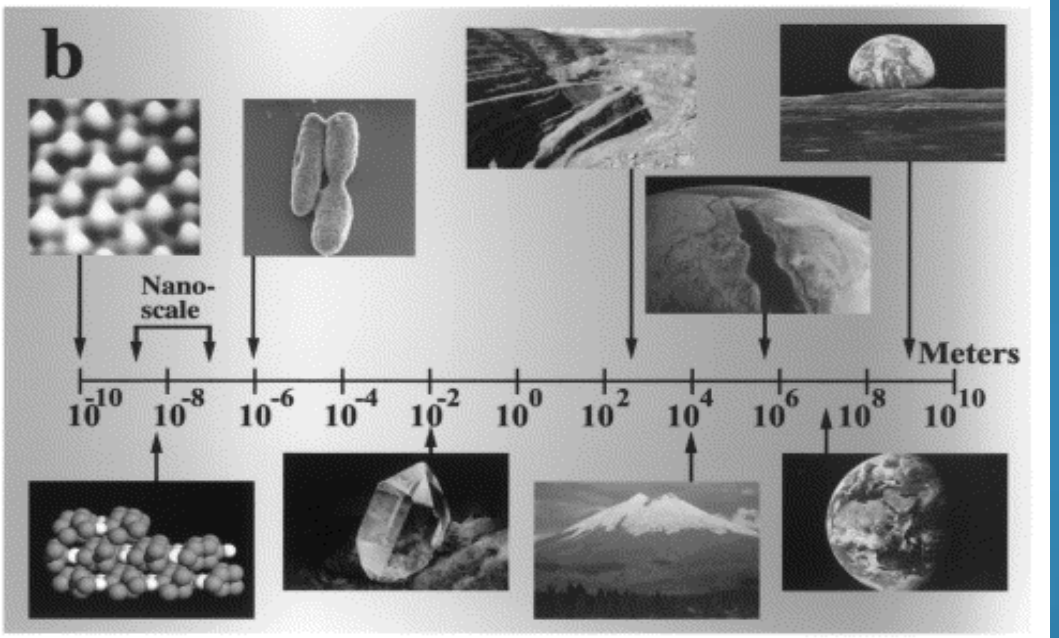
Jamie Lead

I remember when I was at Lilliput, the complexion of those diminutive people appeared to me the fairest in the world...On the other side, discoursing of the ladies in that Emperor's court, he used to tell me, one had freckles, another too wide a mouth, a third too large a nose, nothing of which I was able to distinguish. I confess this reflection was obvious enough.

Travels into Several Remote Nations of the World, in Four Parts. By Lemuel Gulliver, First a Surgeon, and then a Captain of several Ships

Gulliver's Travels, Jonathan Swift

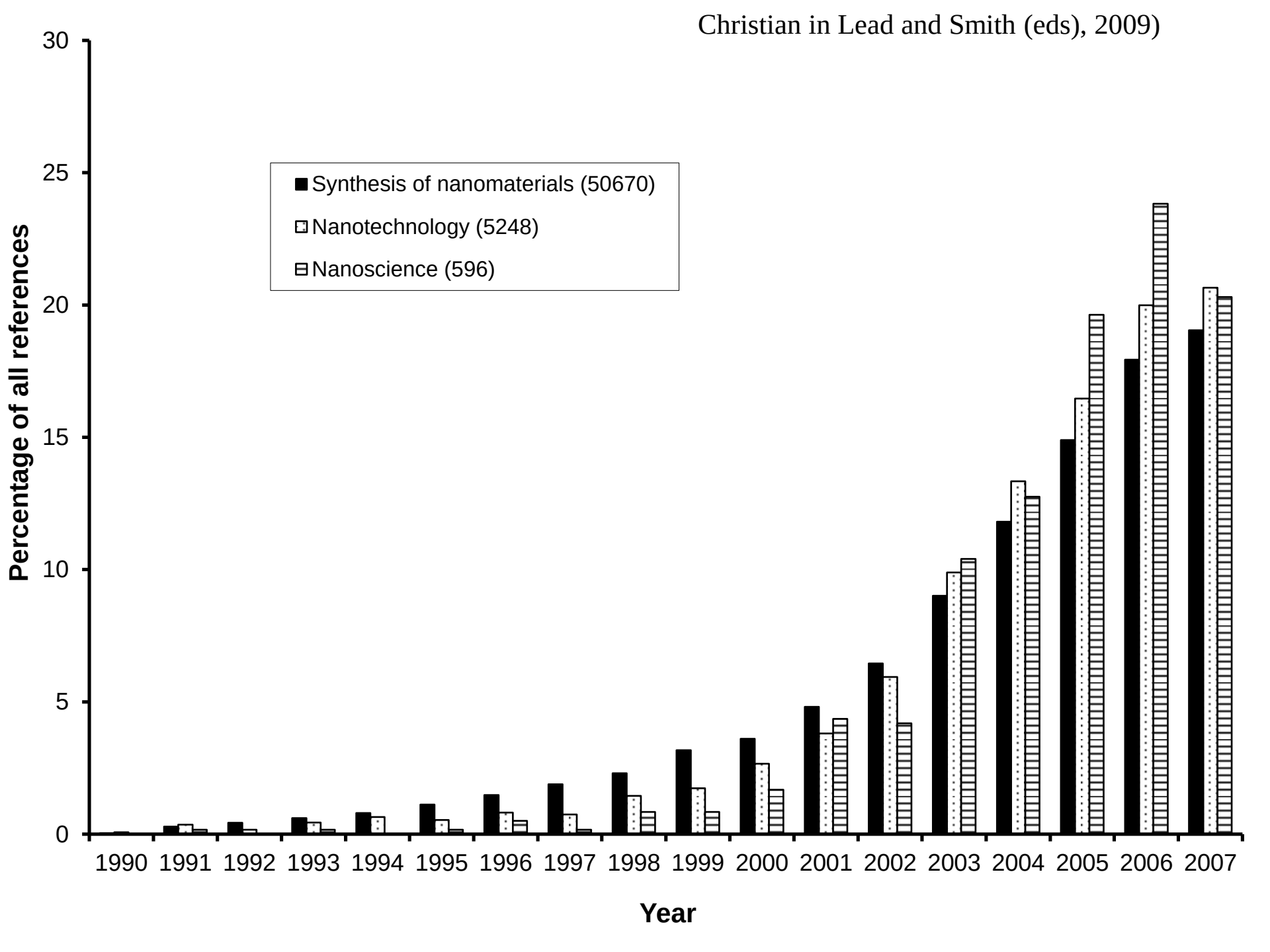




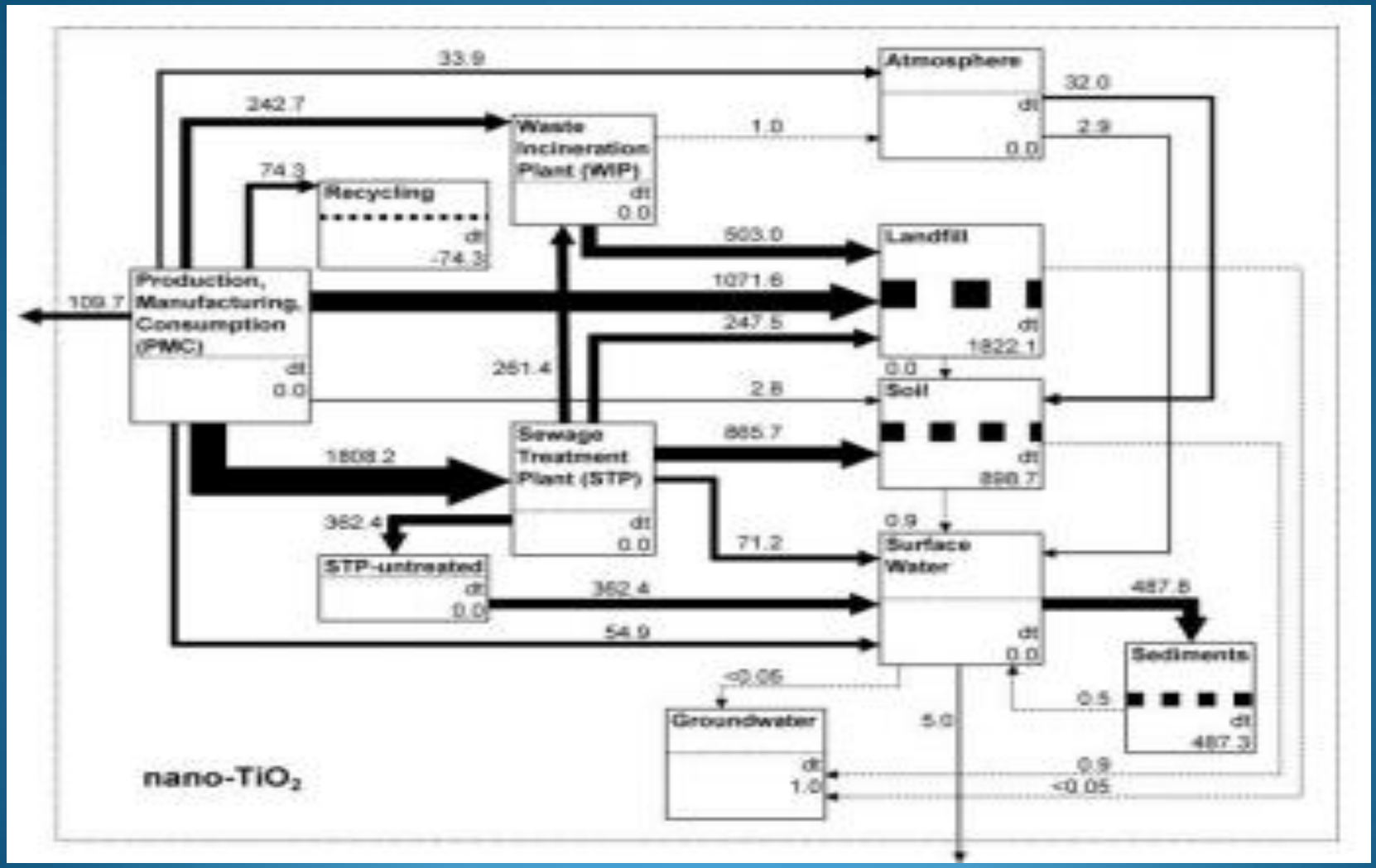
Hochella, 2002

Should we be worried?

Exposure

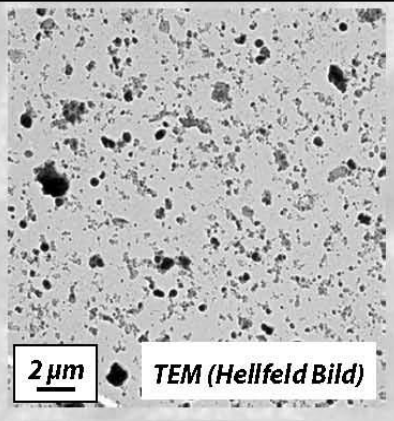

Christian in Lead and Smith (eds), 2009)
Synthesis of nanomaterials (50670)
Nanotechnology (5248)
Nanoscience (596)
Percentage of all references
Year
0
5
10
15
20
25
30
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007

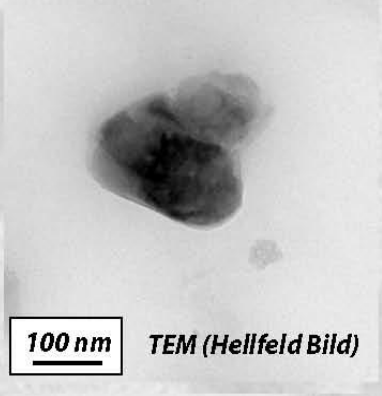
Example ‘exposure model’ for nanoparticles in the environment
Nowack group, EMPA Switzerland.

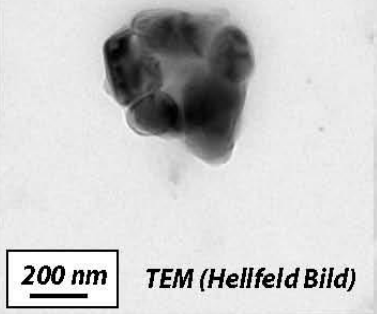


Siedlungsentwässerung

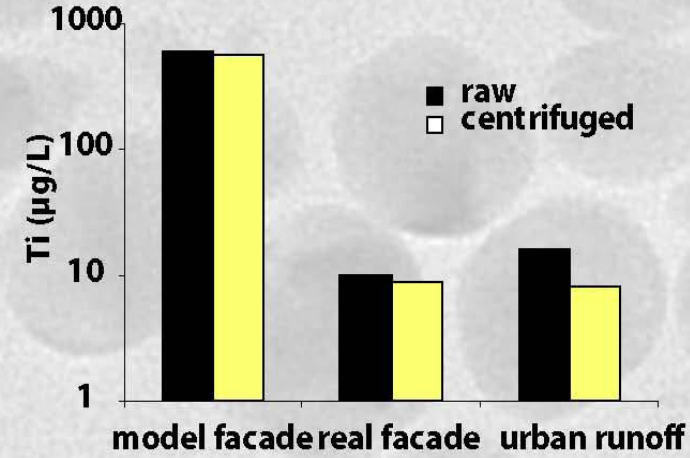
Partikel im 'Siedlungswasser'

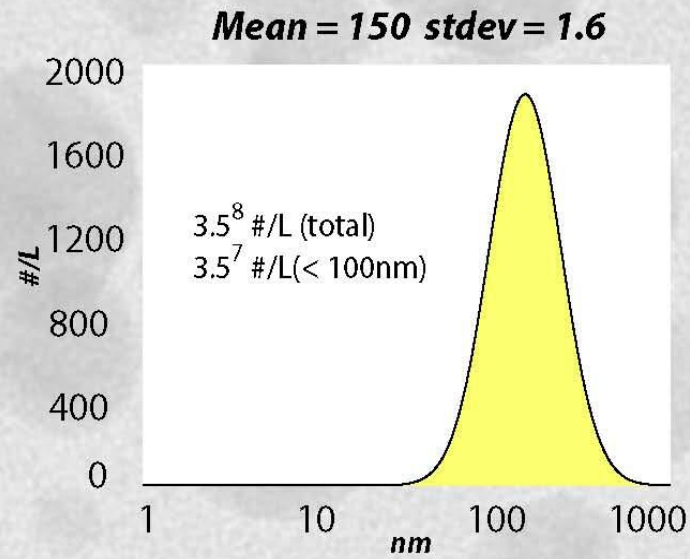




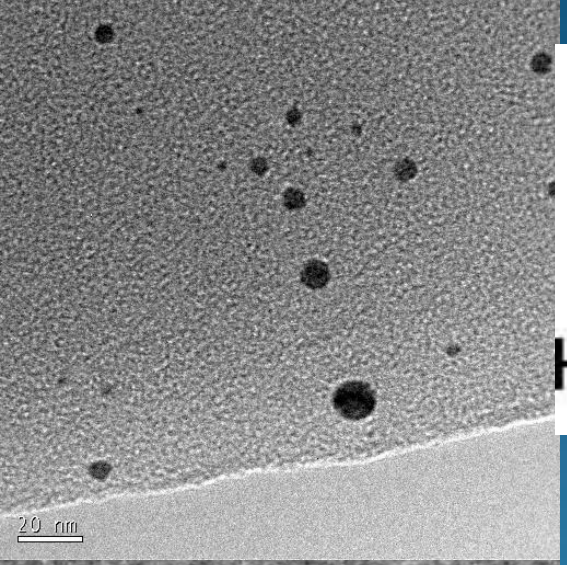


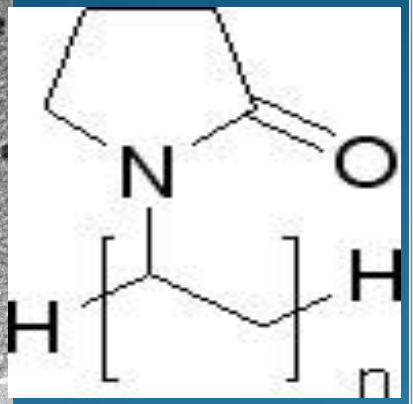
Partikelkonzentrationen

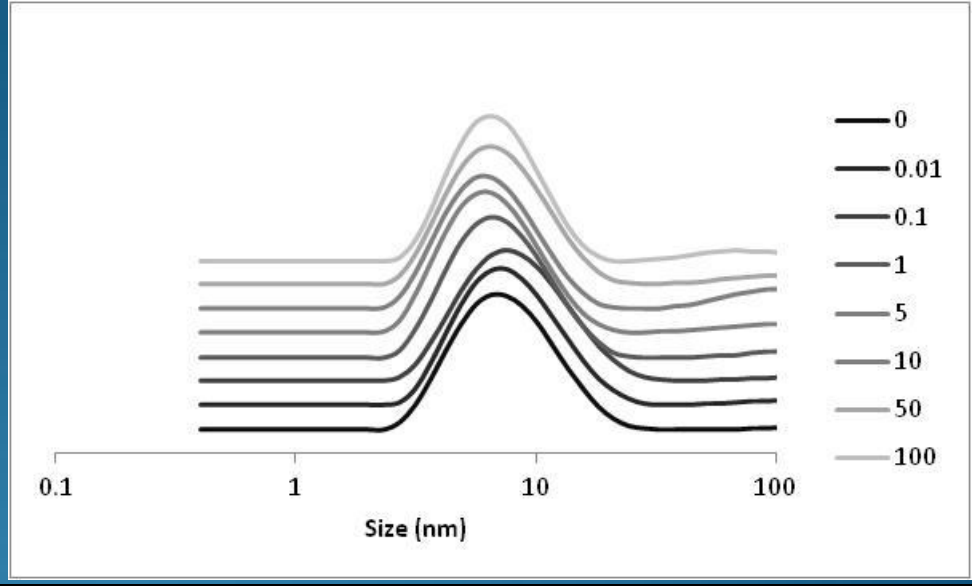


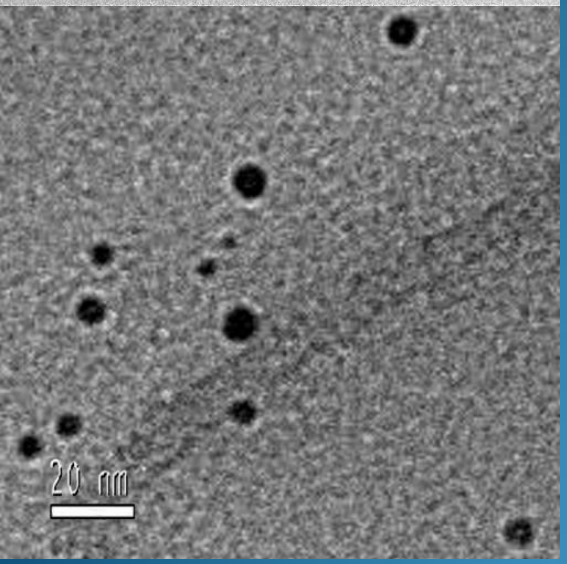


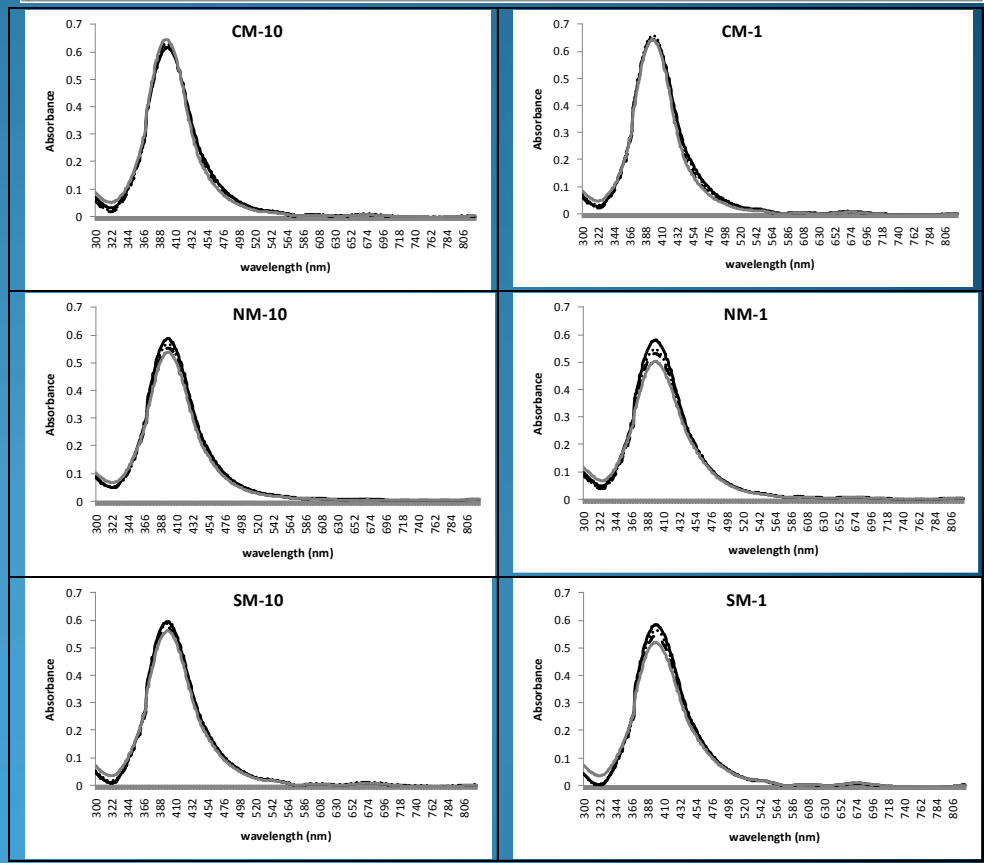
Kaegi et al, 2009



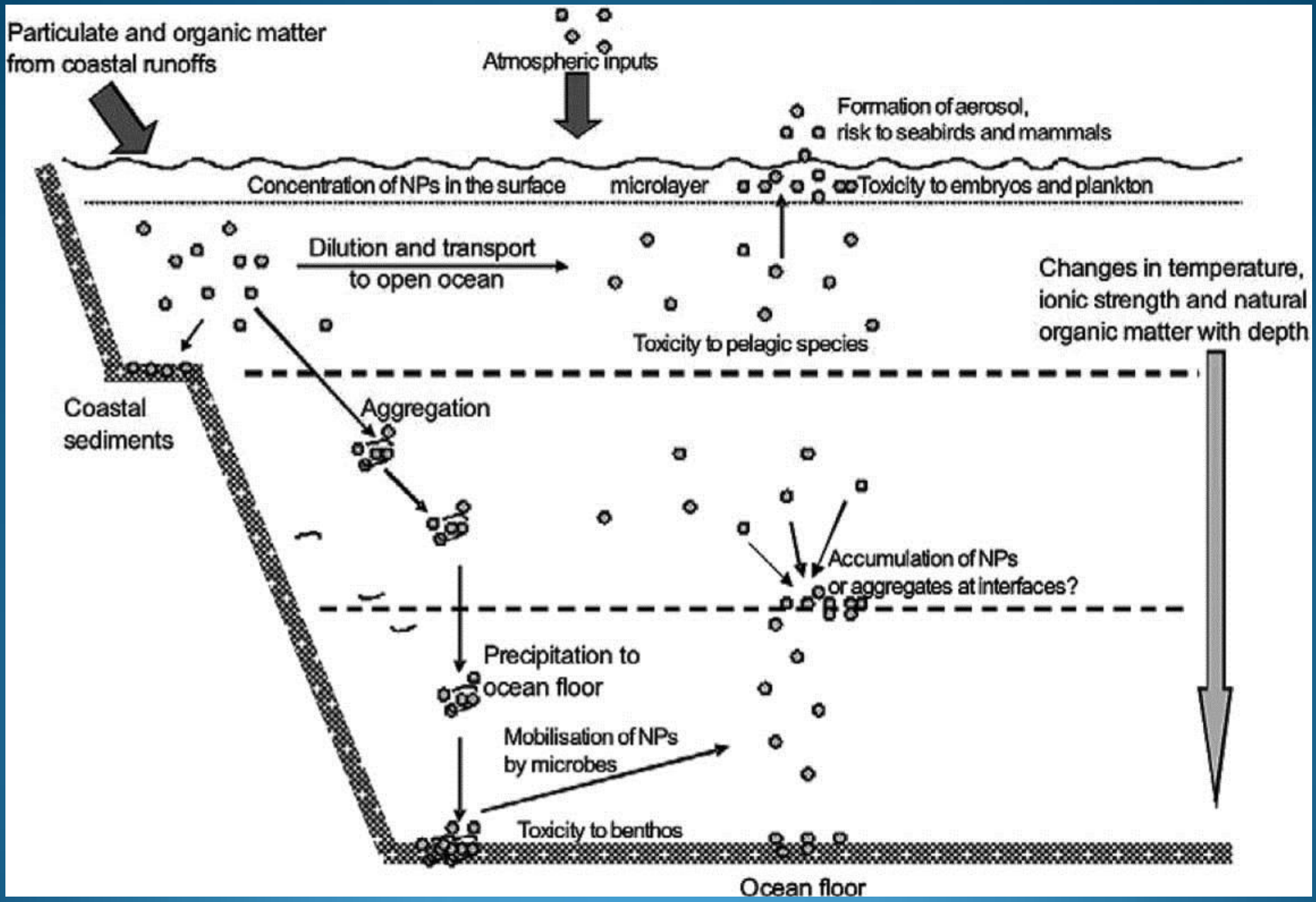








PVP coated gold, ceria and silver nanoparticles – media effects



Possible NP transport in marine environment, Klaine, Lead et al 2008

Lowry et al 2012

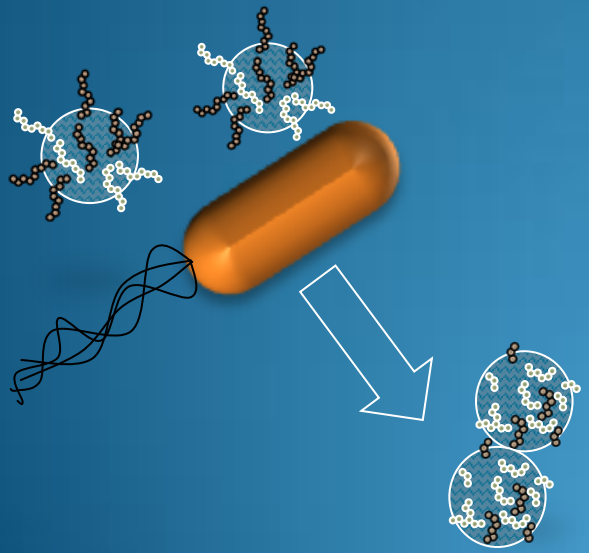
Critical NM Interactions

ENM Inputs

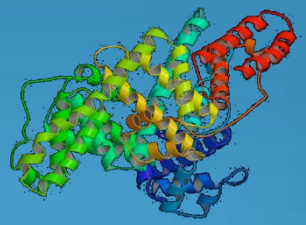
Behaviors

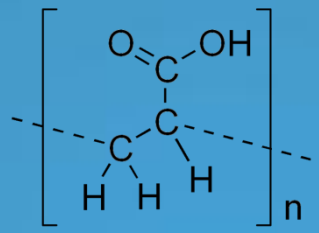
Effects

Biological Transformations

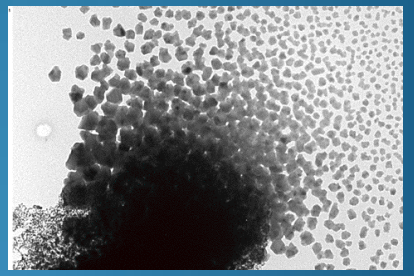


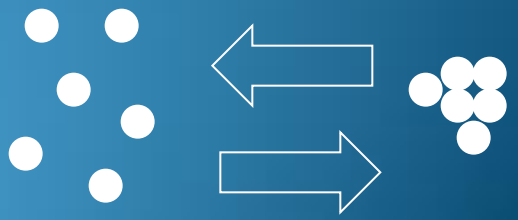
Interactions with Macromolecules





Physical and Chemical Transformations



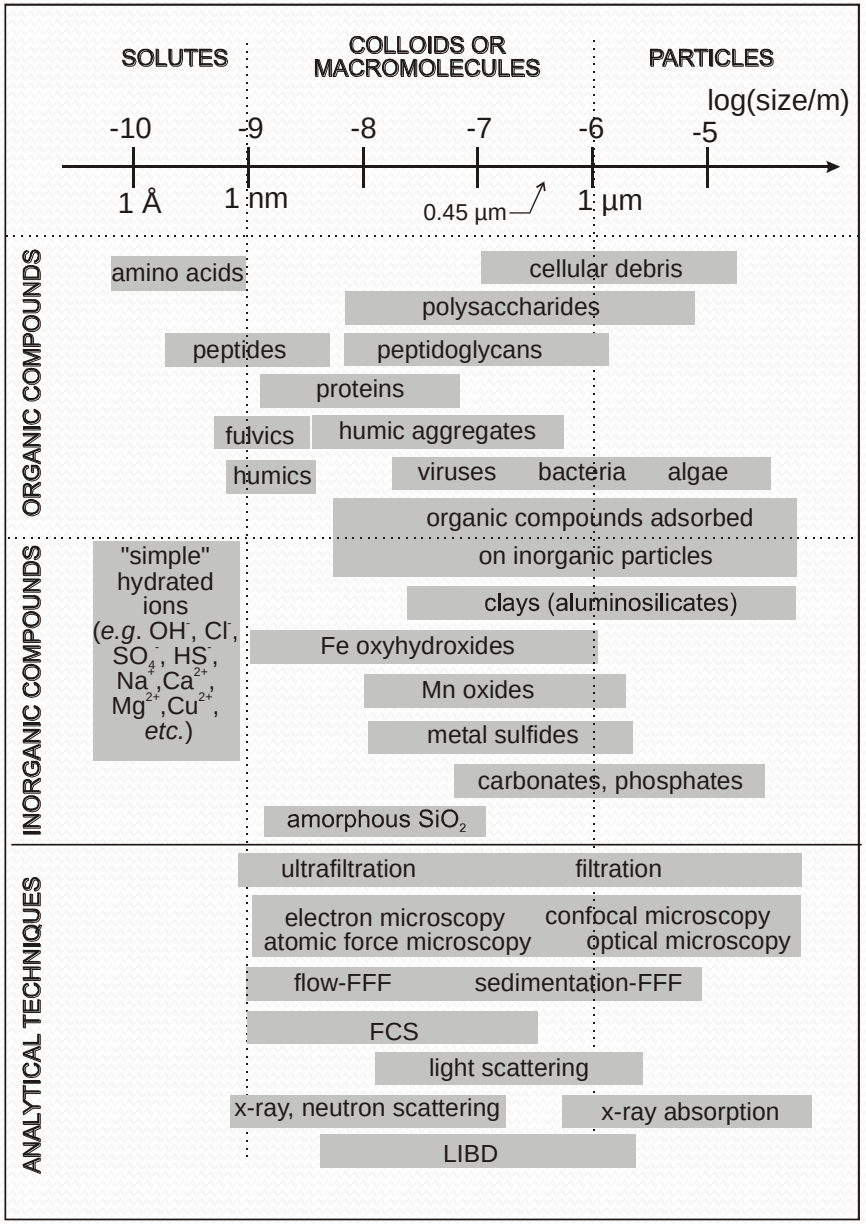


NP chemistry in the environment

Interactions with natural organic macromolecules

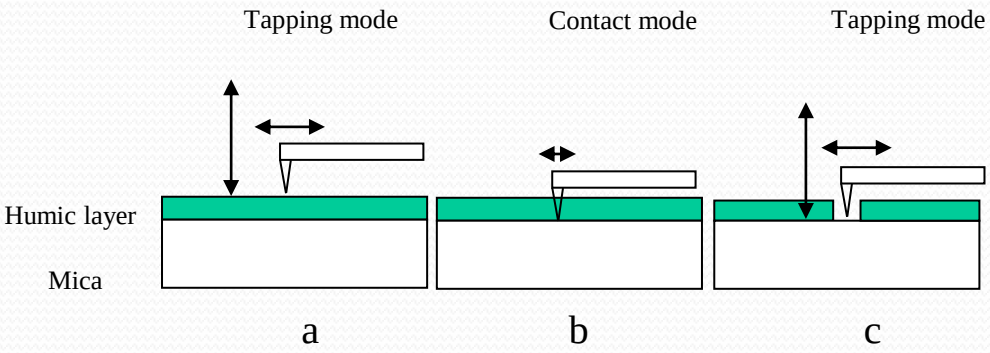
Natural aquatic colloids and nanoparticles

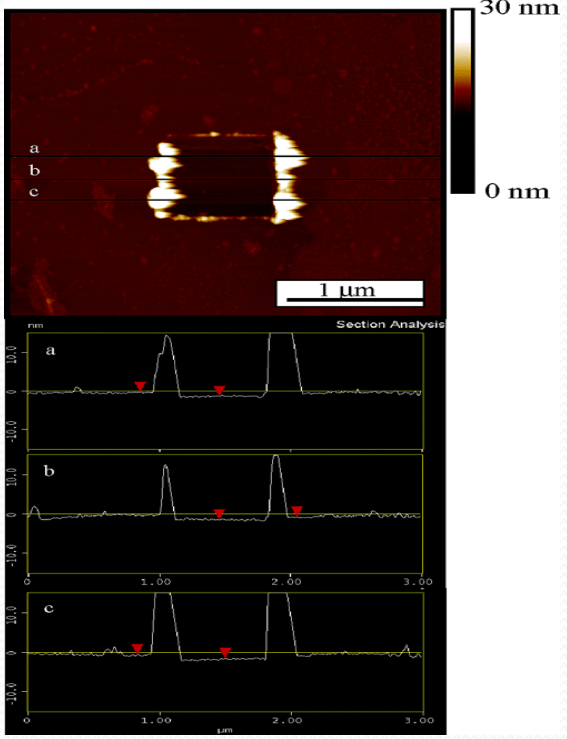
- 1 nm – 1 μm (NPs, 1-100 nm).
- Naturally produced, weathering, hydrolysis, microbial action etc.
- Complex, polydisperse, spatially and temporally variable.
- Present at 0.1-100 mg L^{-1} levels (cf MNPs at 0.1-100 μg L^{-1} .

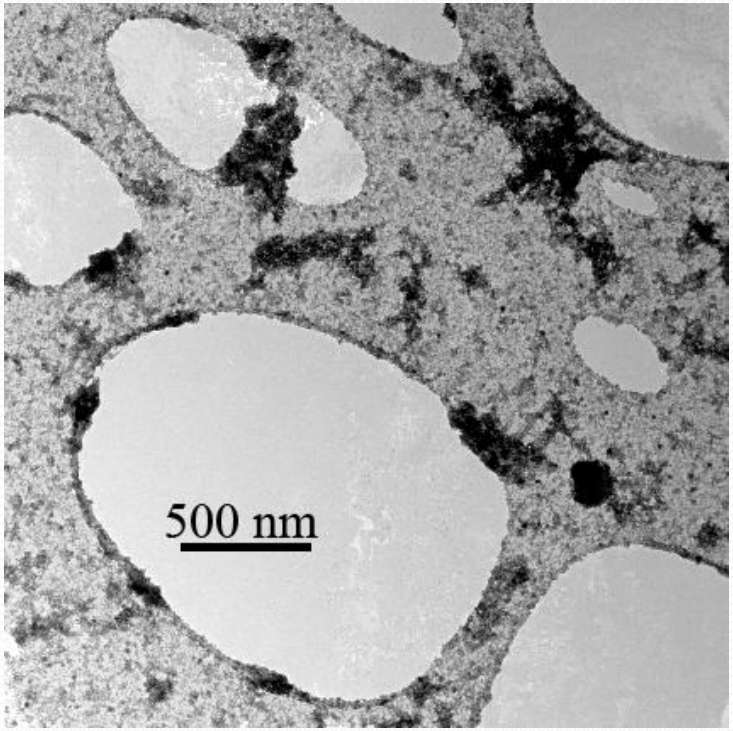


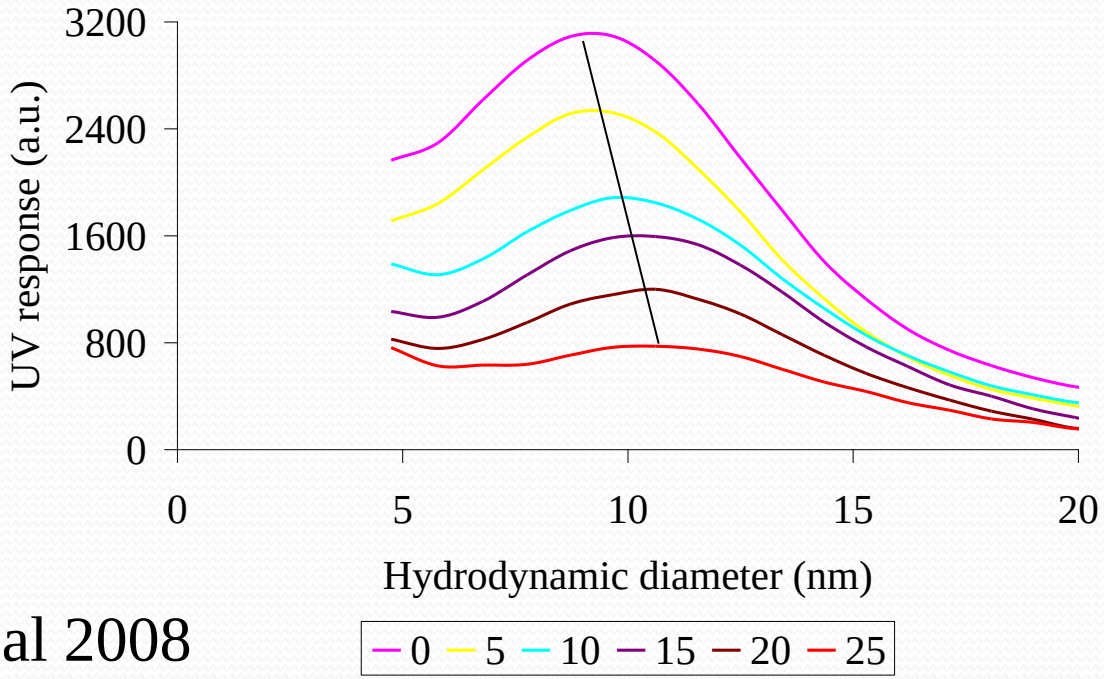
Lead and Wilkinson (2006)

Gibson et al, 2007





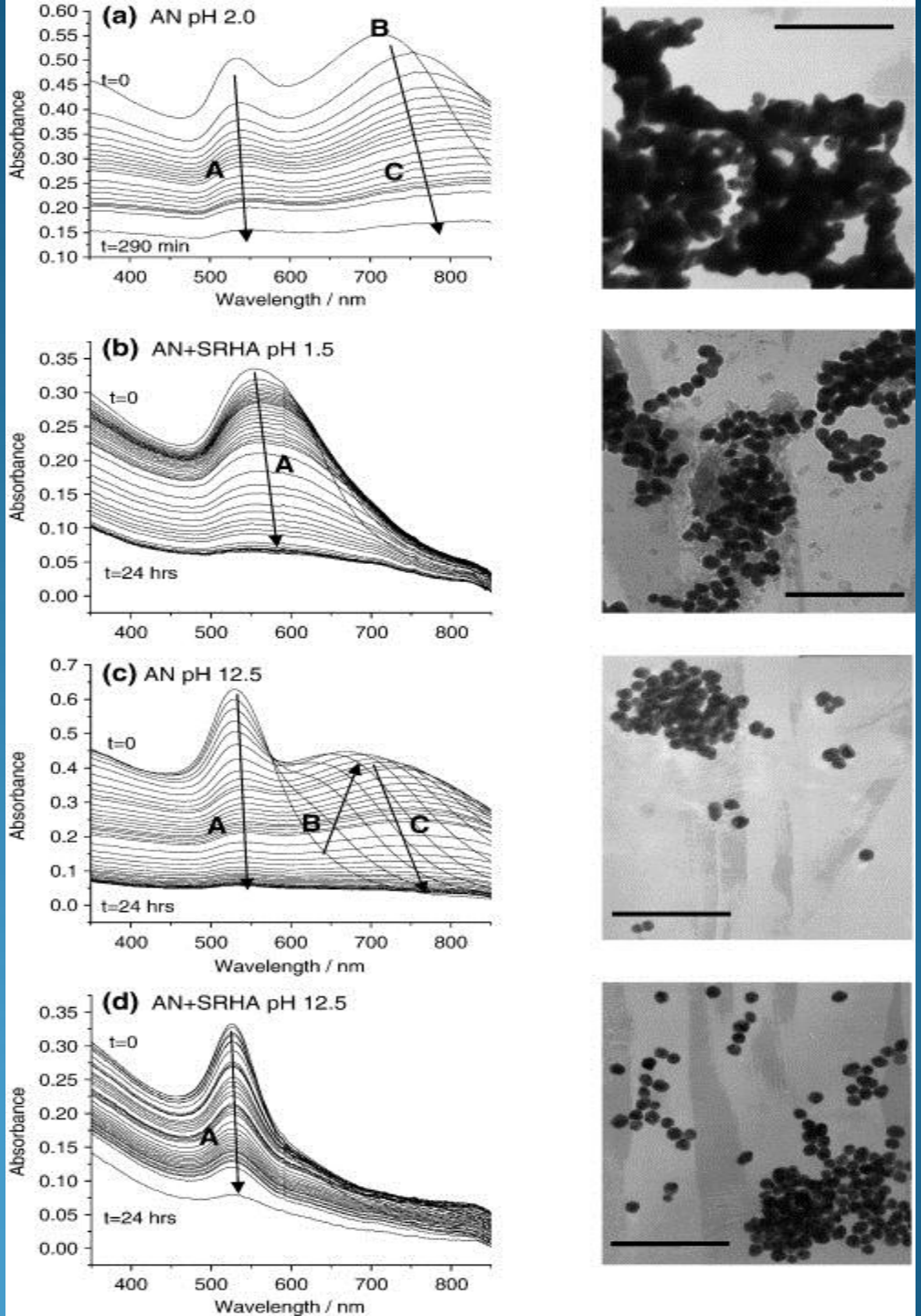


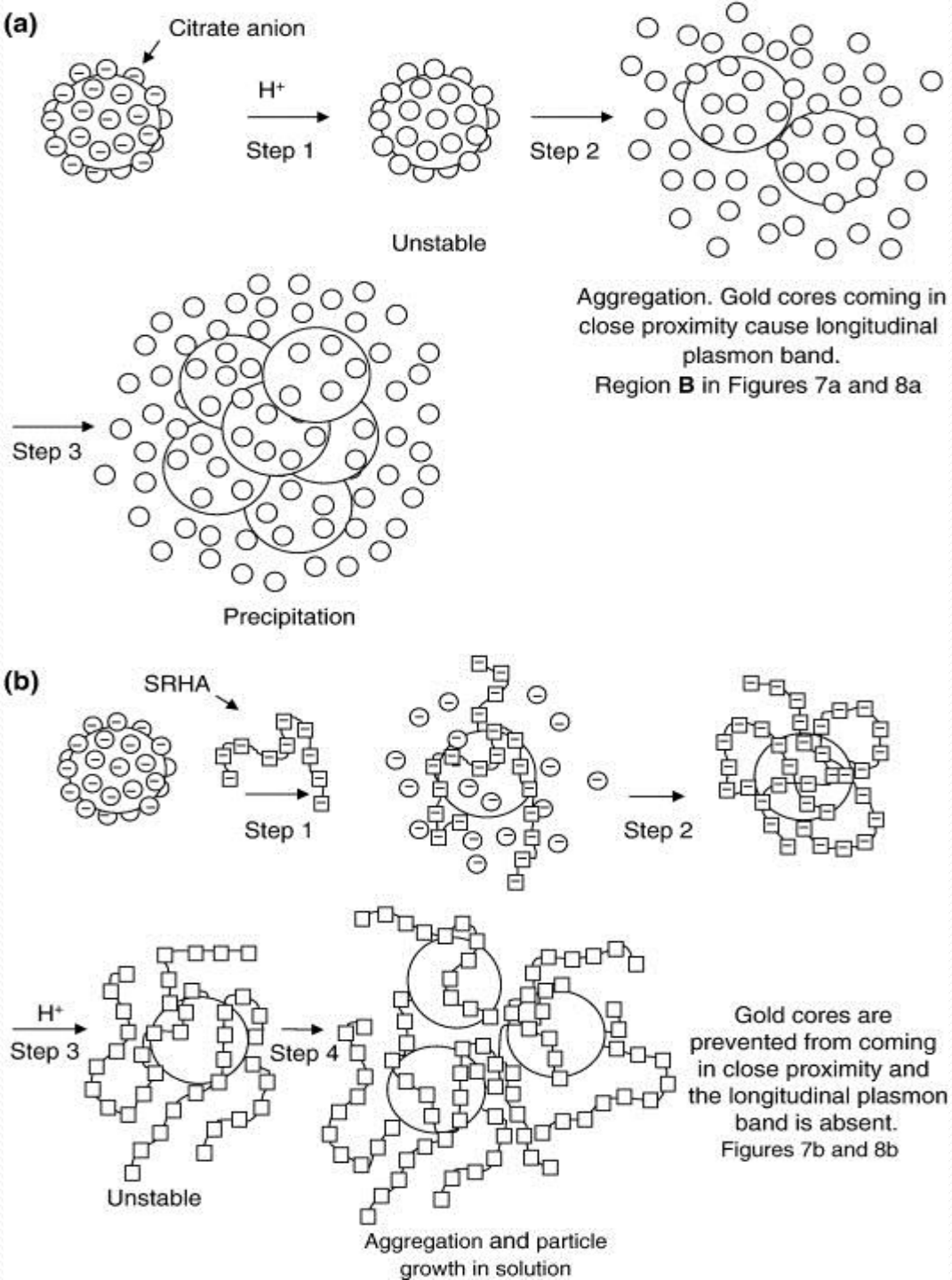


Baalousha et al 2008

- Citrate stabilised gold nanoparticles
- Natural organic matter replaces citrate
- Change in surface plasmon resonance and aggregation

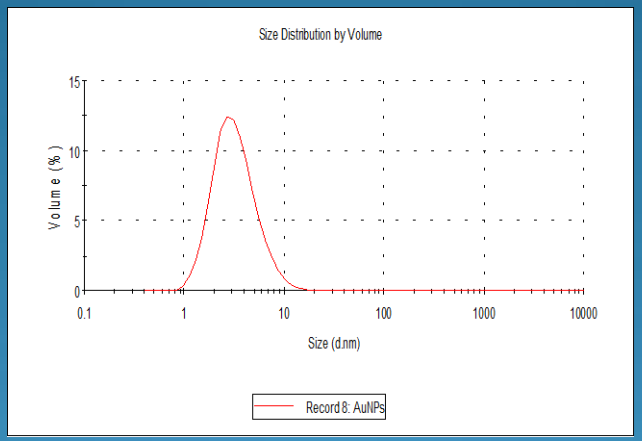
Diegoli et al (2007)

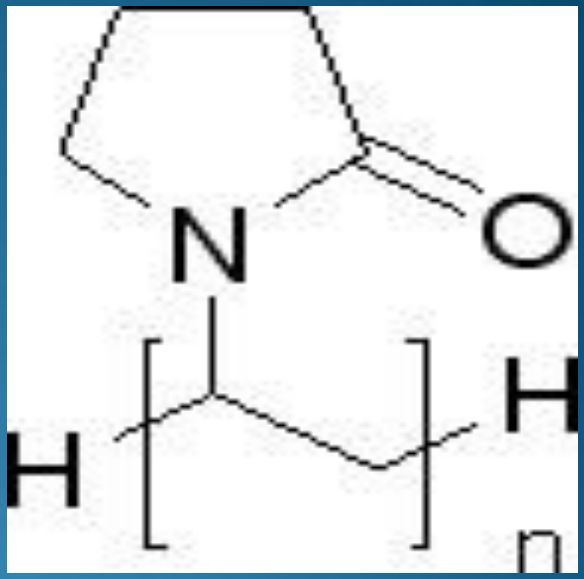


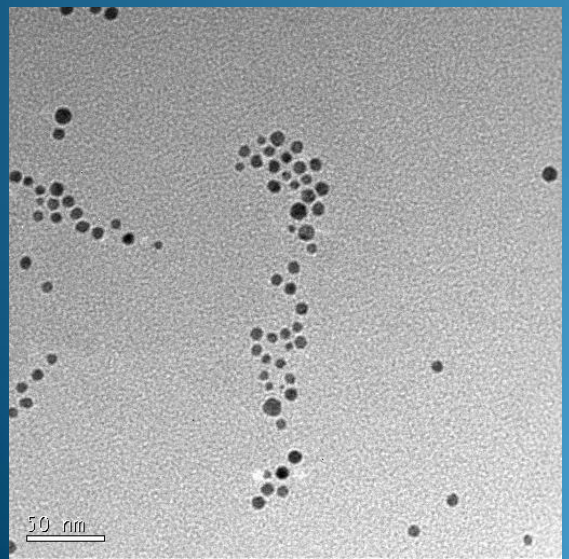

(a)
Citrate anion
H+
Step 1
Unstable
Step 2
Aggregation. Gold cores coming in close proximity cause longitudinal plasmon band.
Region B in Figures 7a and 8a
Step 3
Precipitation
(b)
SRHA
Step 1
Step 2
H+
Step 3
Step 4
Unstable
Aggregation and particle growth in solution
Gold cores are prevented from coming in close proximity and the longitudinal plasmon band is absent.
Figures 7b and 8b

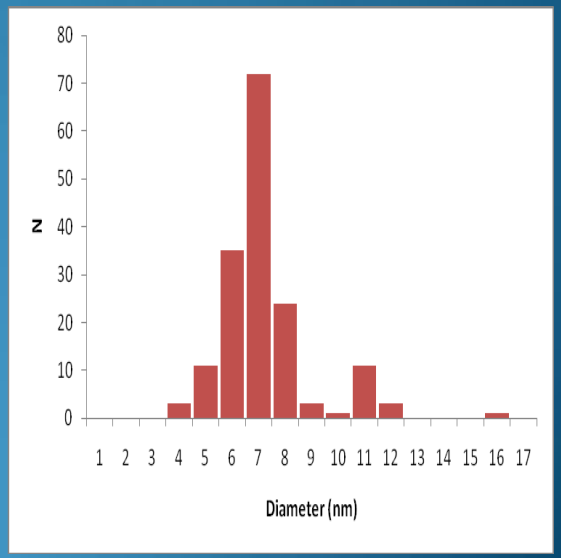
Au Nanoparticles

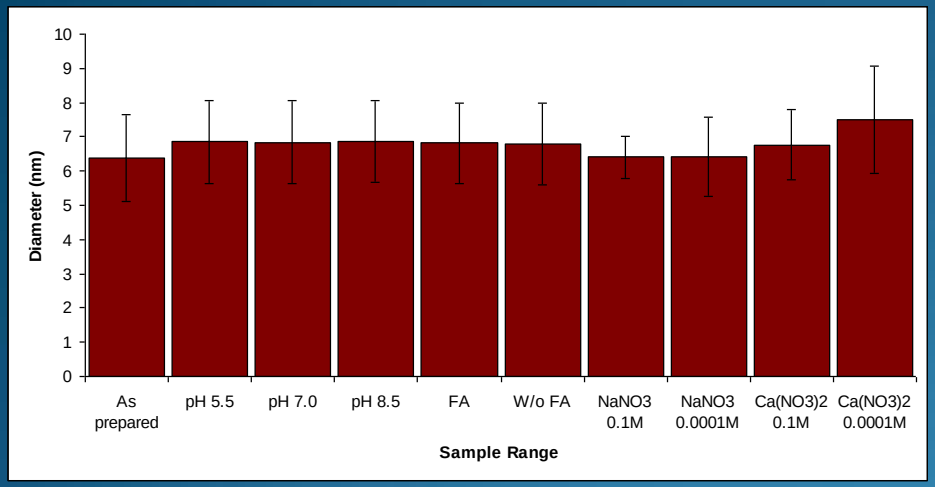
- In house.
- 7 nm, monodisperse
- PVP stabilised

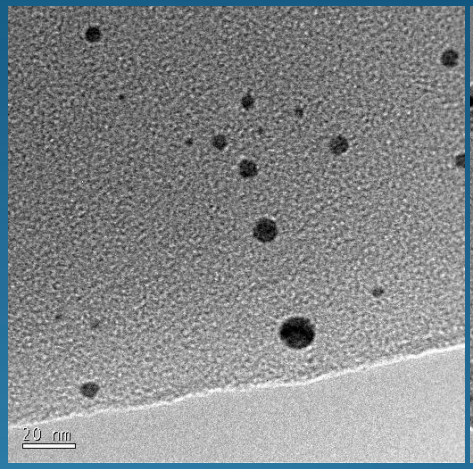


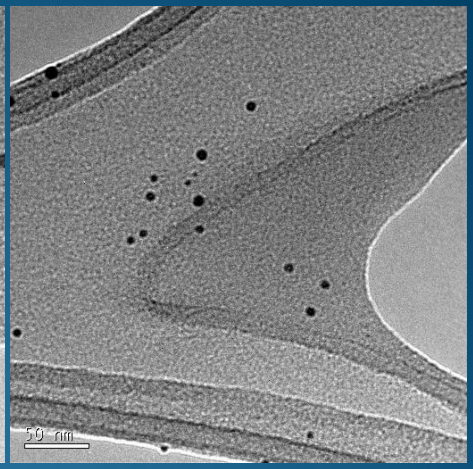




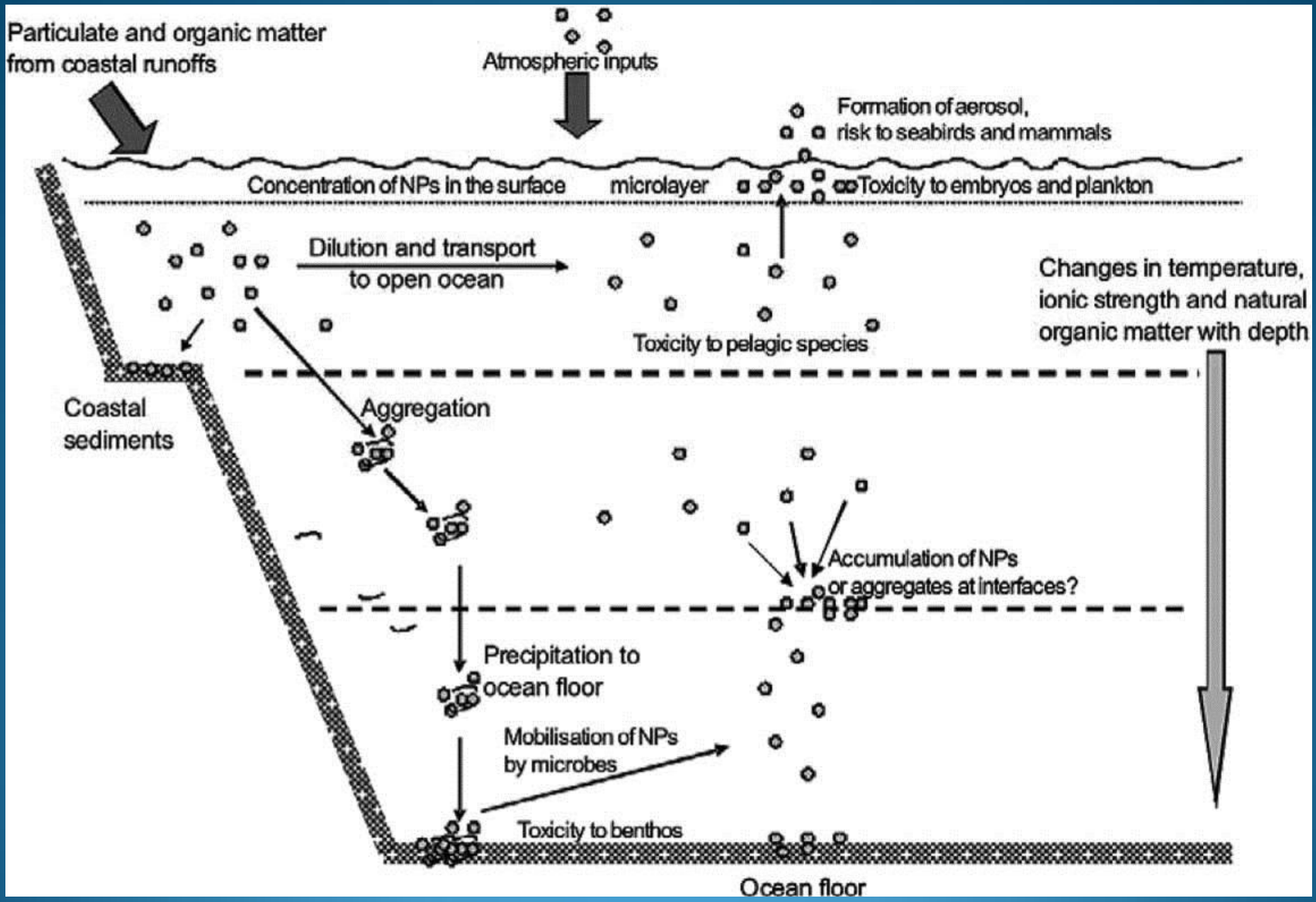








Sample	FFF	DLS
	(nm)	(nm)
As prepared	9.4 ± 0.1	9.3 ± 0.6
0.1 M $NaNO_3$ pH 5.5	9.6 ± 0.1	9.9 ± 0.3
0.1 M $NaNO_3$ pH 5.5 10 mg L^{-1} SRFA	9.6 ± 0.2	9.5 ± 0.3
0.1 M $NaNO_3$ pH 8.5	9.9 ± 0.3	9.2 ± 1.3
0.1 M $NaNO_3$ pH 8.5 10 mg L^{-1} SRFA	9.6 ± 0.1	10.0 ± 1.1



Possible NP transport in marine environment, Klaine, Lead et al 2008