Nanoscience in the Earth and Environmental Sciences Virtual Workshop 2021

Nanomaterial Release in Air/Water/Soil and Potential Impacts on Biota

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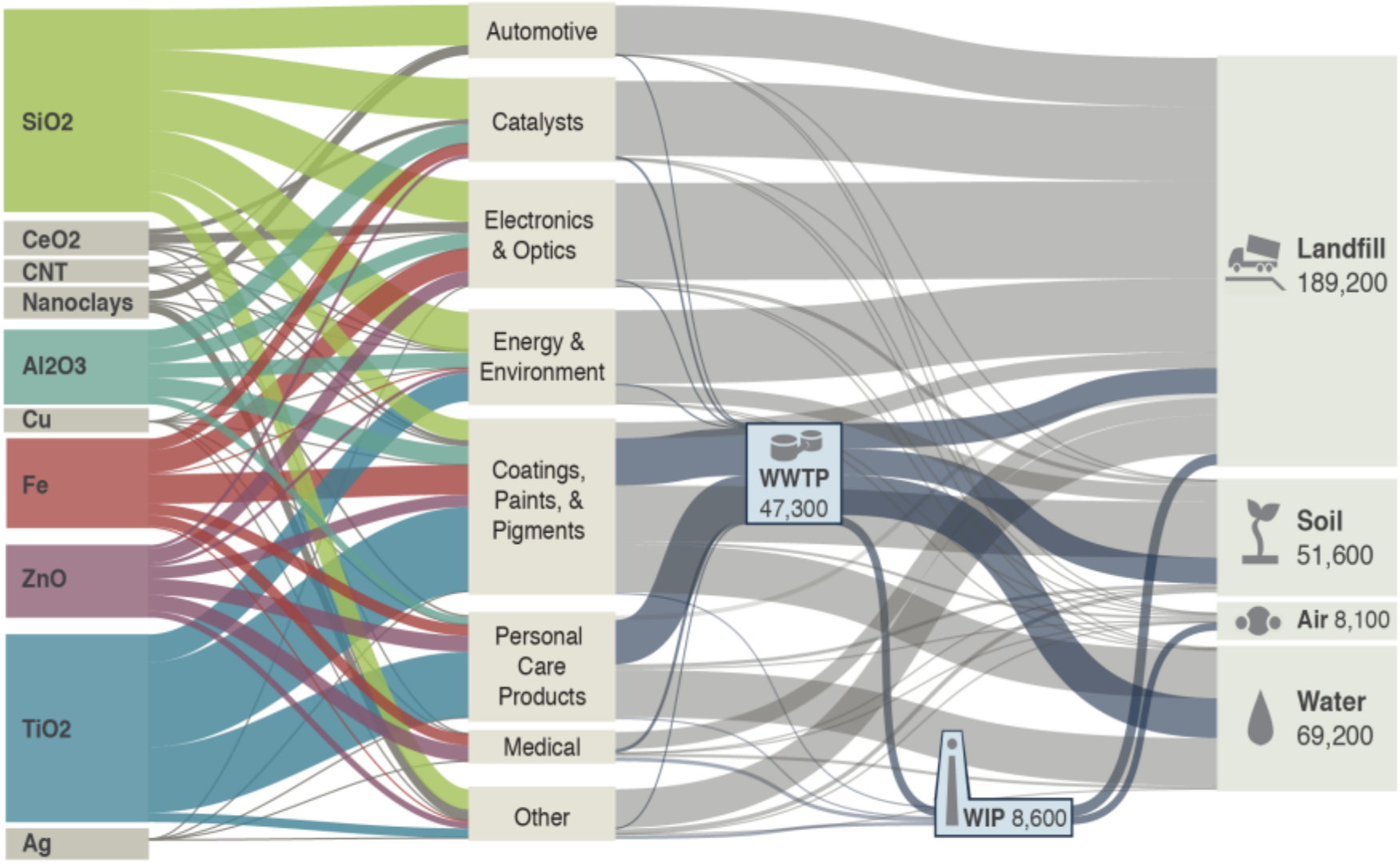
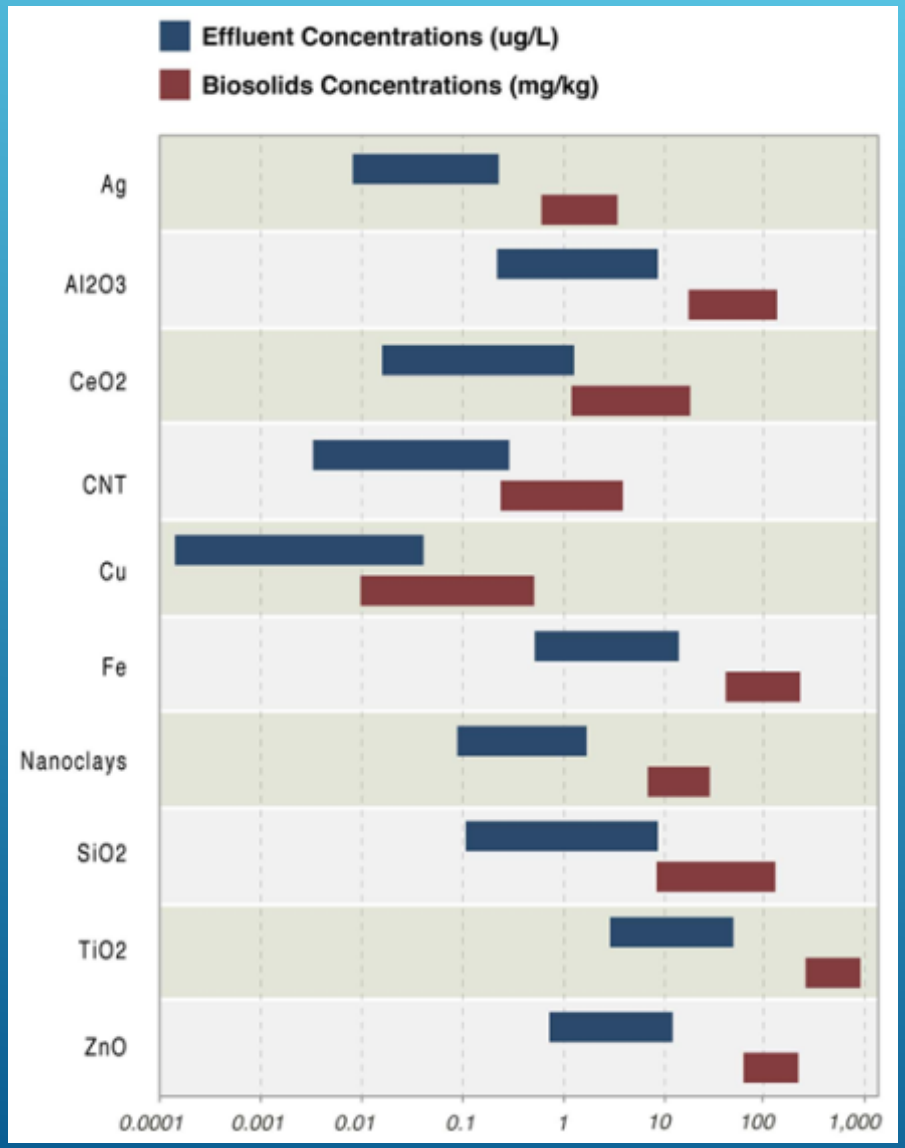
nanoRelease model

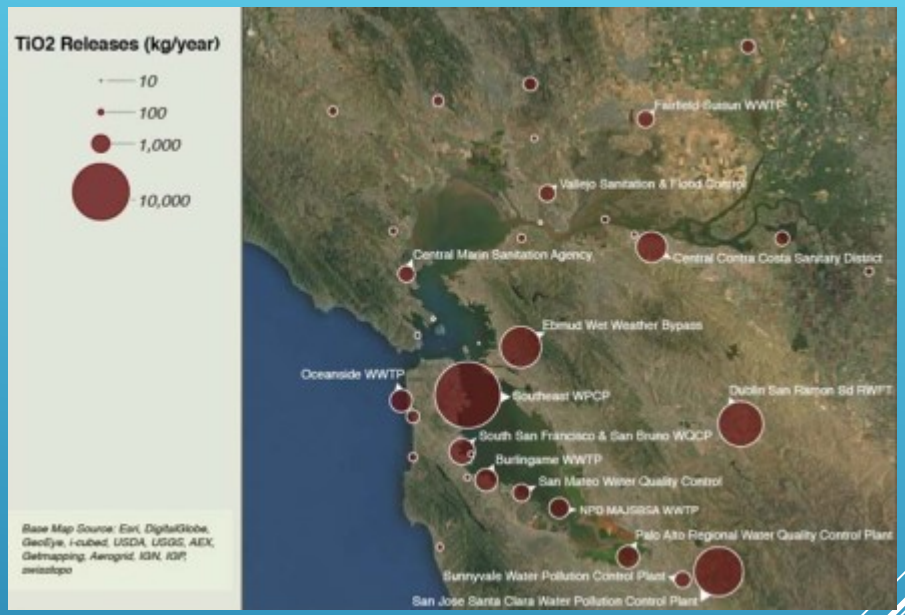


(all flows in metric tons/yr, 2010 estimates from Future Markets, Inc.)

Keller et al., JNR 2013 Keller and Lazareva, ES&TL, 2014

Predicted Initial [ENM]

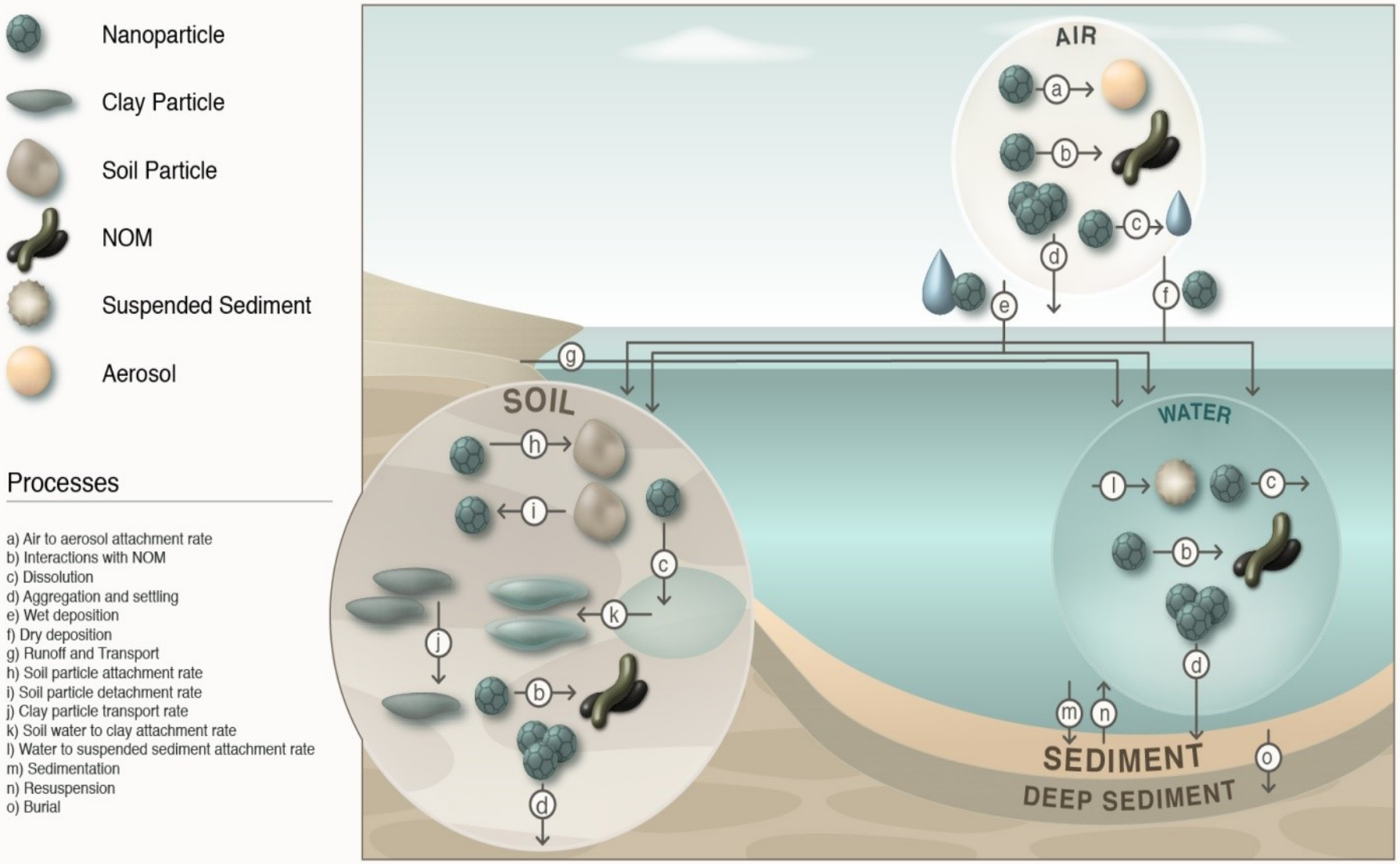




Estimates of ENM concentrations at point of release indicate ng/L to ug/L levels to be expected

Lazareva and Keller, ACS Sus Chem, 2014

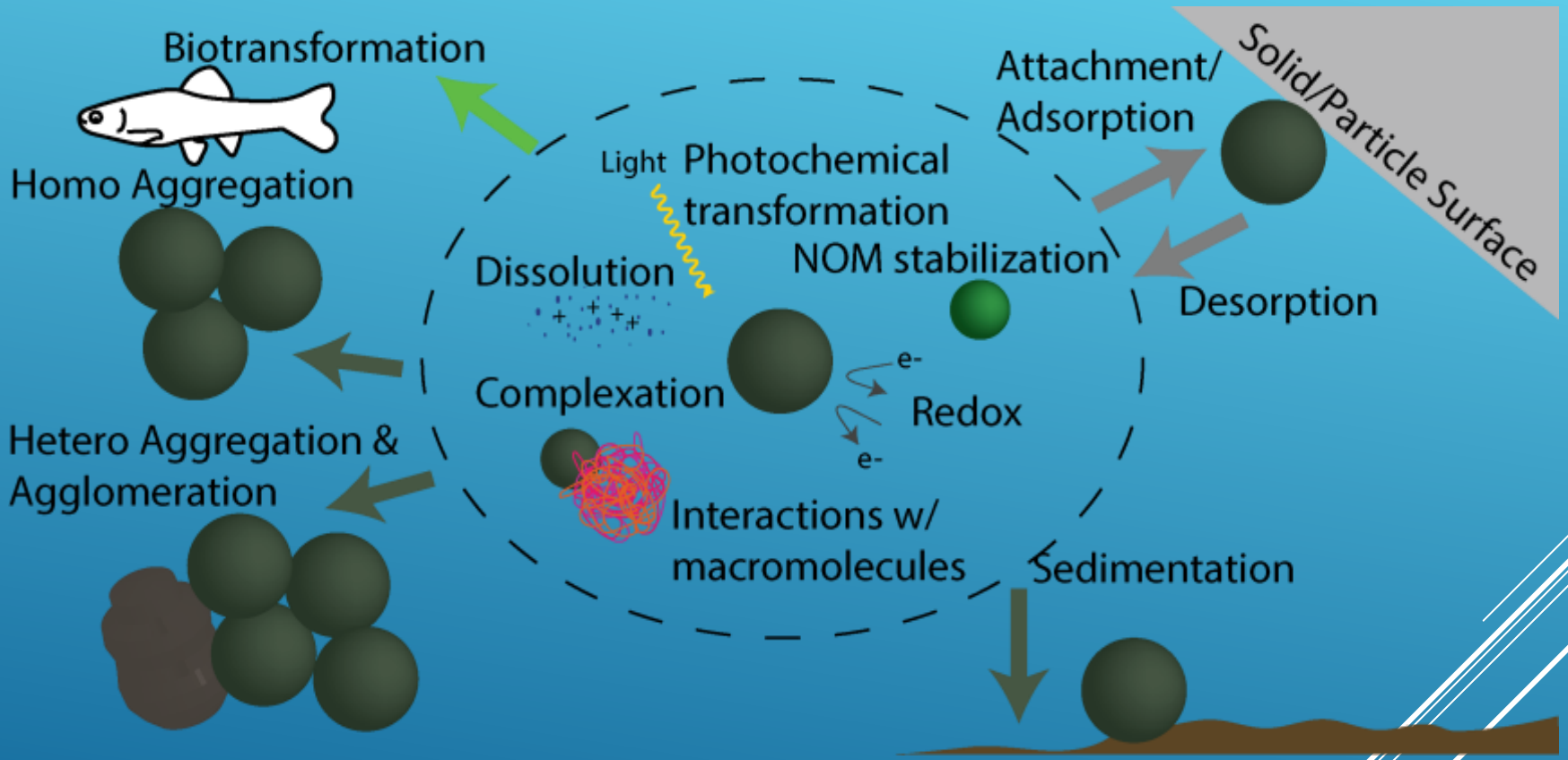
F&T in realistic conditions



Keller et al. ES&T 2010

Garner and Keller, JNR 2014

ENM-Environment Interactions



Montes, Keller et al., J Haz Mat 2012
Adeleye, Keller et al., JNR 2013
Conway, Keller et al., ES&T 2015

Figure from: Garner and Keller, JNR 2014

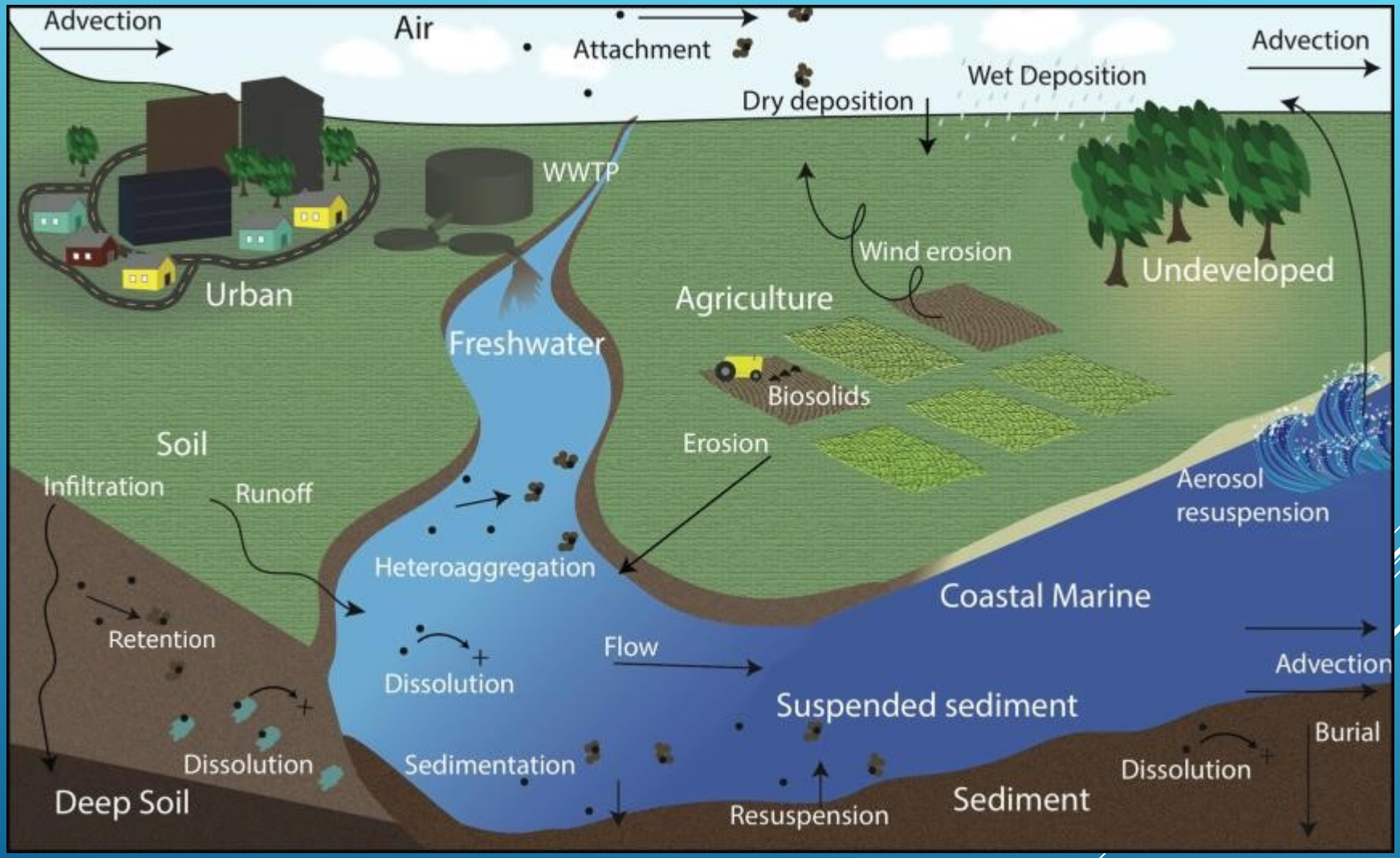
Process Rates from literature

Process	Environment	CeO_2	CuO	TiO_2	ZnO
Heteroaggregation	Freshwater				
	Marine				
Sedimentation	Freshwater				
	Marine				
Dissolution	Freshwater				
	Marine				
	Soil Water				

None Slow Medium Fast Very Fast Extremely Fast

Garner, Keller et al., JNR 2014

nanoFate Model

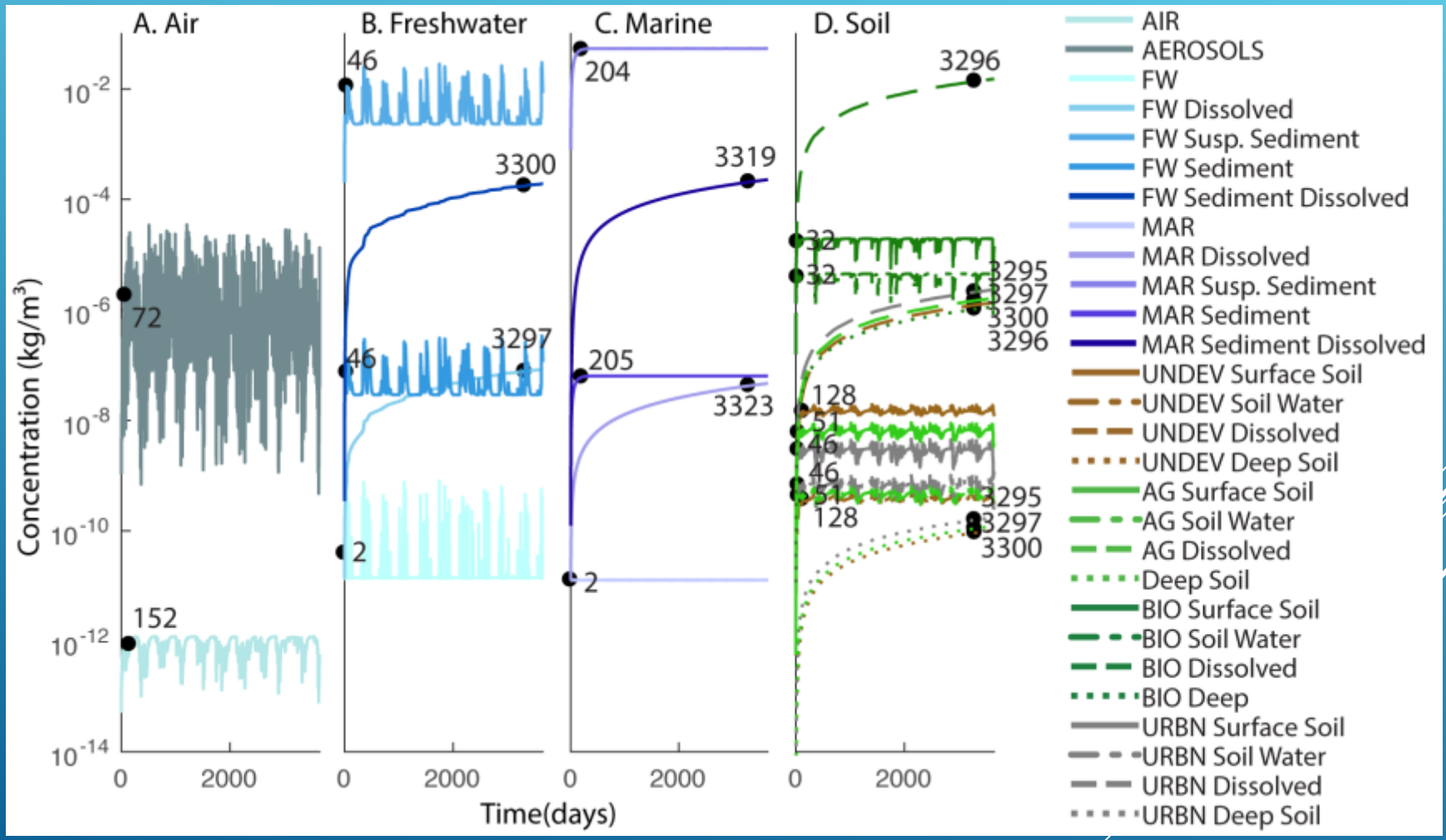


Freely available in GitHub

Garner, Keller et al., 2017

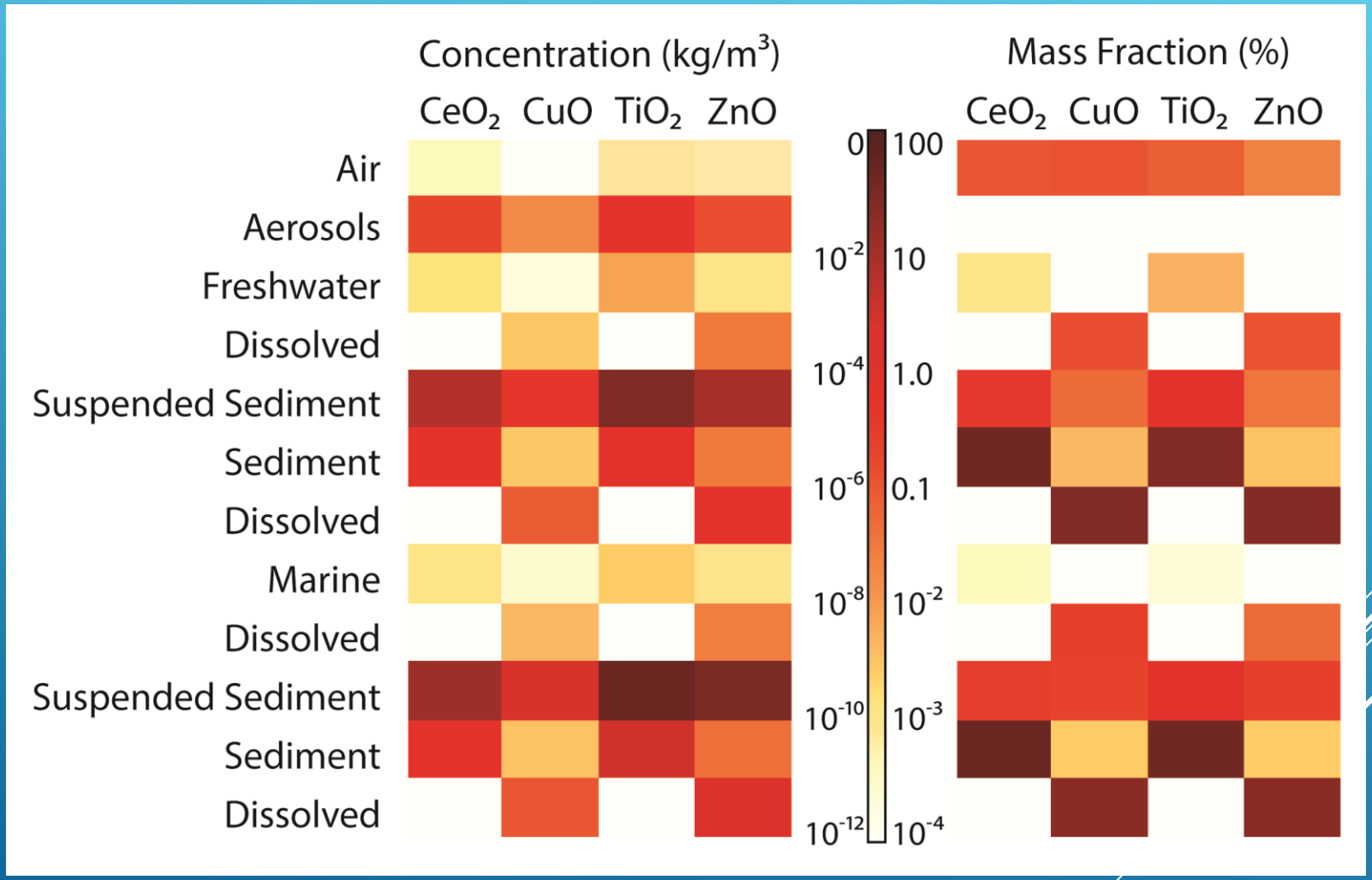
ZnO Concentrations

Assuming ZnO enters as ENM to all compartments



Garner, Keller et al., 2017

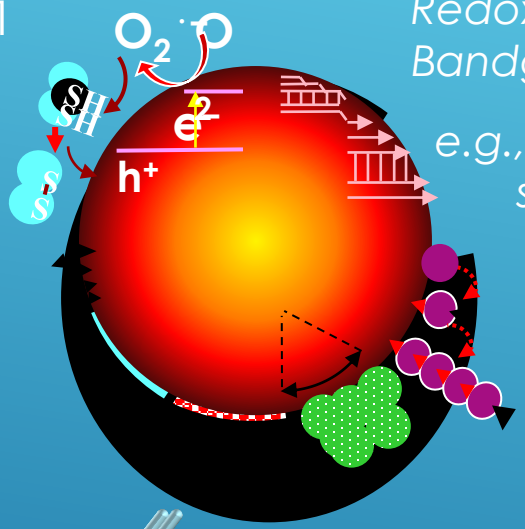
ENM Distribution in Air & Water



Garner, Keller et al., 2017

MECHANISMS OF TOXICITY

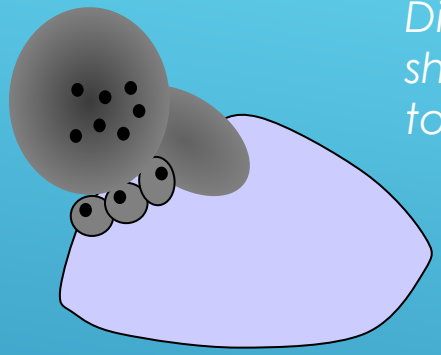
1



Redox activity, Bandgap, ROS

e.g., Me, MeO, silica

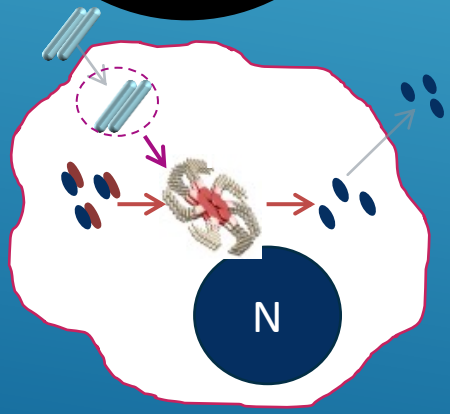
2



Dissolution, shedding toxic Ions

e.g., ZnO, Ag, MeO's

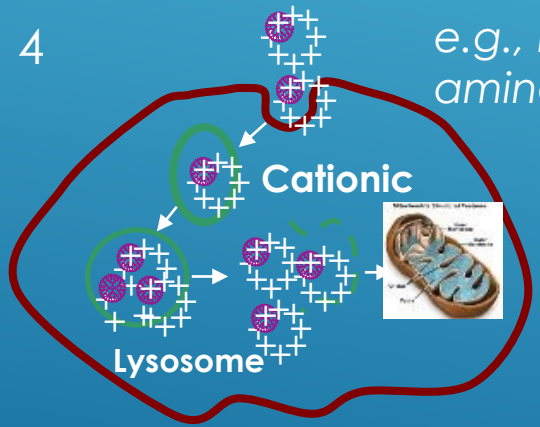
3



Inflammasome activation

e.g., long AR MeOs, CNTs

4



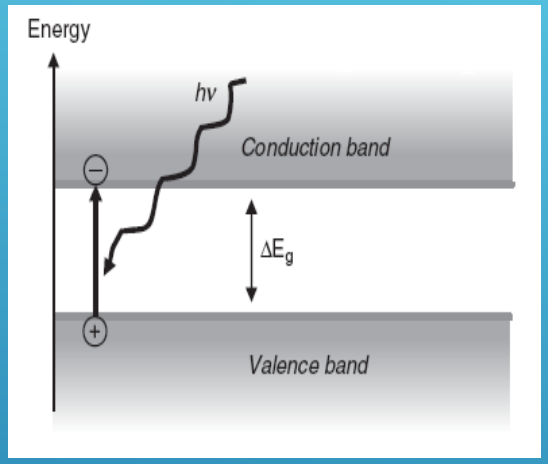
e.g., NPs with surface amines, polyyamines

Cationic toxicity Lysosomal, surface membrane damage

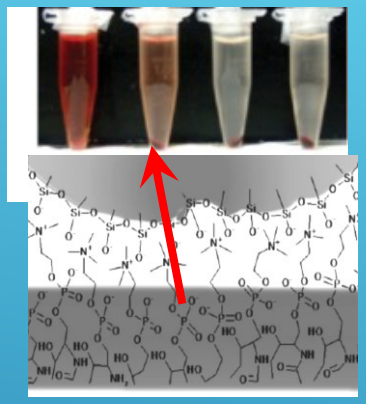
Nel et al, Nature Materials, 2015

Mechanisms of Toxicity

5 *Photo-activation*



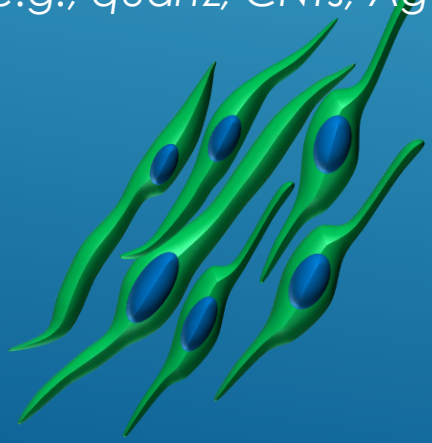
6 *Membrane Lysis*



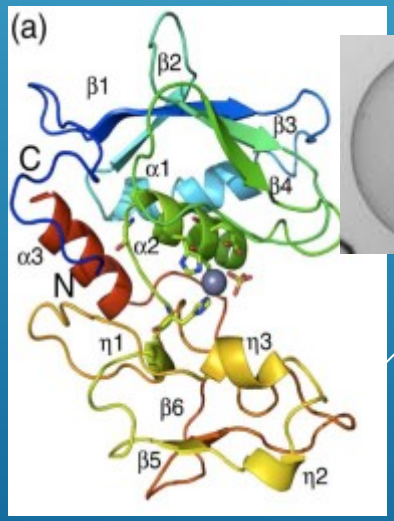
e.g., Si, Ag-plates

7 *Fibrogenesis*

e.g., quartz, CNTs, Ag plates



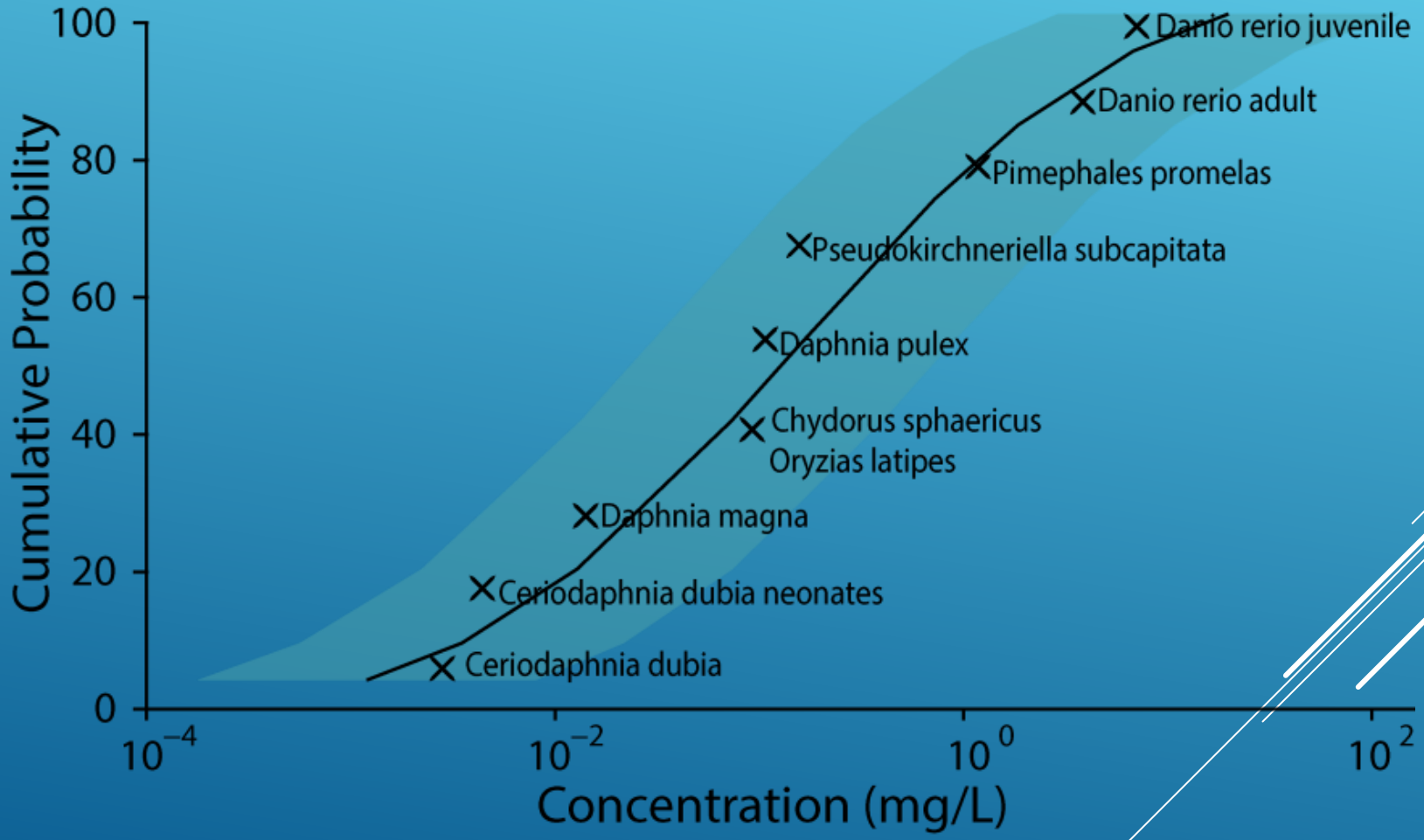
8 *Embryo Hatching (metal-sensitive MTPase*



e.g., Zn^{++}, Cu^{++}

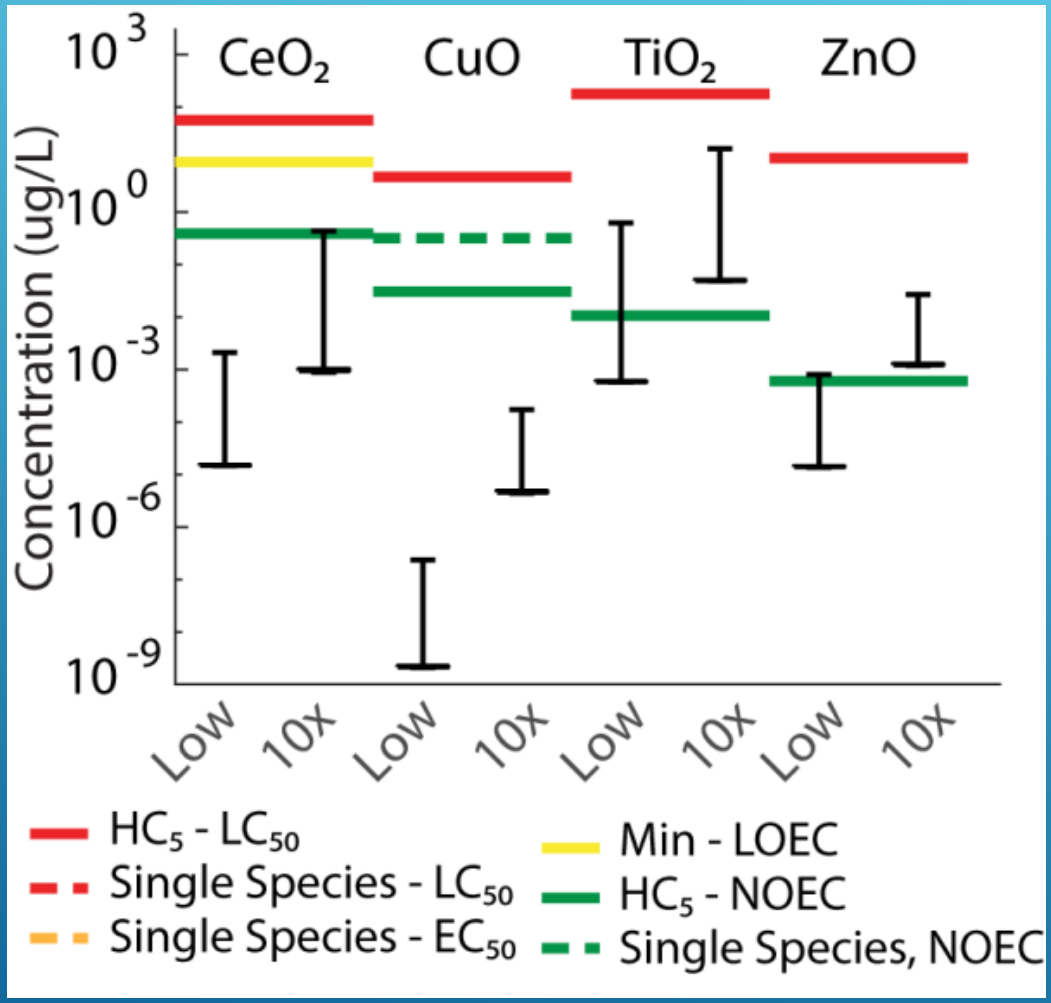
Nel et al, Nature Materials, 2015

nCuO
Species Sensitivity Distribution



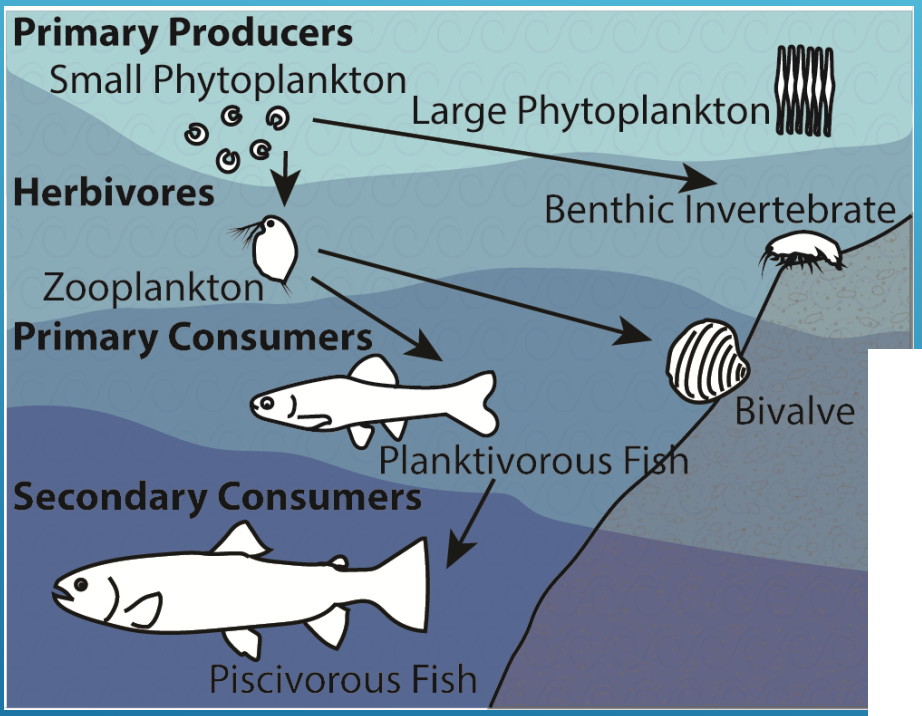
Garner, Keller et al., JNR 2015

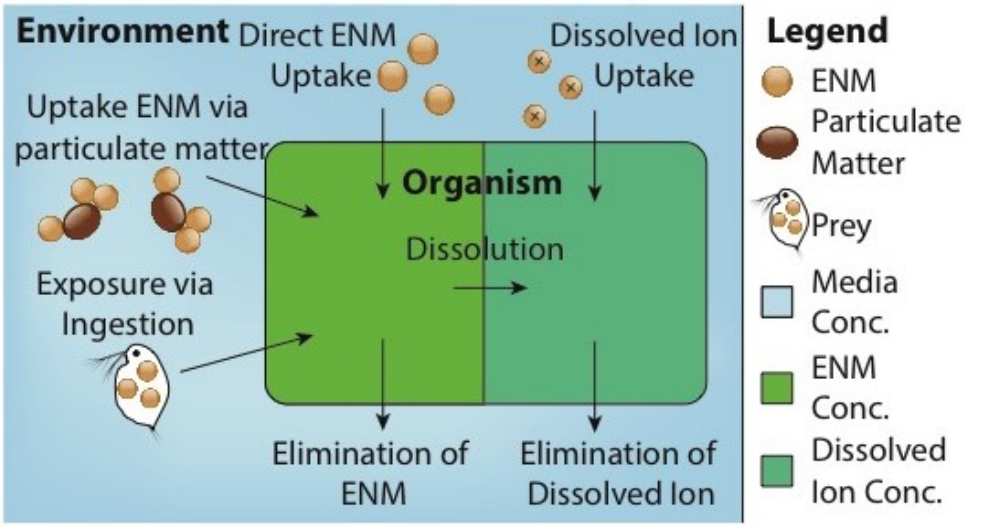
Relative Risk - Freshwater



Garner, Keller et al., 2017

nanoBio model

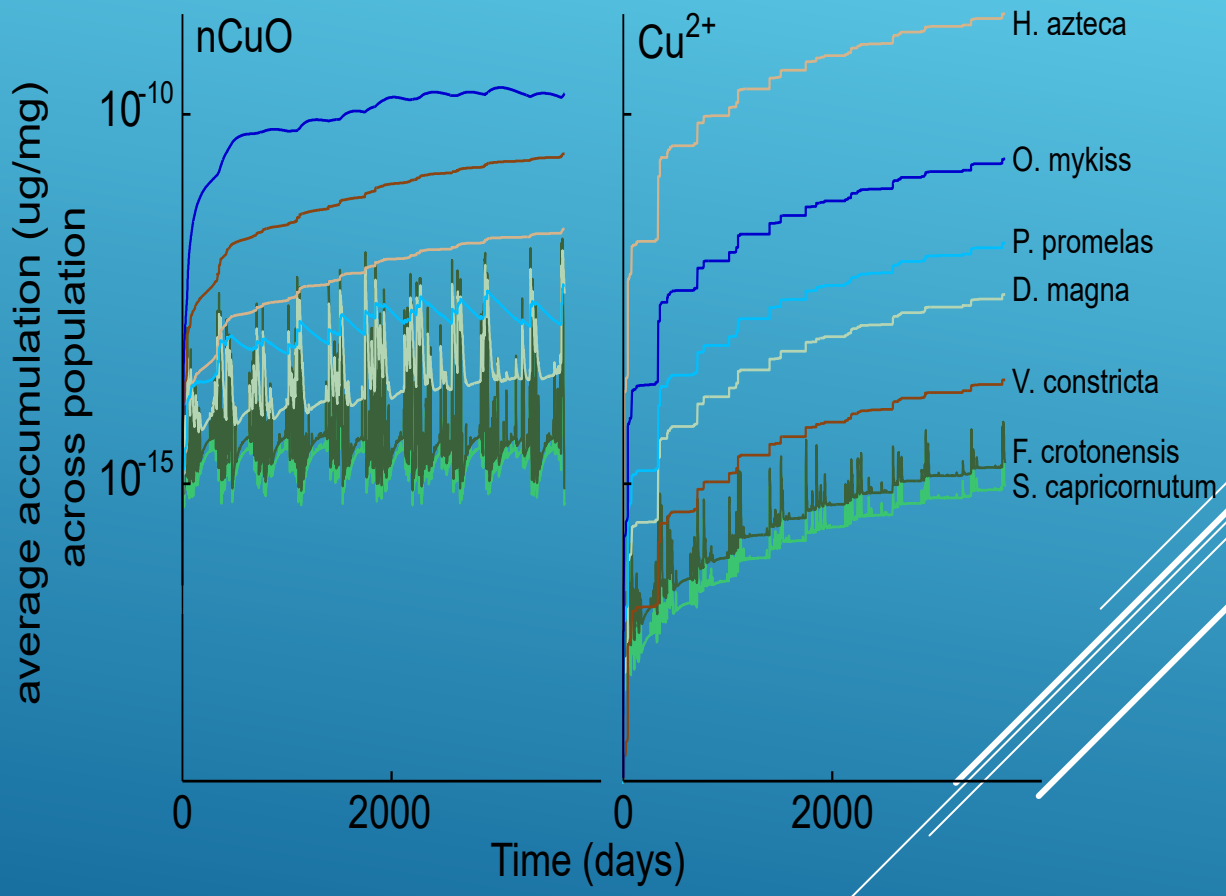




Garner, Keller et al., ACS Sus Chem 2018

Bioaccumulation of nCuO

- Concentrations reflect average across population
- Longer-lived species accumulate more nCuO and take longer to pseudo-steady state
- Ion concentrations continue to increase even after 10 years



Garner, Keller et al., ACS Sus Chem 2018

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