30: More Nano & Semiconductors

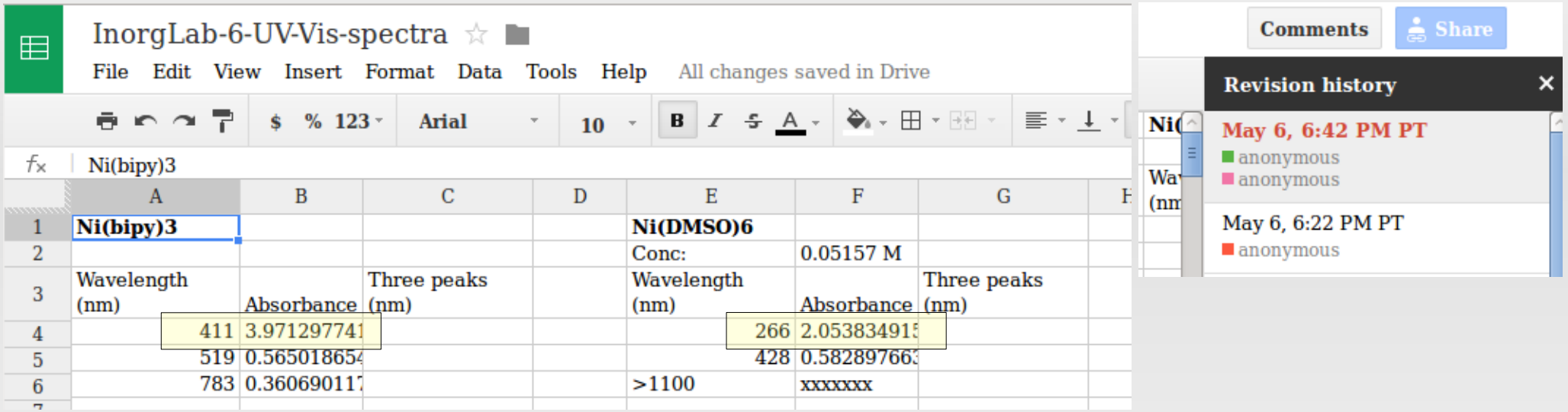
Reading: Ch 24.22-24.30
Ch 8.16-8.17
Ch 3.19-3.20

- Nanotechnology Con't
  - Biology at the Nanoscale
  - Some Applications
  - Are there any concerns?
- More Semiconductors
  - Band Theory Review
  - Experimentally Determining Conductor Type
  - Fermi Level
  - Population of Conductance Band
  - Extrinsic Semiconductors and doping

Announcements

- Lab 6 Report: data on Google Spreadsheet?
- Thursday Lab 7: Silver Nanoprisms
  - Report Due: Friday, May 16, 5pm
- Student Activity Day Friday: Literature Discussion
- Problem Set 12 due Sunday night
- SuperLab
  - Analyses to do: Magnetic susceptibility, CV, chromatography, Mass spec, AAS
  - Report Due: Friday, May 16, 5pm
- Final Exam: Wed, May 14, 11:00am – 1:30pm
- Course Evaluations: open until Mon, May 19

Lab 6 Data



InorgLab-6-UV-Vis-spectra

File Edit View Insert Format Data Tools Help All changes saved in Drive

Comments Share

Revision history

May 6, 6:42 PM PT
anonymous
anonymous

May 6, 6:22 PM PT
anonymous

fx Ni(bipy)3

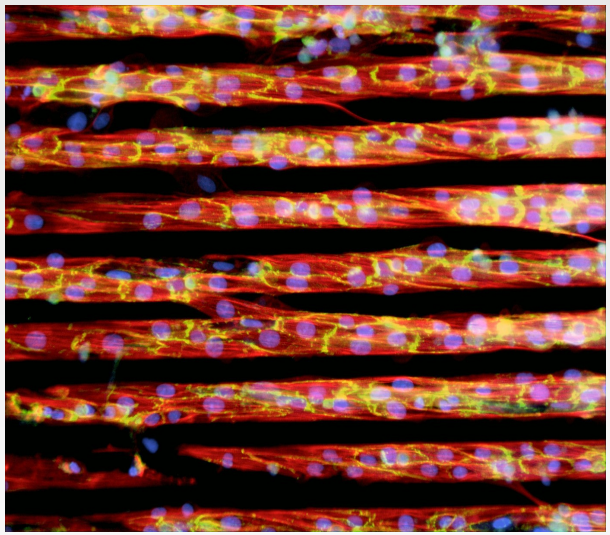
	A	B	C	D	E	F	G
1	**Ni(bipy)3**				**Ni(DMSO)6**		
2					Conc:	0.05157 M	
3	Wavelength (nm)	Absorbance	Three peaks (nm)		Wavelength (nm)	Absorbance	Three peaks (nm)
4	411	3.97129774			266	2.05383491	
5	519	0.56501865			428	0.58289766	
6	783	0.36069011			>1100	xxxxxxx	

Nano-bio interface

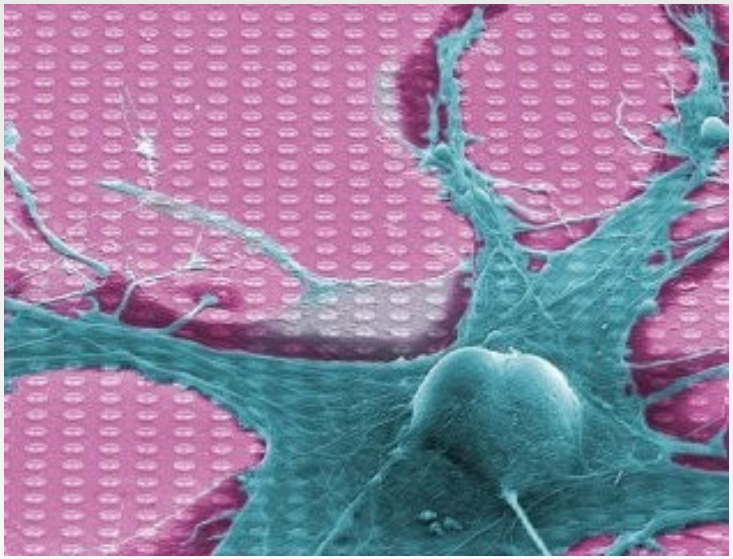
Biology works on the nanoscale

- DNA, proteins, organelles are nanosized

- We can interface with bio systems
- We can learn how to do nanotechnology from bio systems



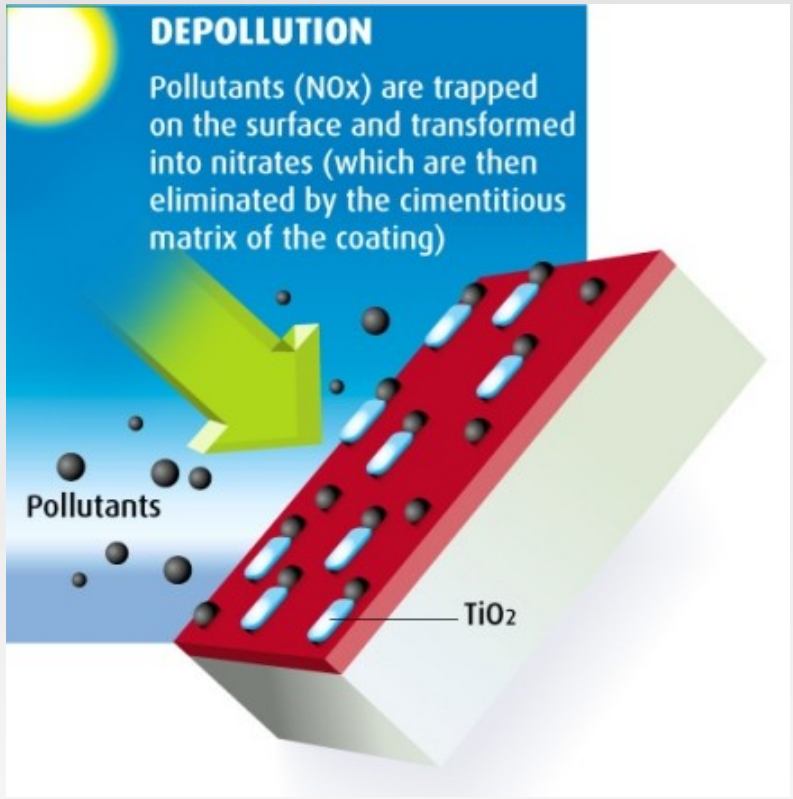
Cardiac tissue grown with the help of nanofiber filaments



Snail neuron grown on a chip that records the neuron's activity

Paint that Cleans the Air

Nanoparticle catalysts can decompose air pollution

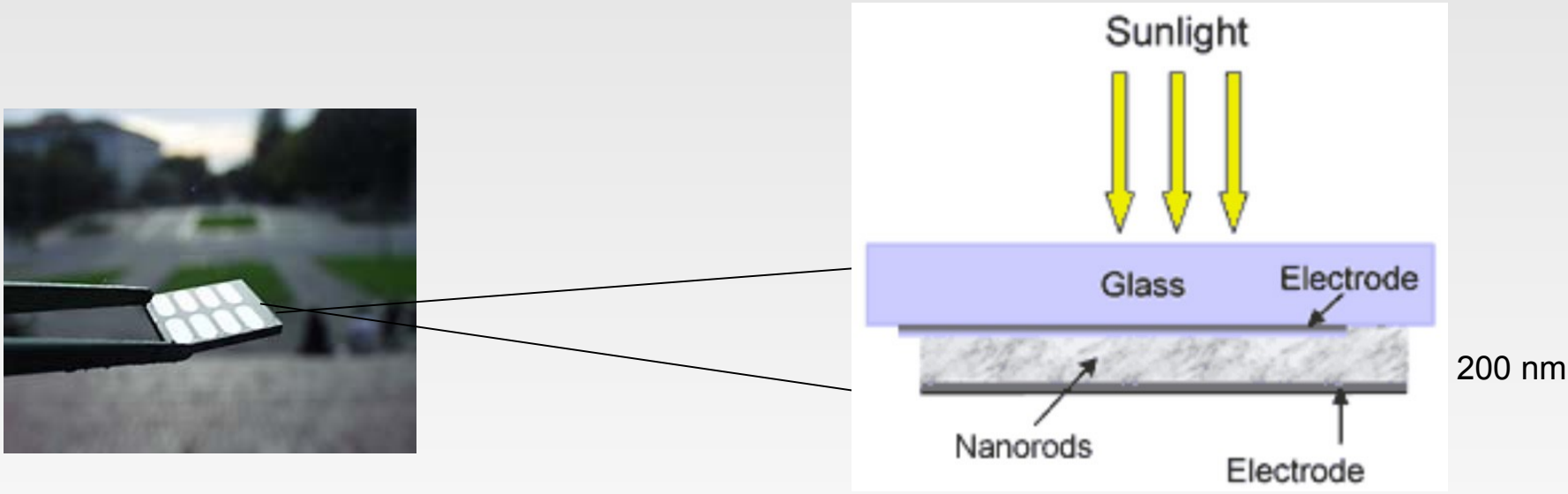


Buildings as air purifiers?

Sources: http://www.picada-project.com
http://english.eastday.com/eastday/englishedition/metro/userobject1ai710823.html

Solar Cells

- Light absorbed depends on the size
- Control of electronic properties
- Nanosized solar cells can be printed or even painted on!



Nano solar cell: Inorganic nanorods embedded in semiconducting polymer, sandwiched between two electrodes

Source: http://www.berkeley.edu/news/media/releases/2002/03/28_solar.html

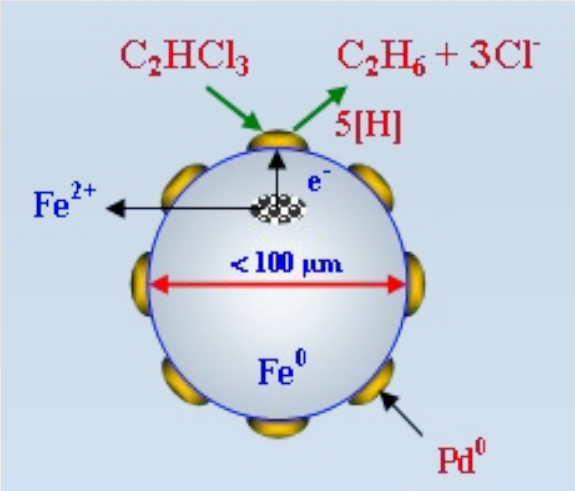
Nano-enabled Printing Solar Cells

nanosolar

- Nanomaterials printed on metal foil
- 15.3% efficient
- Much cheaper!

http://www.youtube.com/watch?v=vIXkB5nrEiY

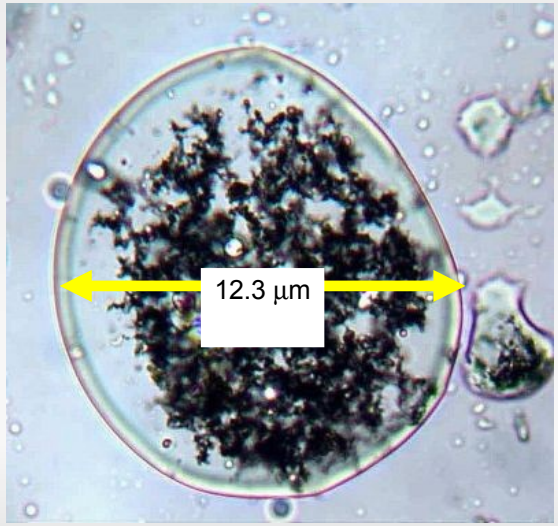
Cleaning Environmental Pollutants

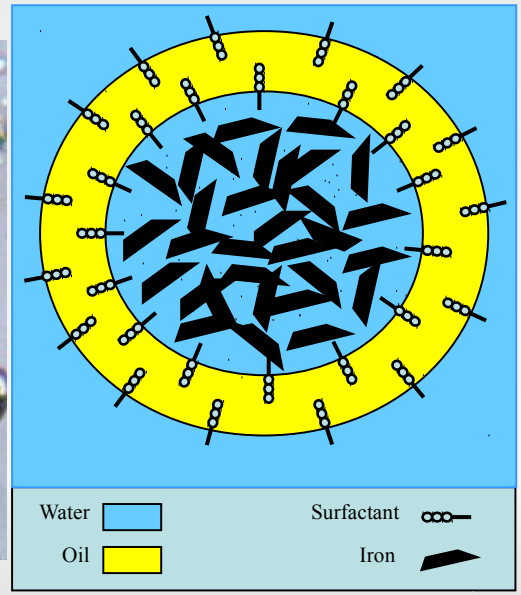


NPs of Zero-Valent Iron with surface Pd used to remediate site at Naval Air Station in Jacksonville, FL

Wei-xian Zhang, Civil and Environmental Engineering, Lehigh University

Zero-Valent Iron NPs encapsulated in food-grade surfactant, vegetable oil, and water used to remediate NASA sites.





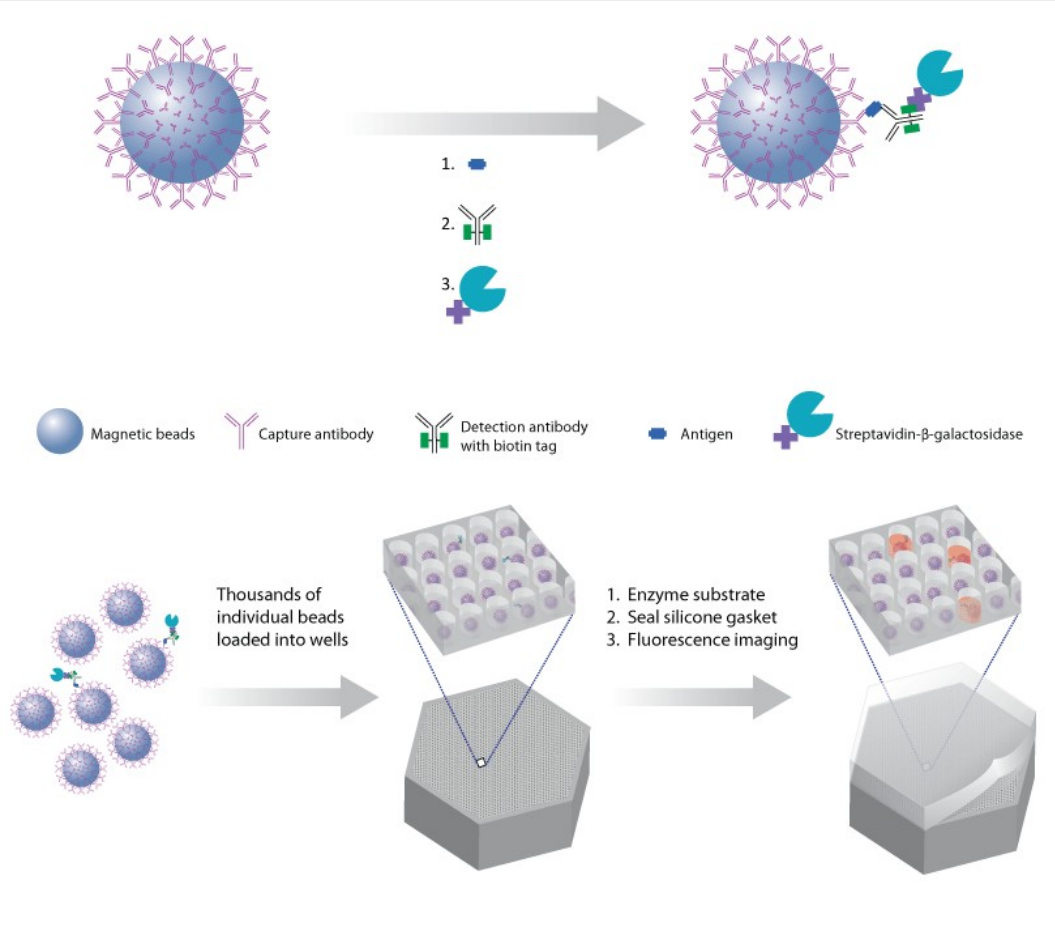
Jacqueline Quinn, NASA

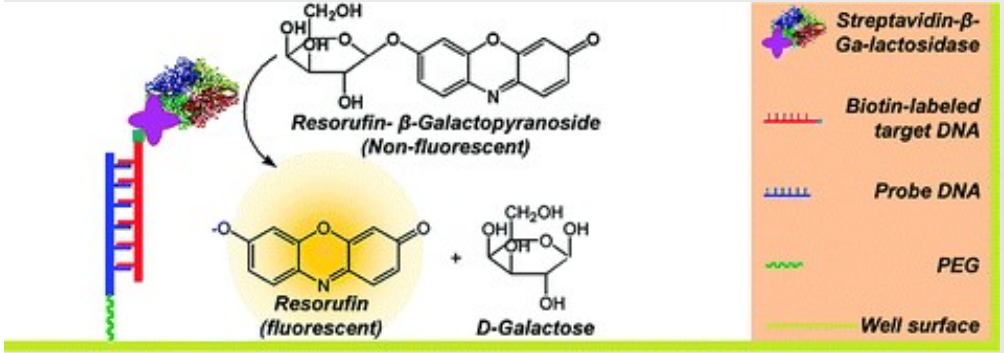
Biocompatible Bone Implants

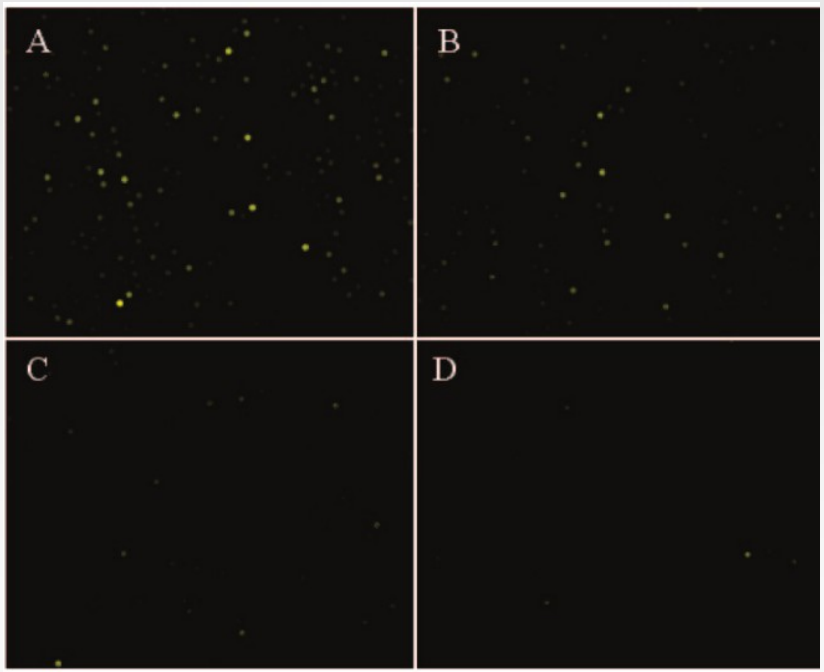
NanOss™ Bone Void Filler by Angstrom Medica

I. Nano-sized hydroxyapatite (calcium phosphate found in bone)
II. Stronger than traditional hydroxyapatite
III. Biocompatible (unlike metal implants)
IV. Bone bonding in 2 weeks
V. No need to remove – slowly replaced by natural bone

Single Molecule Sensors







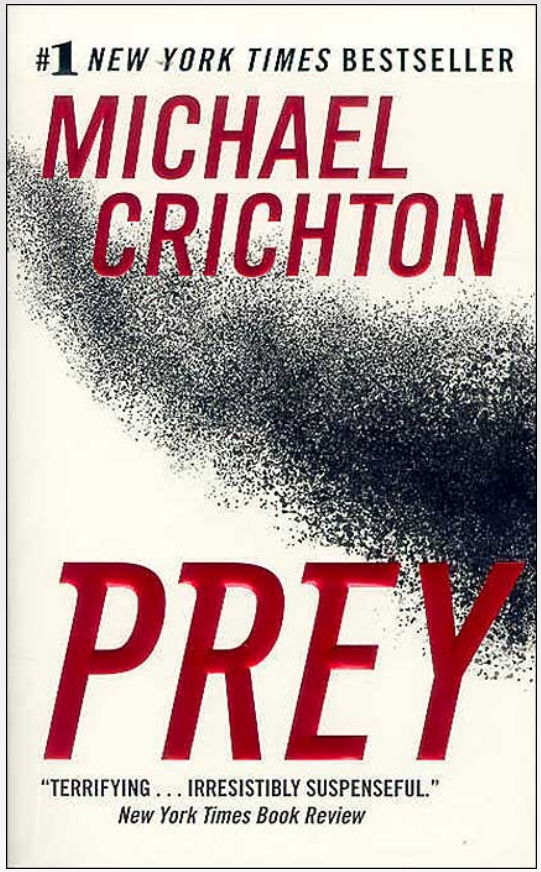
Complementary target DNA (A) 100, (B) 10, and (C) 1fM and (D) control

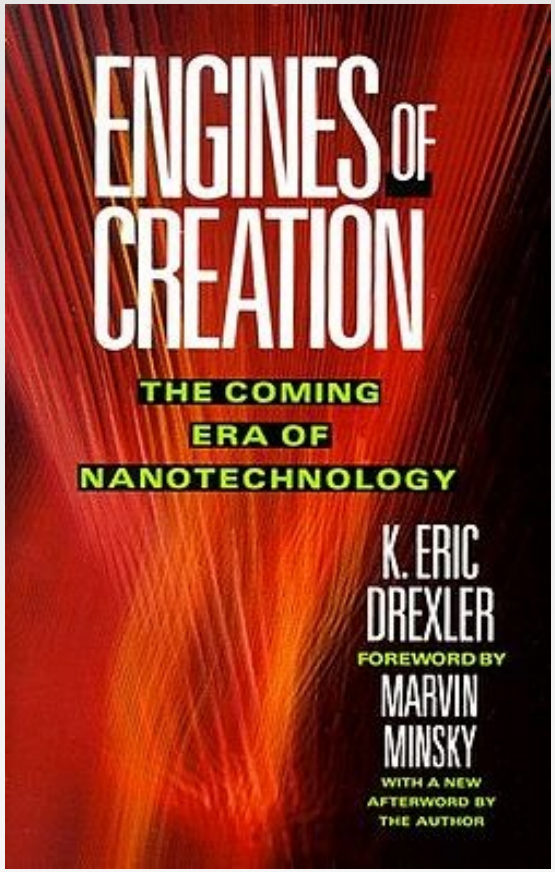
http://www.quanterix.com

JACS 2008 130 (38), 12622-12623

Potential Risks?

Little robots that will destroy the world?





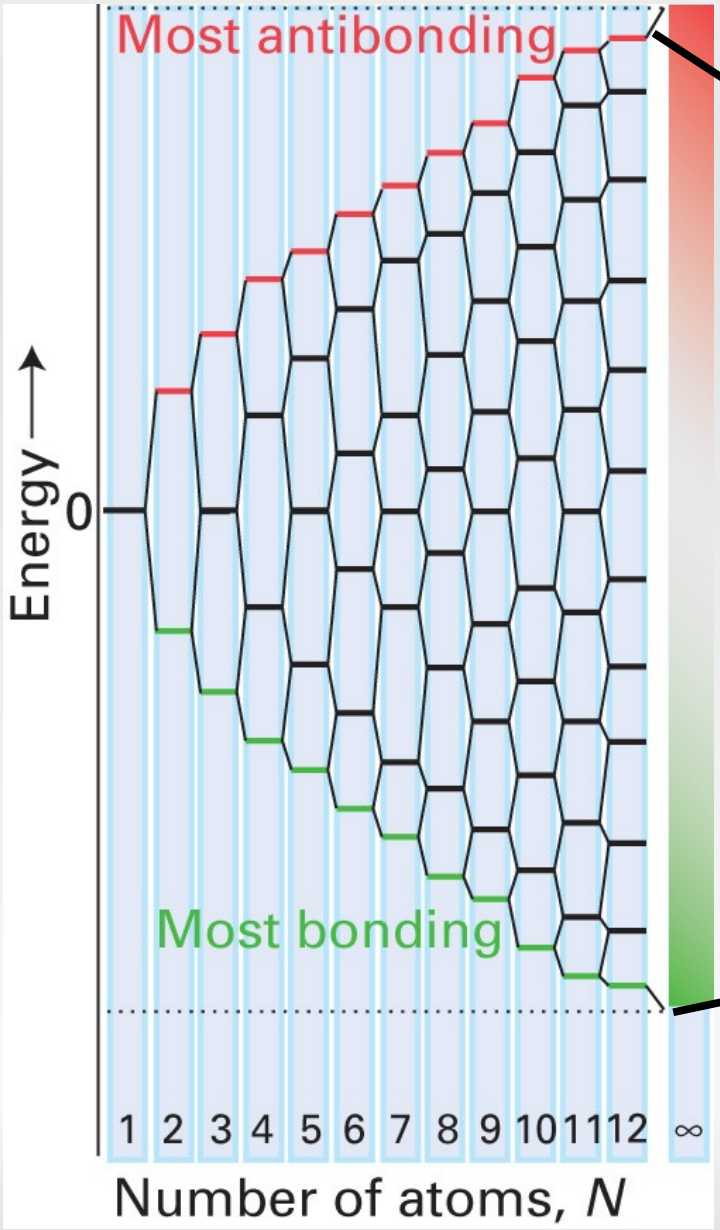
Not Likely.

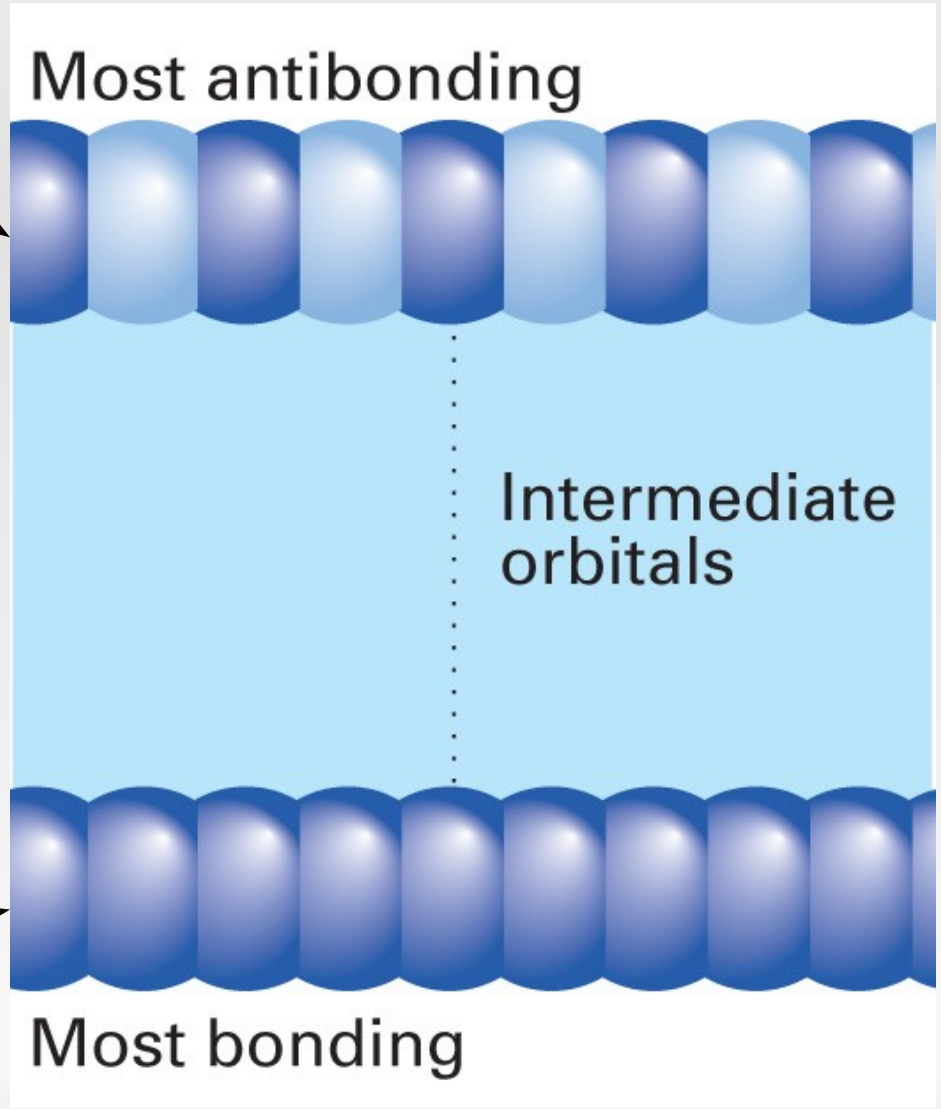
Potential Risks?

- Fullerenes and C_{60} induce oxidative stress in the brain of juvenile largemouth bass. *Oberdorster, E. . Environ Health Persp, 112:1058 (2004)*
- Pulmonary toxicity of ultrafine TiO_2 (20 nm) is much greater than fine TiO_2 (250 nm) in rats. *Baggs, R.B. et al. Vet Pathol, 34(6):592 (1997)*
- Single-walled carbon nanotubes cause lung injury in rats with little or no inflammation (new mechanism of lung injury?). *Lam, C-W. et al., Toxicol Sci 77:126 (2004)*
- Nano alumina slows growth in plant roots. *Yang, L. Watts. D. Toxicol Lett, 158(2):122 (2005)*

Nanomaterials are *chemicals* with unique or enhanced properties.
There are likely toxic effects that need to be known and controlled.

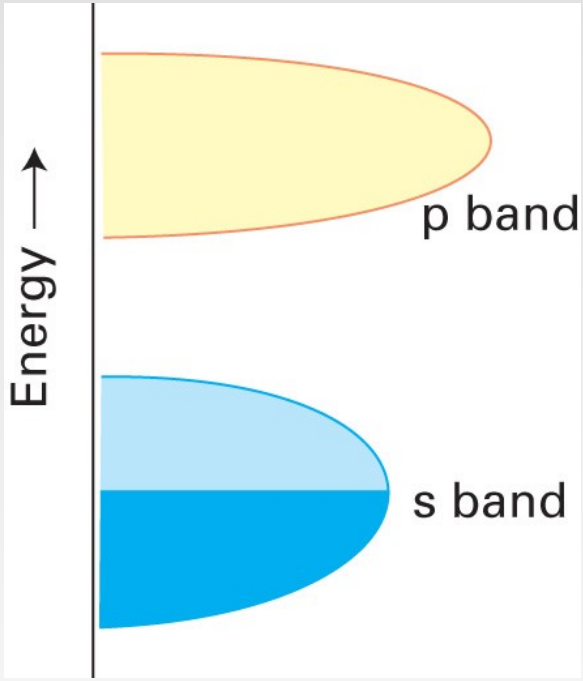
Origin of “Bands” in Solid State



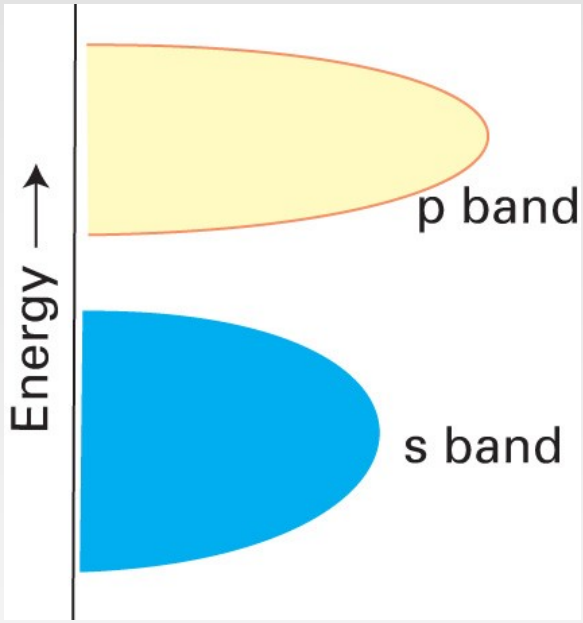


ρ in Types of Conductors

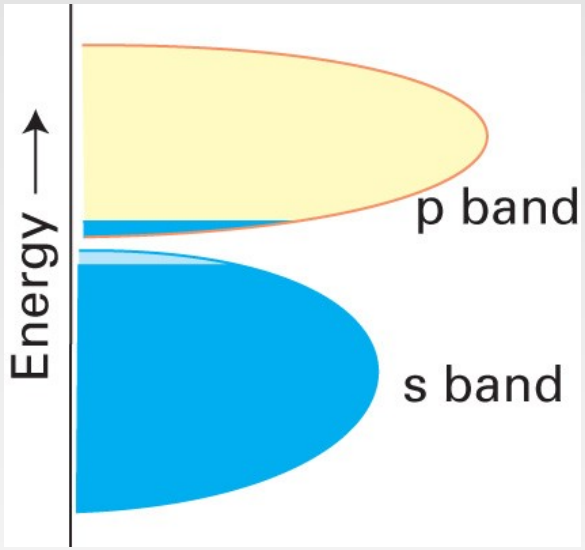
Metallic Conductor



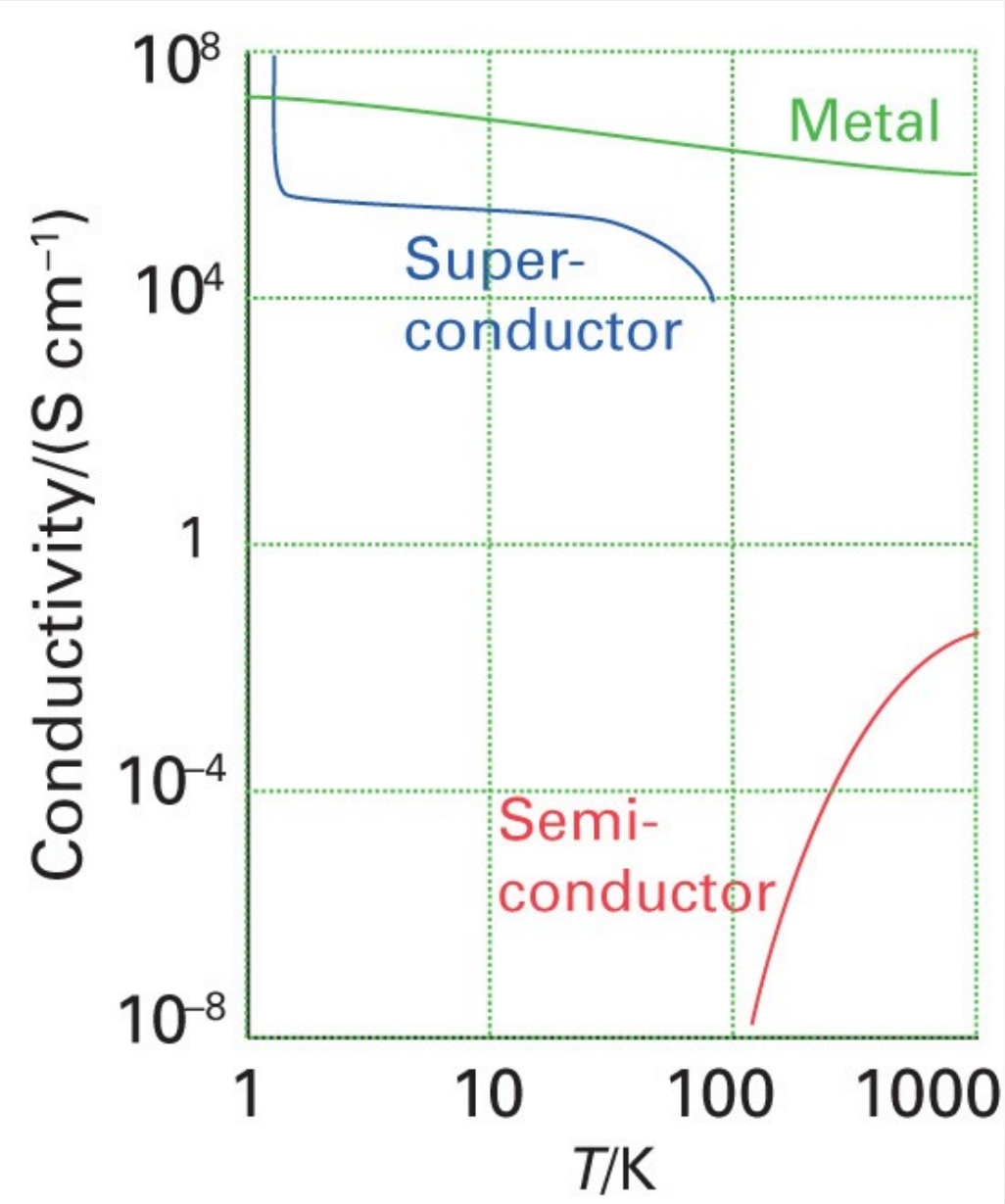
Insulator



Semi-Conductor

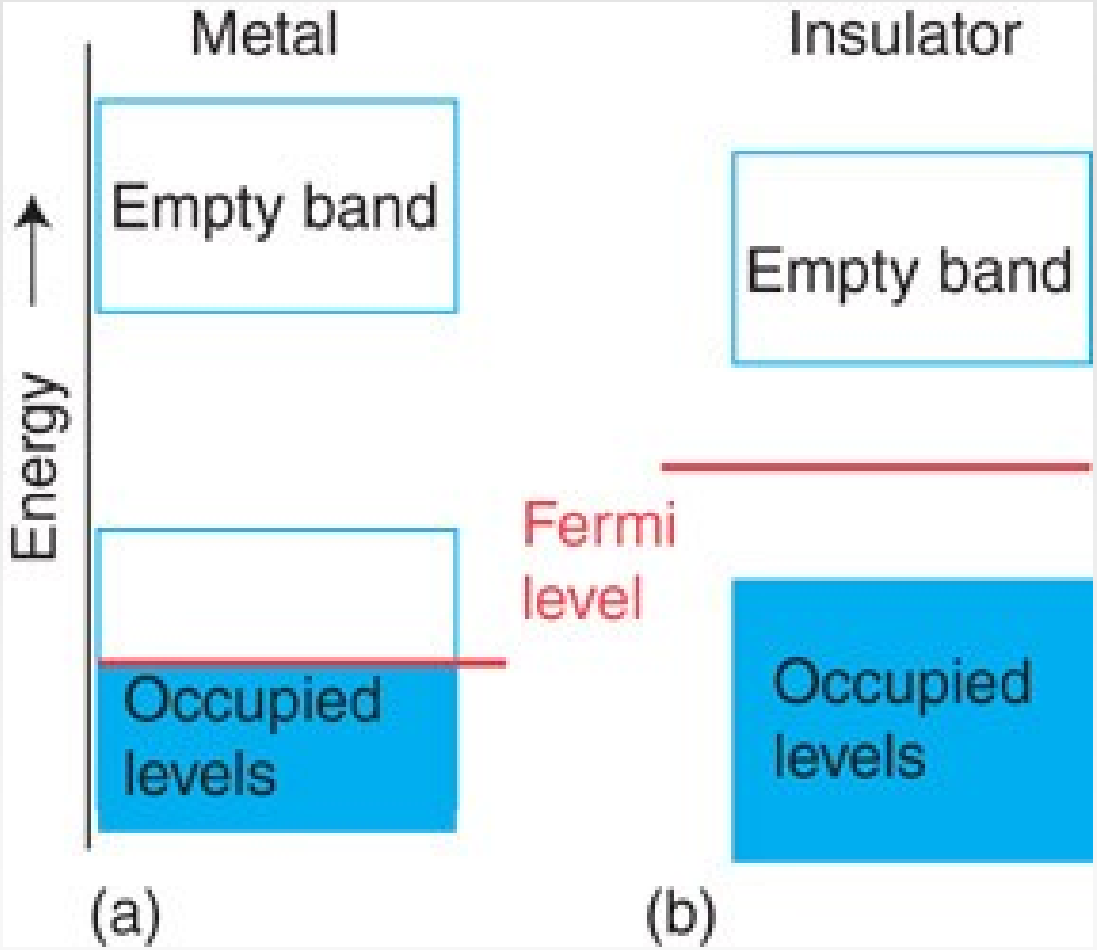


Conductor Types over Range of Temperature



Material	E_g/eV
Carbon (diamond)	5.47
Silicon carbide	3.00
Silicon	1.11
Germaniun	0.66
Gallium arsenide	1.35
Indium arsenide	0.36

Fermi Level


Metal
Insulator
Empty band
Empty band
Energy
Fermi
level
Occupied
levels
Occupied
levels
(a)
(b)

Doping Semi-Conductors

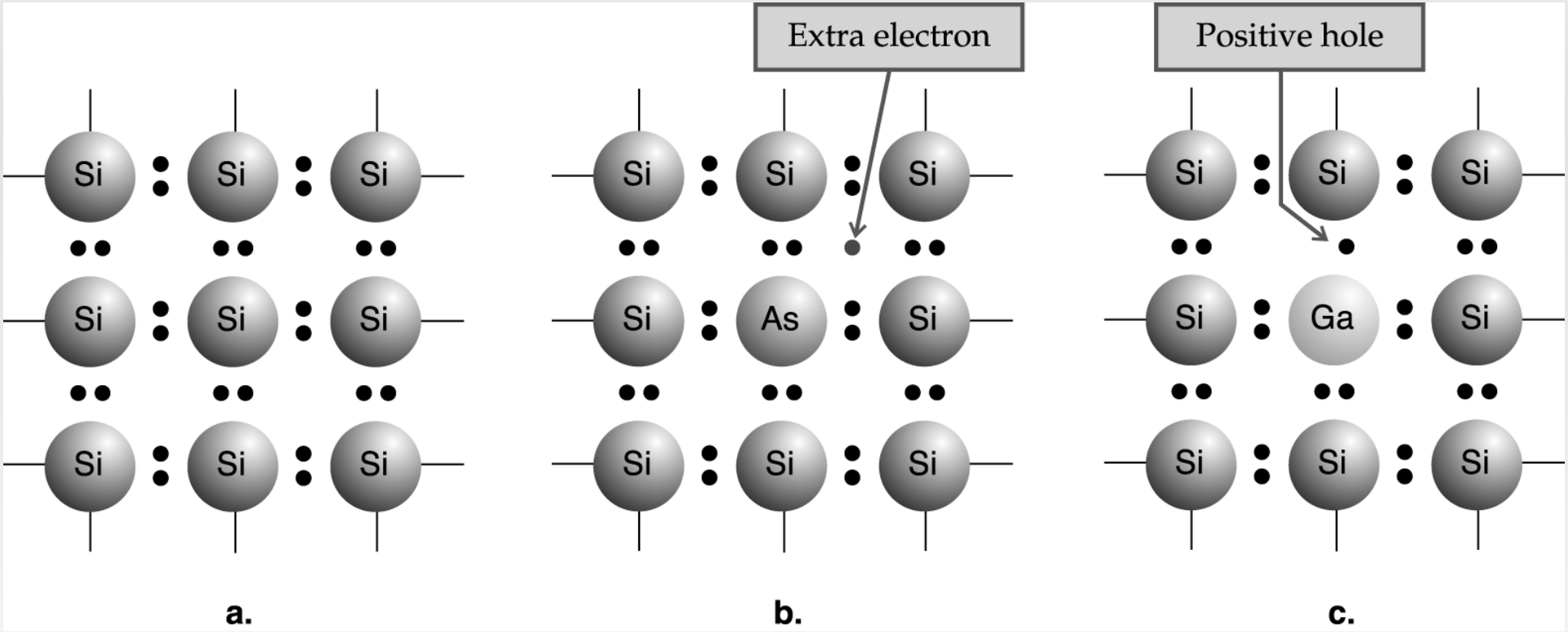
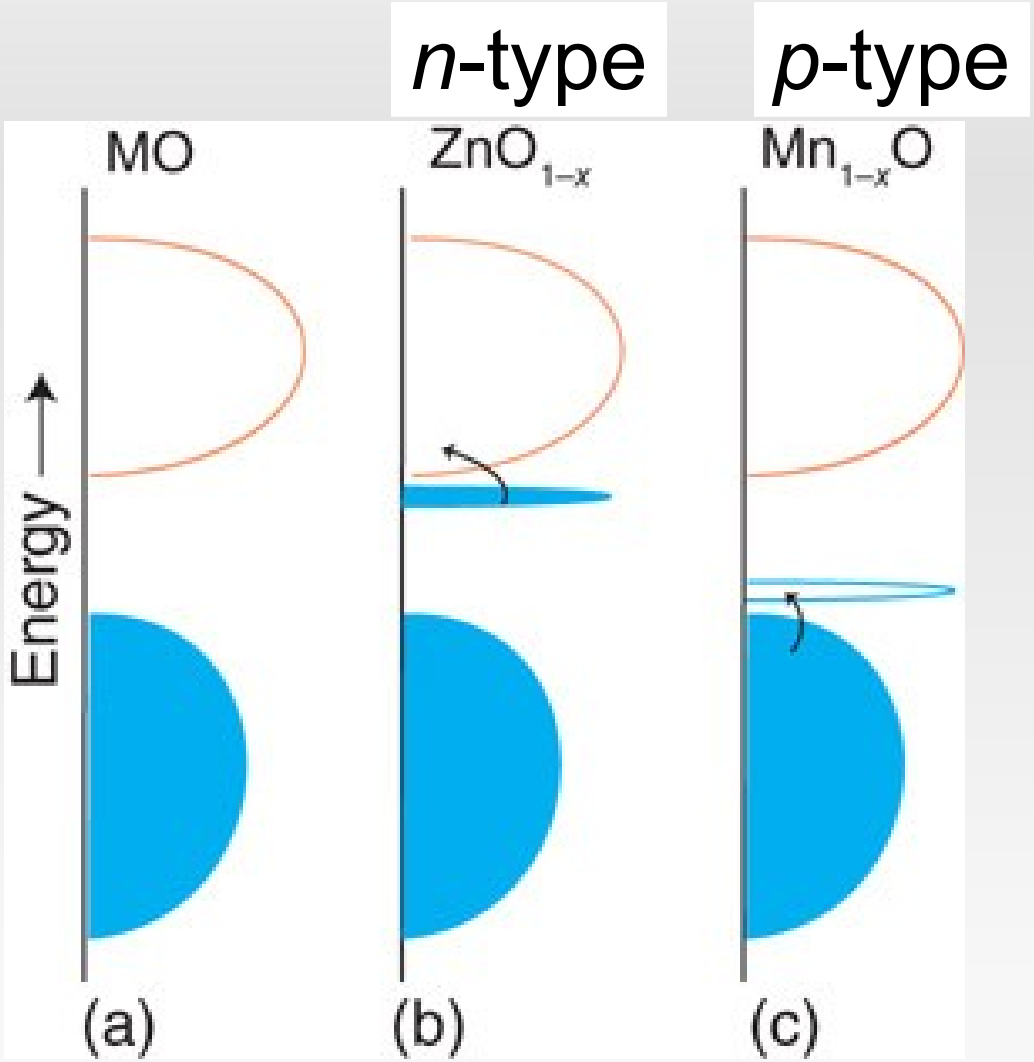


Figure 12.4 from
Principles of Environmental Chemistry, 2e, Girard

Extrensic Semiconductors



p-n Junction Energy Diagram

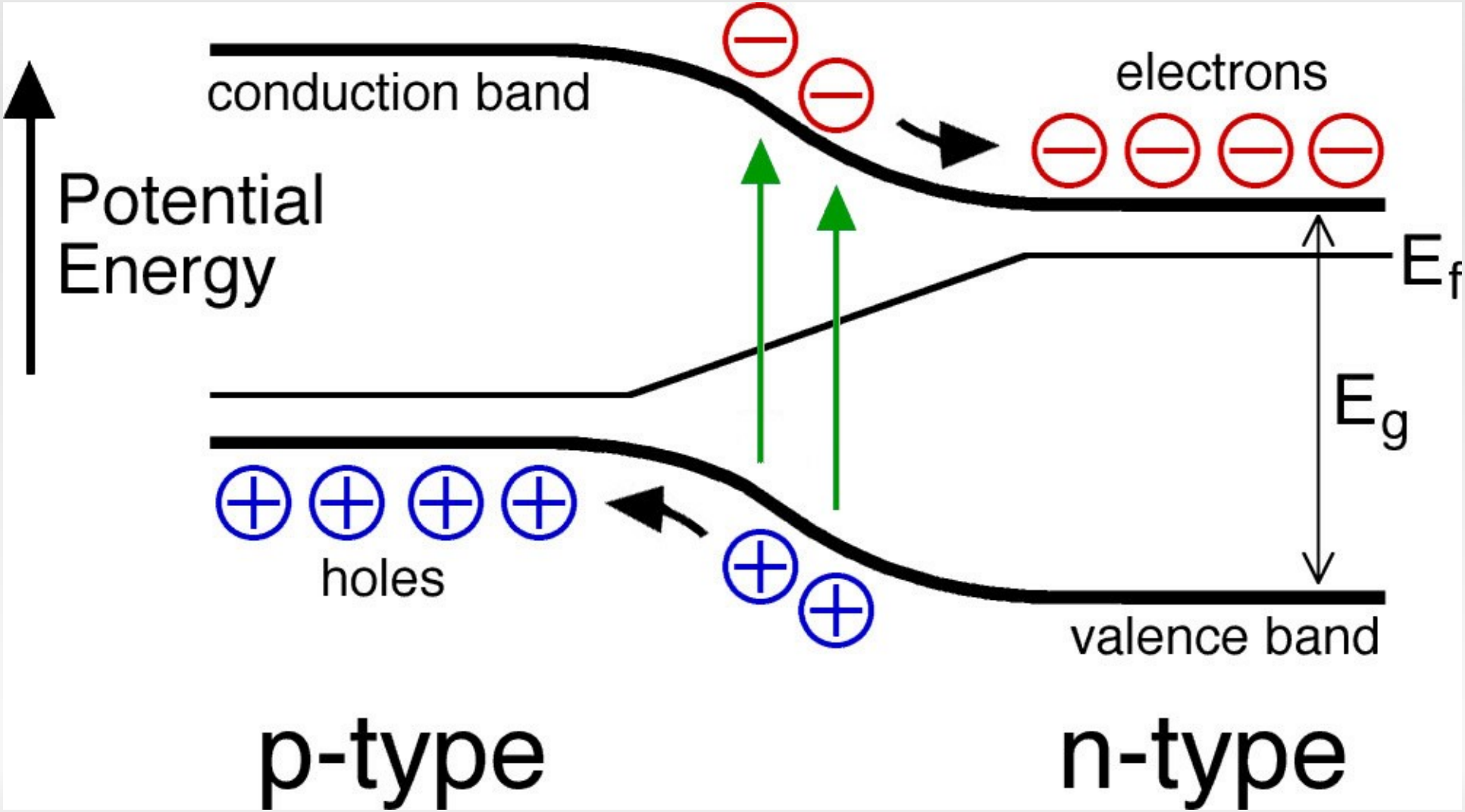


Figure from http://education.mrsec.wisc.edu/Edetc/SlideShow/slides/pn_junction/pn_junction_solar.html

Solar Cell Construction

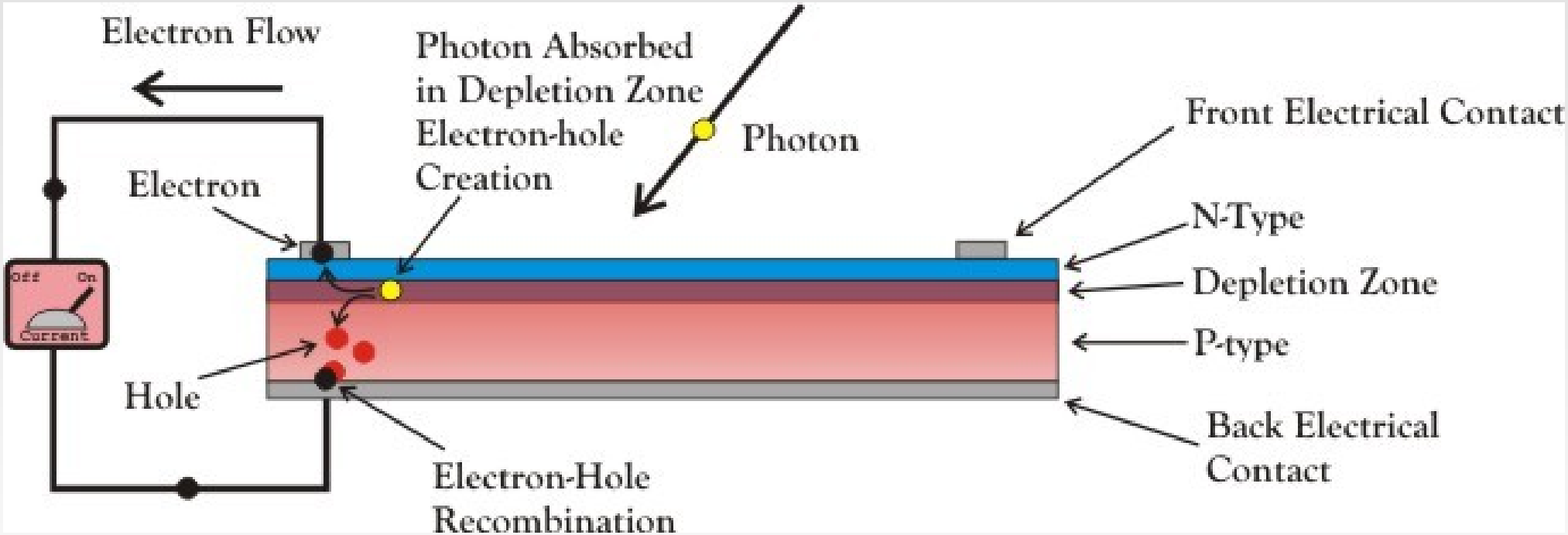


Figure from http://www.imagesco.com/articles/photovoltaic/photovoltaic-pg4.html