

M3D4: TEM

05/04/2016



Only 3 days left ?!#?

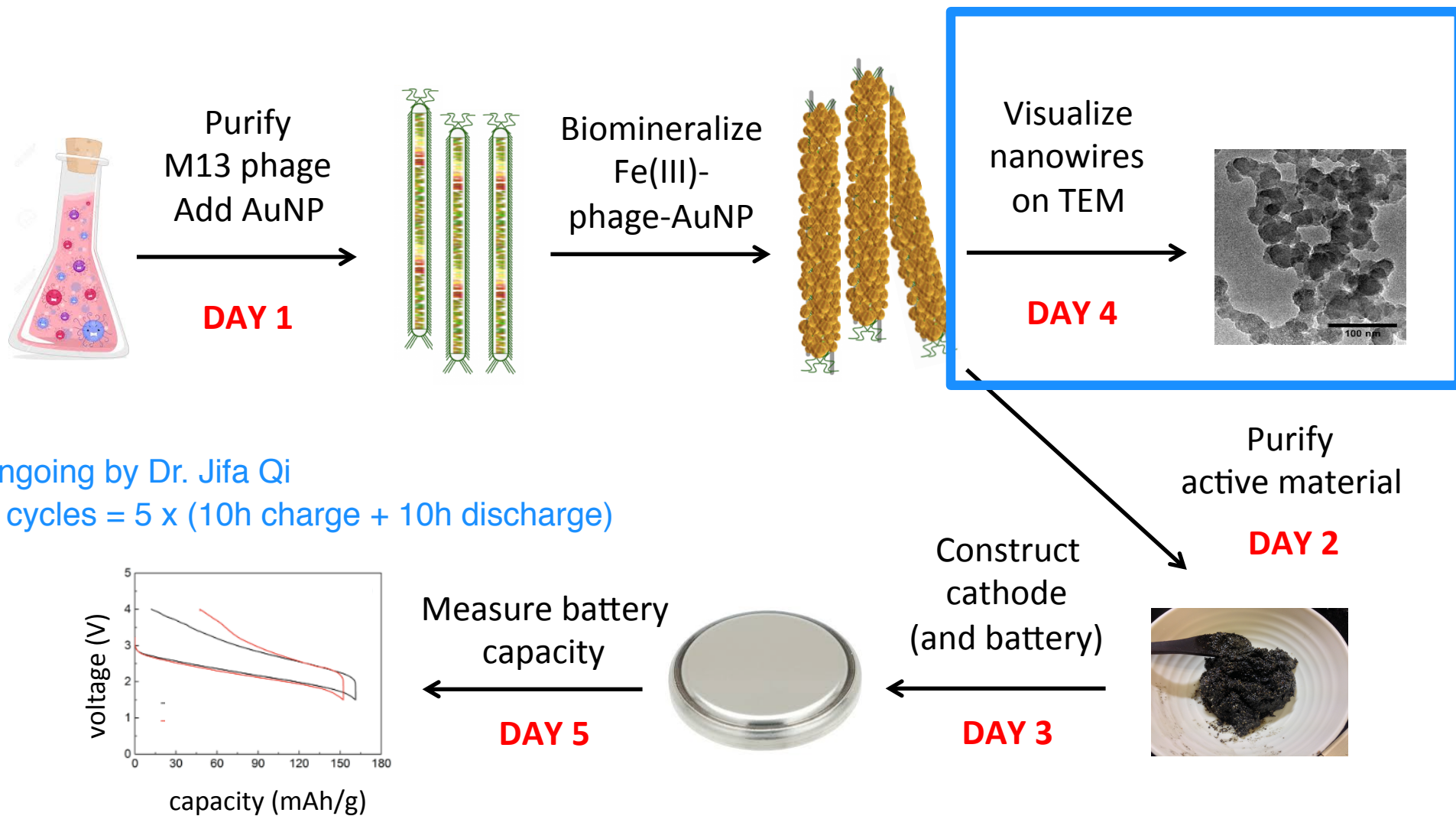
overall approach, TEM images, elemental map (spectrum), charge/discharge plot, capacity, class-wide data analysis



- Visit BE Communication Lab once
- M3 mini-report (5%)
 - due Friday, May 6th at 10pm
 - extra OH Friday, 6pm – 10pm in 16-220 (pizza & subs)
 - 2-3 pages, no abstract, no methods section, combined results and discussion
 - figures:
- M3 research proposal (20%)
 - feedback on your M3D4 homework on May 5th
 - extra OH Sunday, May 8th, 11am – 5pm in 56-302
 - slides due Wednesday, May 11th at 1pm
 - bring one print-out of your slides to 16-336
- Quiz on M3D5
- Blog(s)
 - due Saturday, May 14th at 11am

Module 3: biomaterials engineering

How does gold size/quantity affect battery capacity?



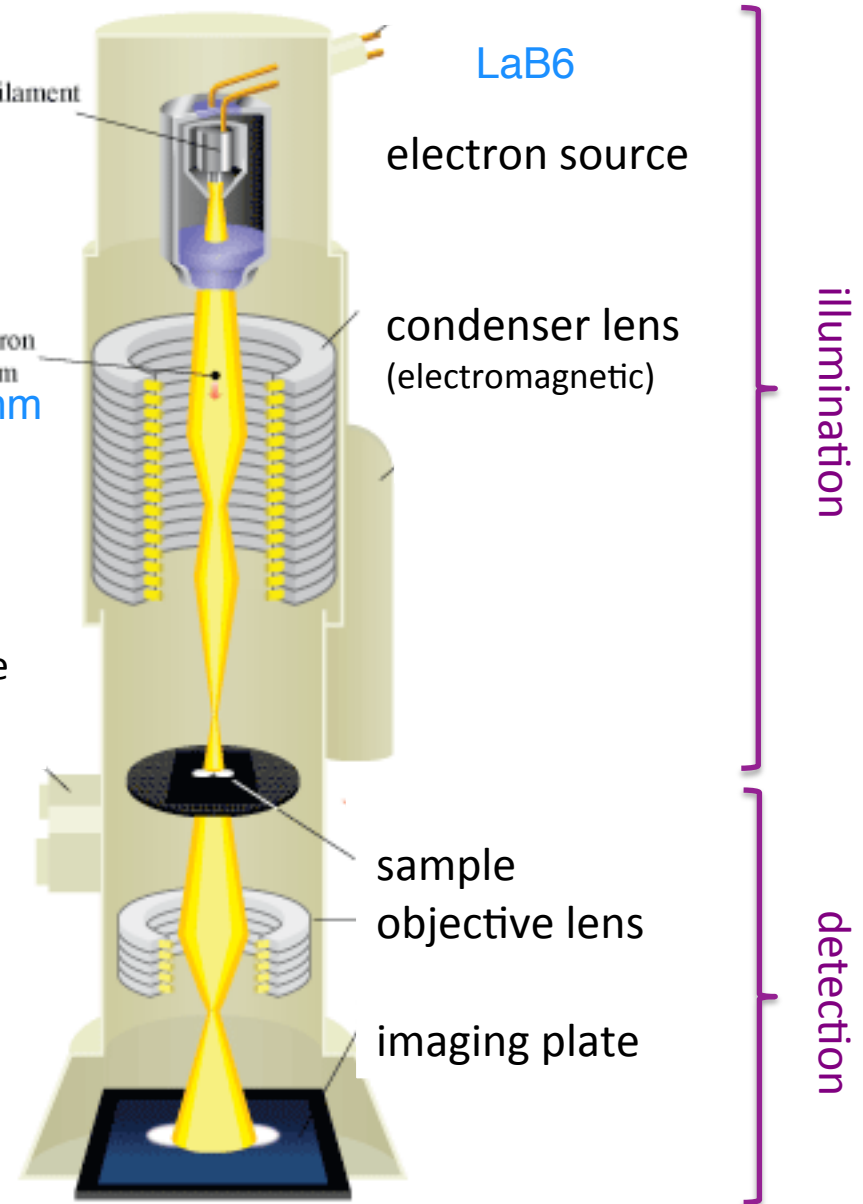
TEM: foundations

transmission electron microscopy

1931 Ernst Ruska (1986 Nobel Physics)

- High resolution $\sim 0.14 \text{ nm}$
 - de Broglie wavelength $\lambda_{(e^-)} \sim 5 \text{ pm} = 0.005 \text{ nm}$
 - compare to $\lambda_{(\text{blue light})} \sim 400 \text{ nm}$
 - Rayleigh $R_{\text{light}} = 0.61 * \lambda / \text{NA} \sim 400 \text{ nm}$
- Electron source: 200 kV
 - thermionic emission by lanthanum hexaboride
 - vacuum and focusing lenses
- Sample preparation
 - thin and sturdy $10 \text{ nm} - 100 \text{ um}$
 - grid: copper (conductive), formvar (carbon)
sturdy
 - biology: not *in situ*
- Image \approx sample *density*
 - e^- pass through & are also scattered
 - phosphor screen, YAG-coupled CCD

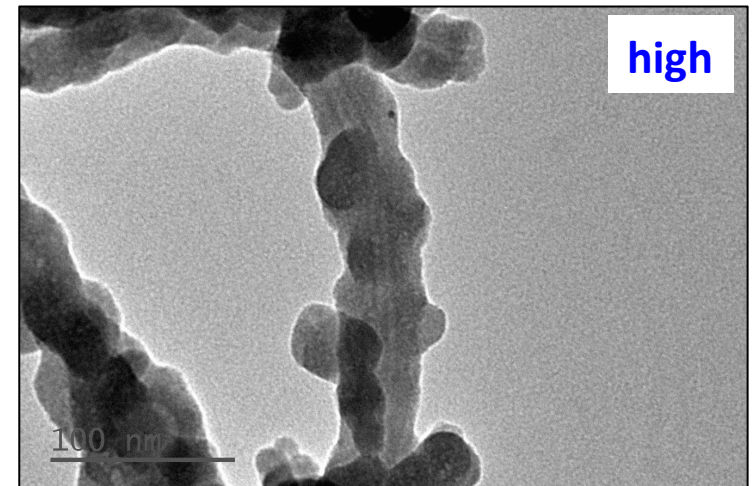
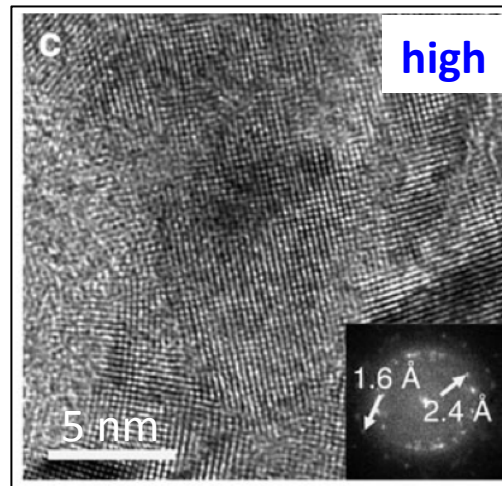
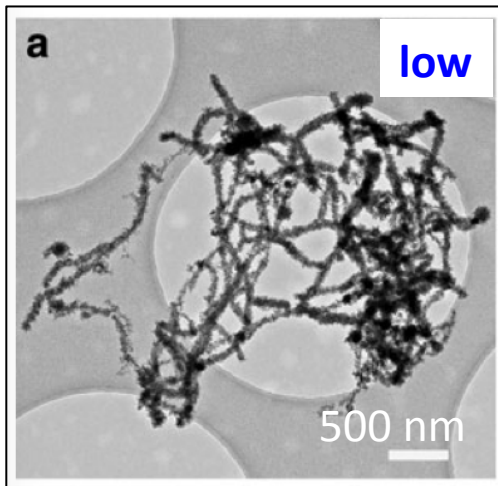
electrons to photons



TEM: your experiments, your mini-report

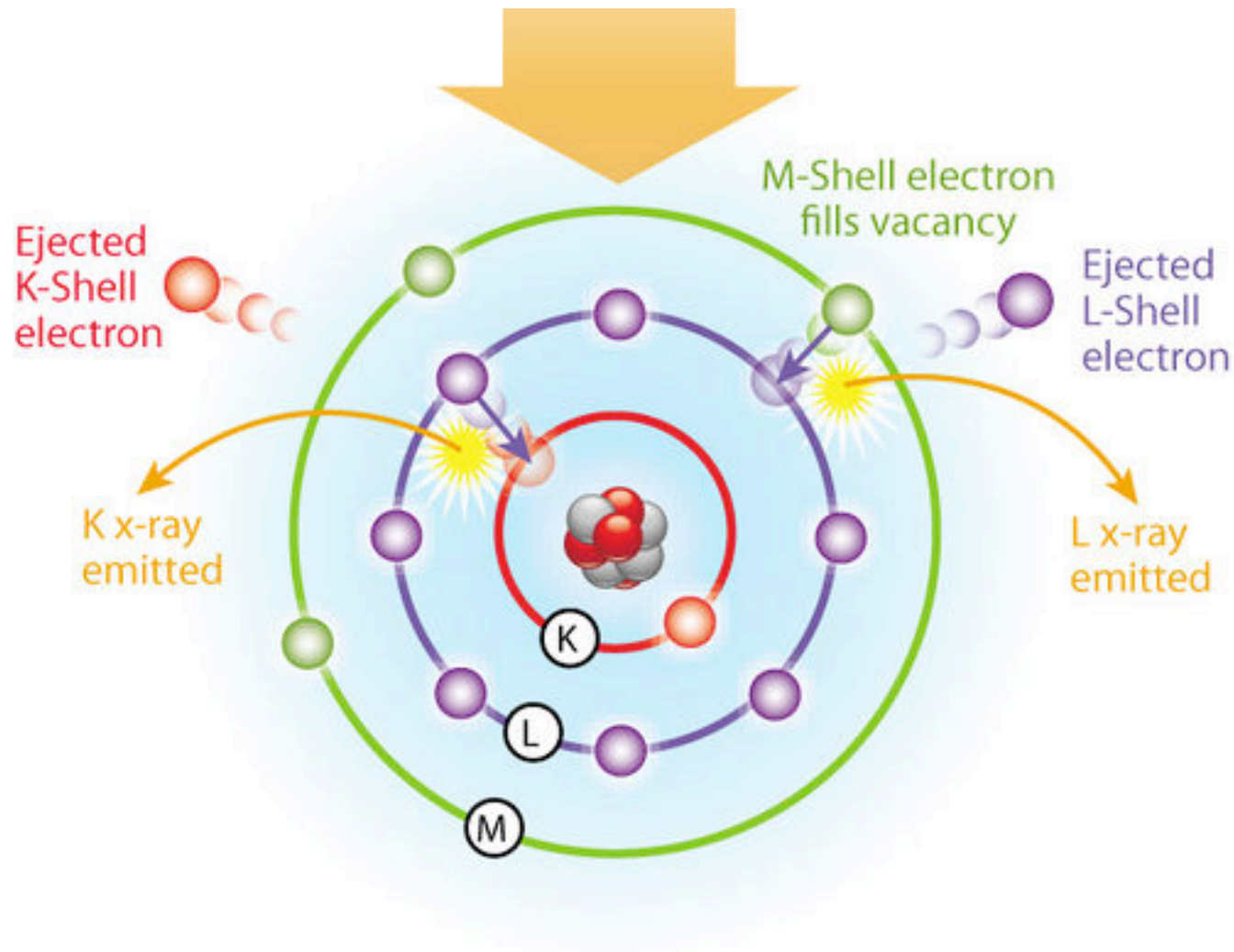
➤ What will you learn?

- at low ~~resolution:~~ **magnification;** overall structure and density, "yield": how many phage gave rise to nanowires, extent of biomineralization (clumps of naked phage? or not), gold distribution, uniformity, length of nanowires
- at high ~~resolution:~~ **magnification;** amorphous vs. crystalline Fe(III)PO₄, diameter of nanowires, lattice of gold,



Elemental mapping by EDX

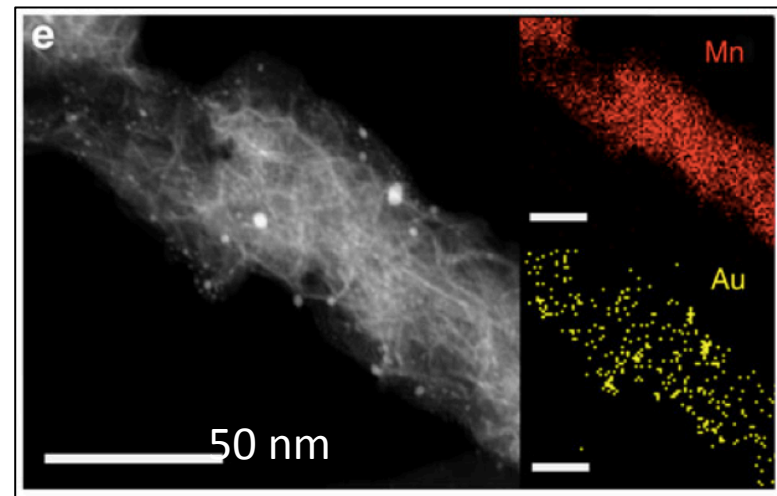
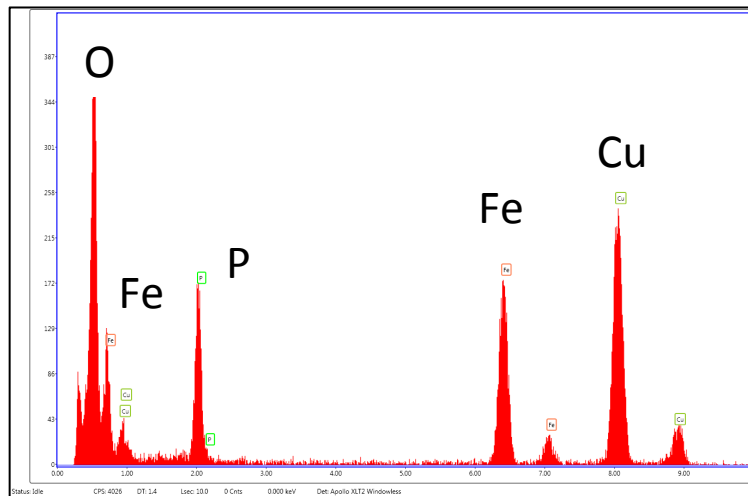
- X-ray emission spectrum is characteristic of unique atomic structure of element



TEM: also with the JEOL 2010 instrument...

➤ What will you learn?

- EDX: energy-dispersive X-ray spectroscopy analysis
 - atomic composition of heavier elements in material ($> \text{Na}^{11}$)
 - X-ray emission spectrum is characteristic of unique atomic structure of element
 - expected: Fe, P, O, Au, (Cu)
 - contamination: Na left? N, S (small elements, so buried in low-energy noise)



Today in lab

- TEM in 13-1012
 - 1:35pm: red/purple teams
 - 2:15pm: orange
 - 2:55pm: blue/pink
- How do TEM images relate to AuNP size / number ?
(see M3D1 Discussion page for details)



- Use your time wisely in 56-322:
 - M3 research proposal
 - M3 mini-report (outline)
 - Blog