

M3D4: Transmission Electron Microscopy (TEM)

05/04/2017



Only 3 days left ?!#?

- M3 research proposal (20%)
 - slides due Thursday, May 11th at 1pm
 - **bring one print-out** of your slides to 16-336
- Extra office hours **in the 56-322 lab** :

– Monday 05/08	2-5pm	Noreen
– Tuesday 05/09	9:30-11am	Leslie
–	2-5pm	Leslie
– Wednesday 05/10	9:30-11:20am	Leslie
–	2-5pm	Maxine
–	5-7pm	Noreen
– Thursday 05/11	9:30-10:30am	Maxine
–	5-7pm	Noreen



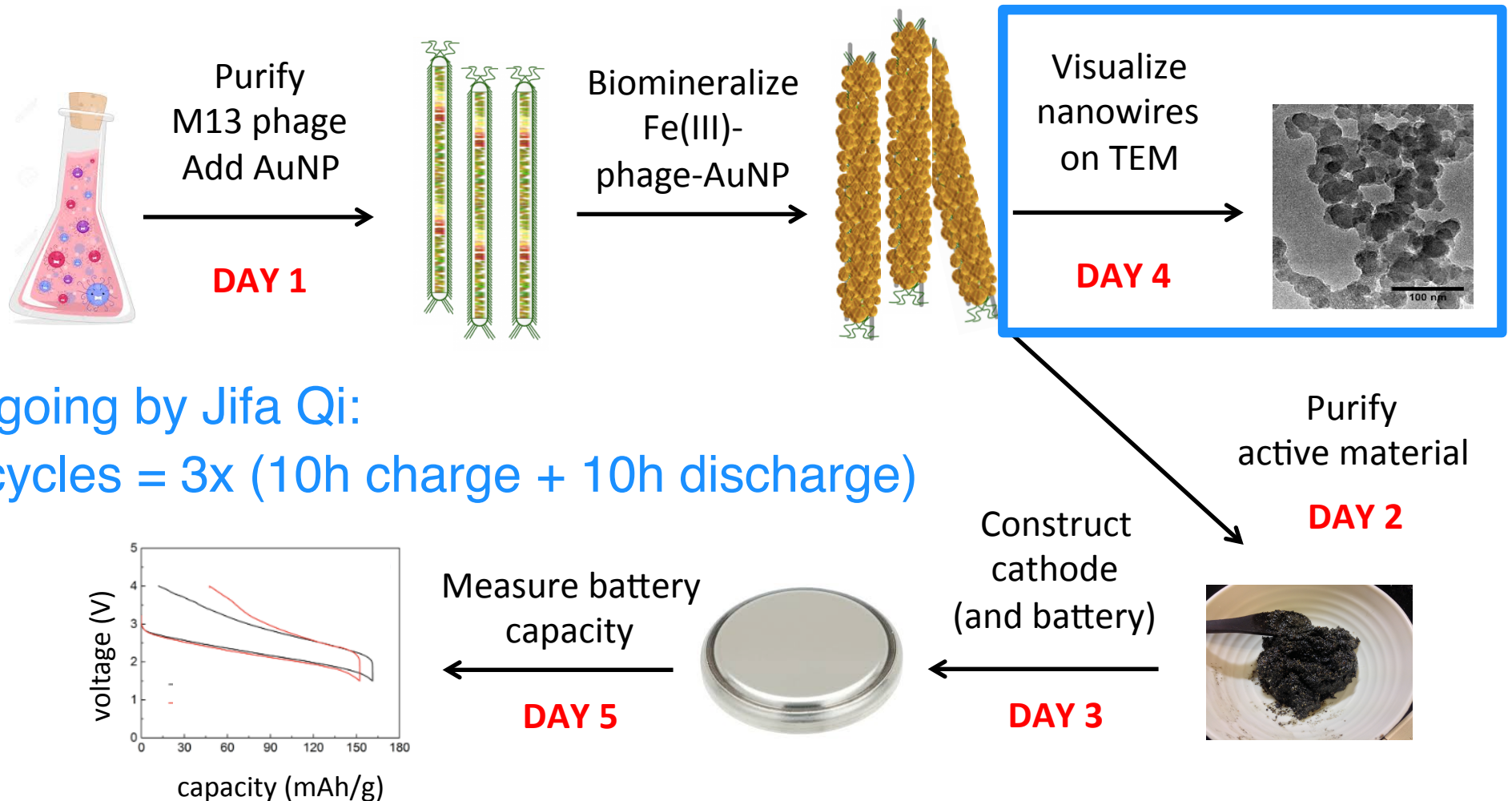
Only 3 days left ?!#?



- Blog post
 - due Thursday, May 11th at 10pm
- M3 mini-report (5%)
 - due Tuesday, May 16th at 10pm
 - 2-3 pages, no abstract, no methods section, combined results and discussion
- Quiz on M3D5

Module 3: biomaterials engineering

How does gold quantity affect battery capacity?

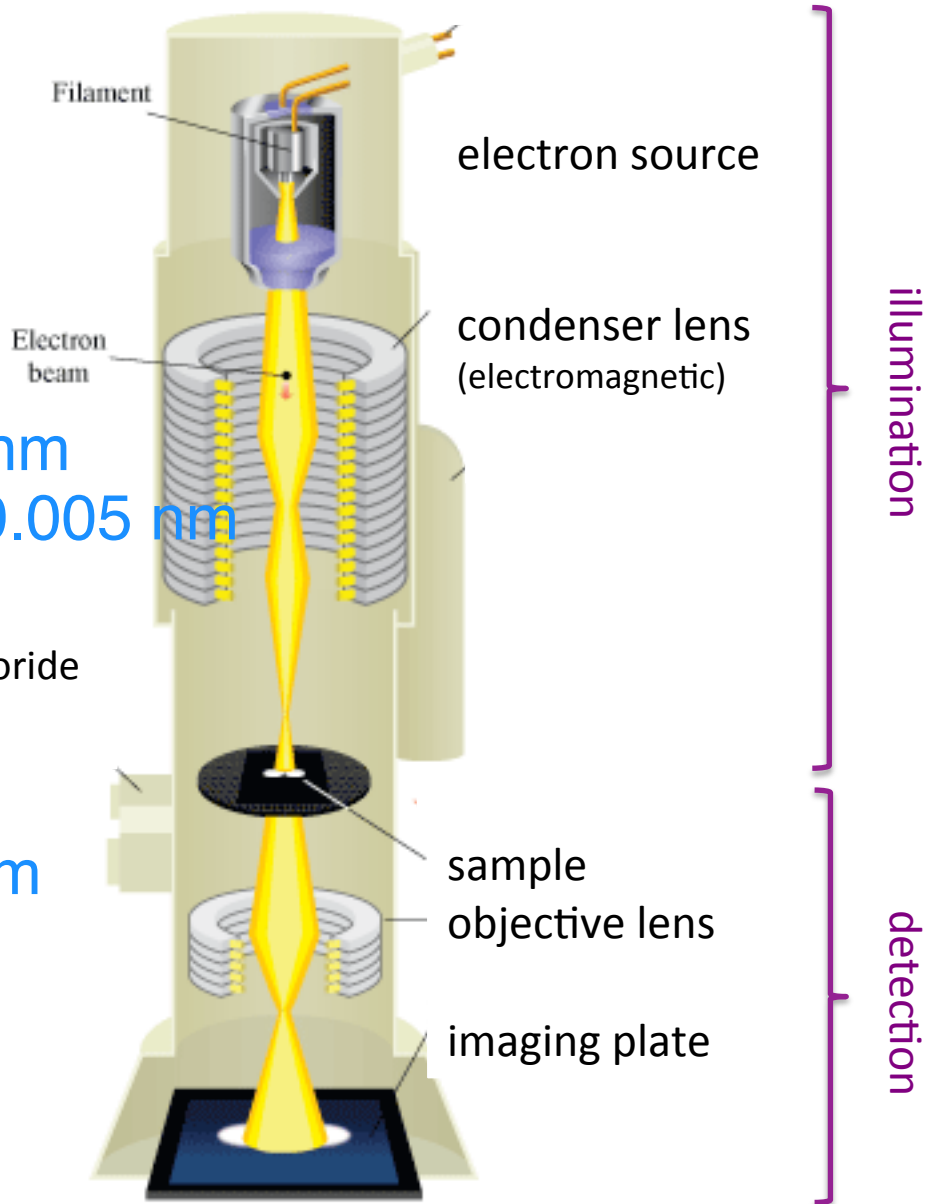


TEM: foundations

transmission electron microscopy

1931 Ernst Ruska (1986 Nobel Physics)

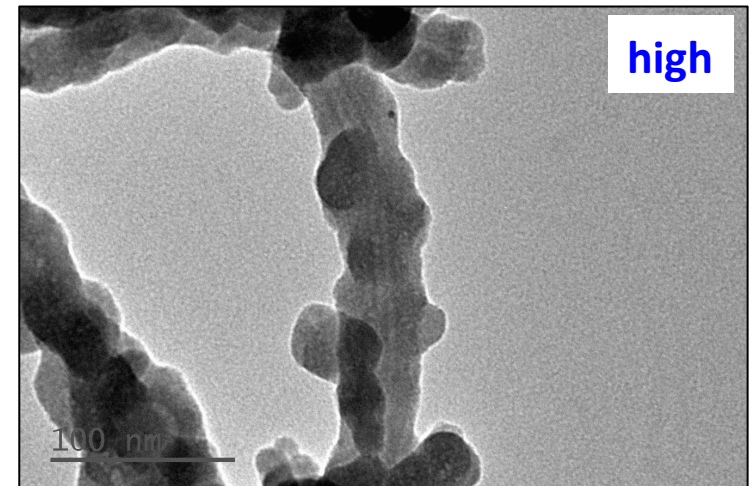
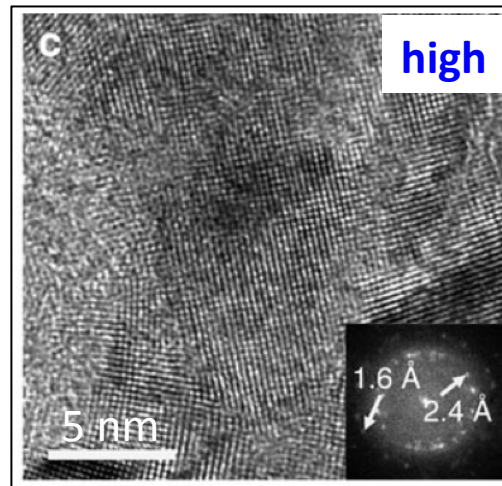
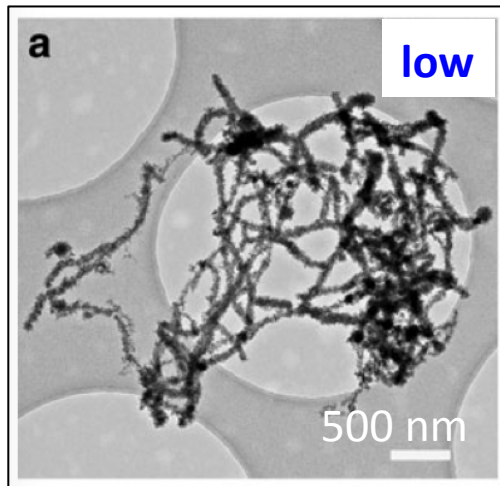
- High resolution $\sim 0.2 \text{ nm}$
 - compare to $\lambda_{\text{(blue light)}} \sim 400 \text{ nm}$
 - Rayleigh $R_{\text{light}} = 0.61 * \lambda / \text{NA} \sim 250 \text{ nm}$
 - de Broglie wavelength $\lambda_{(e^-)} \sim 5 \text{ pm} = 0.005 \text{ nm}$
- Electron source: 200 kV
 - thermionic emission by lanthanum hexaboride
 - vacuum and focusing lenses
- Sample preparation
 - thin and sturdy $10 \text{ nm} - 100 \text{ um}$
 - grid: **Cu conductive**
 - biology: not *in situ*
- Image \approx sample *density*
 - e^- pass through & are also scattered
 - phosphor screen, YAG-coupled CCD



TEM: your experiments, your mini-report

➤ What will you learn?

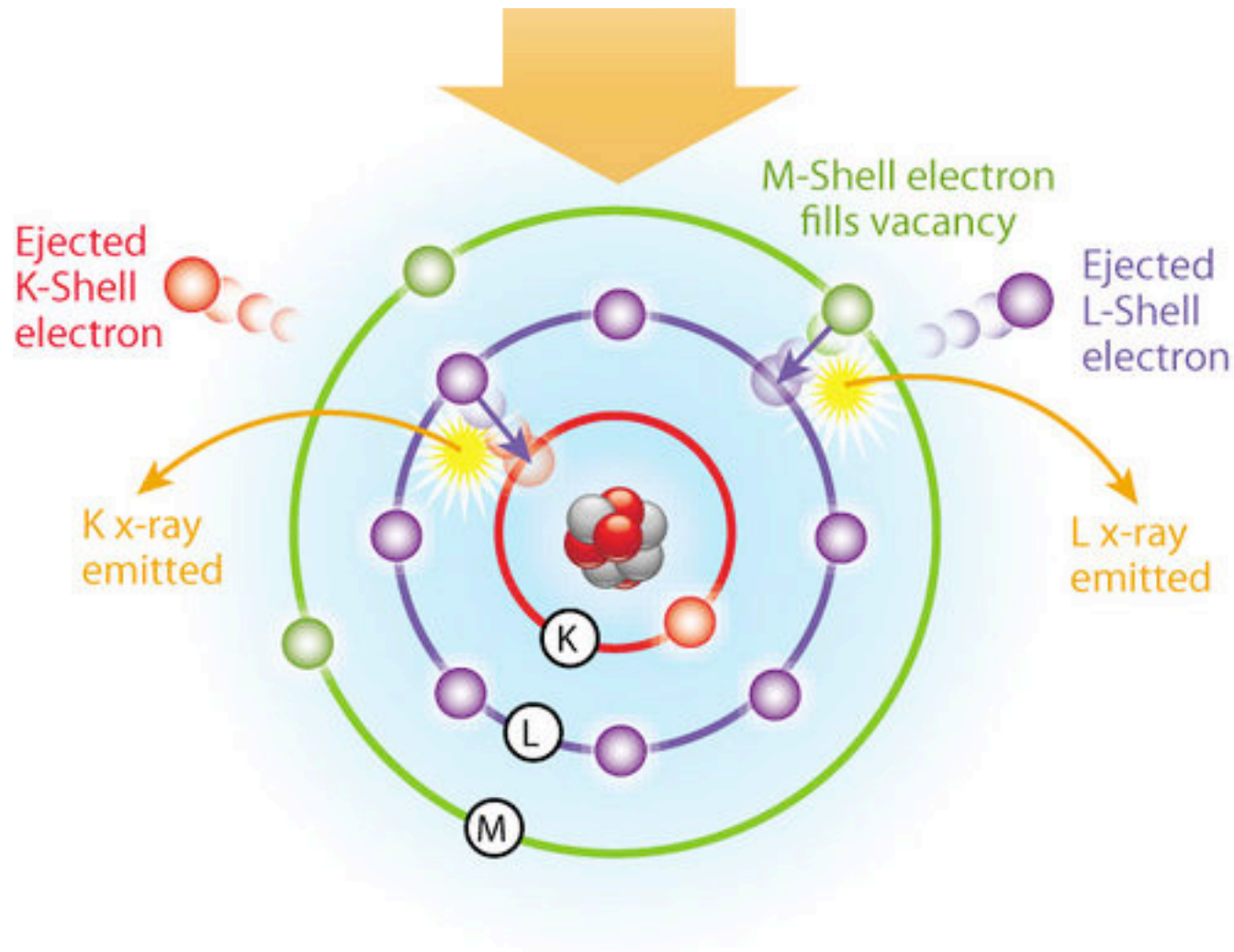
- at low magnification: density of nanowire, uniformity, overall morphology, "cross linking", length
- at high magnification: nanoparticles, possibly crystal lattice of Au, amorphous FePO₄, diameter of nanowire, phase?



from Belcher Lab's *Nature Communications* 2013, doi:10.1038/ncomms3756

Elemental mapping by EDX

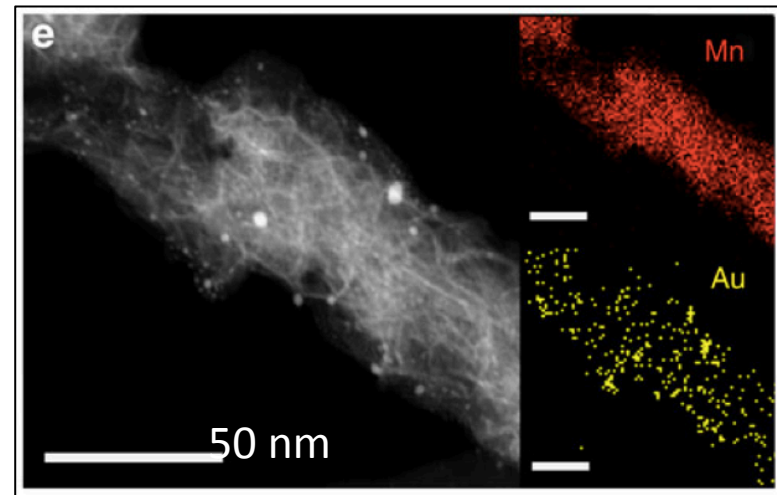
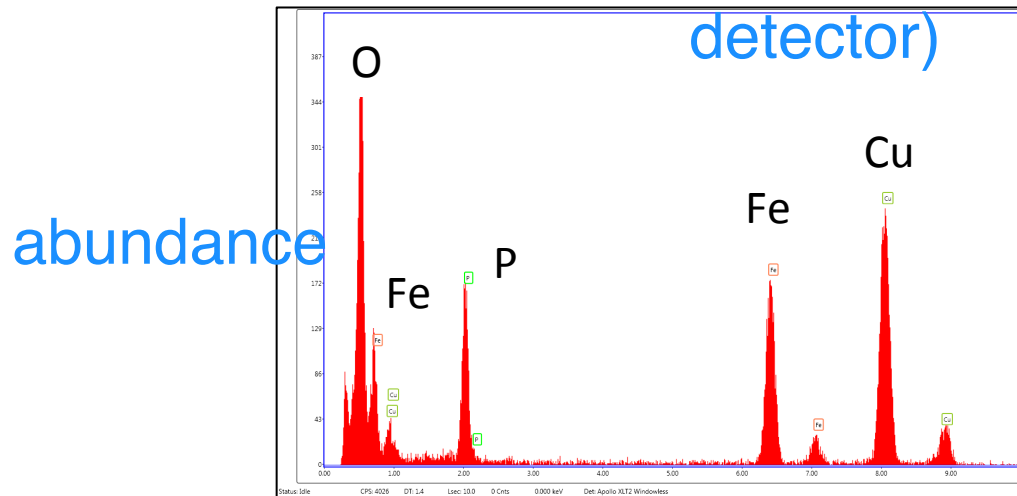
- X-ray emission spectrum is characteristic of unique atomic structure of element



TEM: also with the JEOL JEM-2100 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: **P, O, Fe, Au, Cu, (C)**
 - contamination: **S (from $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2$)**
Na (from Na PO_4), and maybe Si (from X-ray



energy (eV) from Belcher Lab's *Nature Communications* 2013, doi:10.1038/ncomms3756

Today in lab

- TEM at the Koch Institute (76):
 - What can your TEM images suggest about the phage biomineralization and AuNP binding?
 - Are the AuNP the correct size?



- Use your time wisely in 56-322:
 - draft your research proposal slides
 - discuss how the presentation speaking parts will be shared
 - review rubric to make sure you are including all components necessary