

M3D4: TEM

Transmission Electron Microscopy

12/02/2016



14
WORLD CLASS INSTITUTIONS

8
WEEKS OF MENTORED RESEARCH

1
TRIP TO WASHINGTON DC

The 2017 National Cancer Institute

**Systems Biology &
Physical Sciences in Cancer
Summer Research Program**

Undergraduate students interested in solving complex problems in cancer through interdisciplinary research are encouraged to apply at <https://Frederick.cancer.gov/SummerProgram> by February 15, 2017.

Open to Rising Junior and Senior Undergraduates

Must be a US Citizen

\$4000 Stipend + Free Housing

Support for Travel to/from Research Institution

Two-Day Research Conference at NIH in Bethesda, MD

SPONSORED BY THE NATIONAL CANCER INSTITUTE OF THE NIH

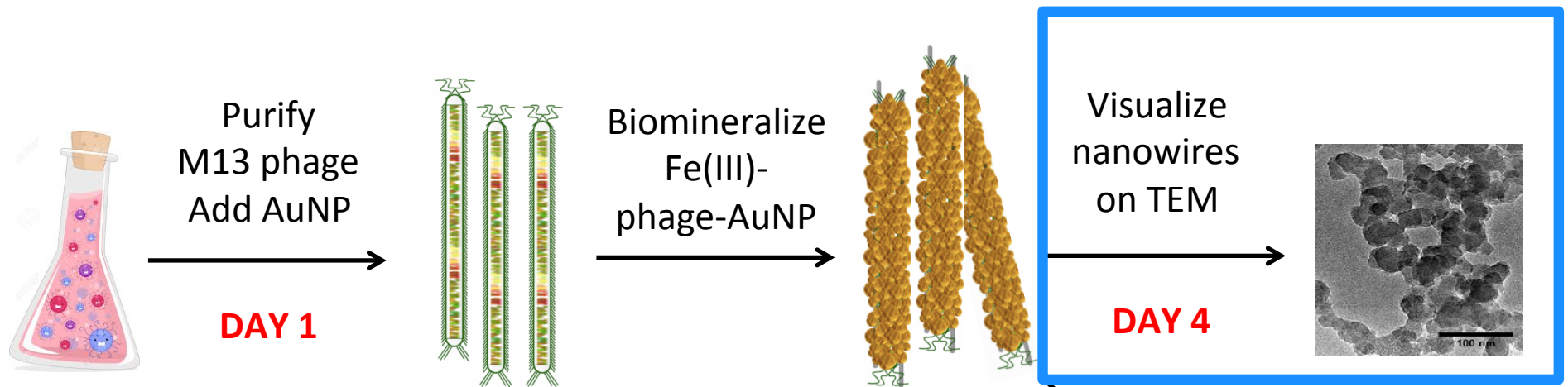
Only 3 days left ?!#?



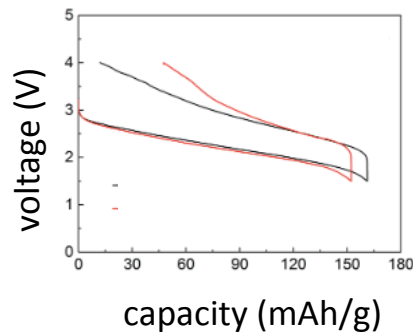
- M3 research proposal (20%)
 - slides due Friday, December 9th at 1pm
 - bring one print-out of your slides to 16-336
 - extra office hours:
 - Monday 12/05 1-7pm 56-302
 - Tuesday 12/06 10-11am 16-239
 - Wednesday 12/07 11am-12pm 16-239
 - 5-7pm 56-302
- M3 mini-report (5%)
 - due Monday, December 12th at 10pm
 - 2-3 pages, no abstract, no methods section, combined results and discussion
- Quiz on M3D5
- Blog posts
 - due Wednesday, December 14th at 10pm

Module 3: biomaterials engineering

How does gold size affect battery capacity?



ongoing by Jifa Qi
3 cycles = 3x (2h charge + 2h discharge)



Measure battery capacity
DAY 5



Construct cathode (and battery)
DAY 3



Purify active material
DAY 2

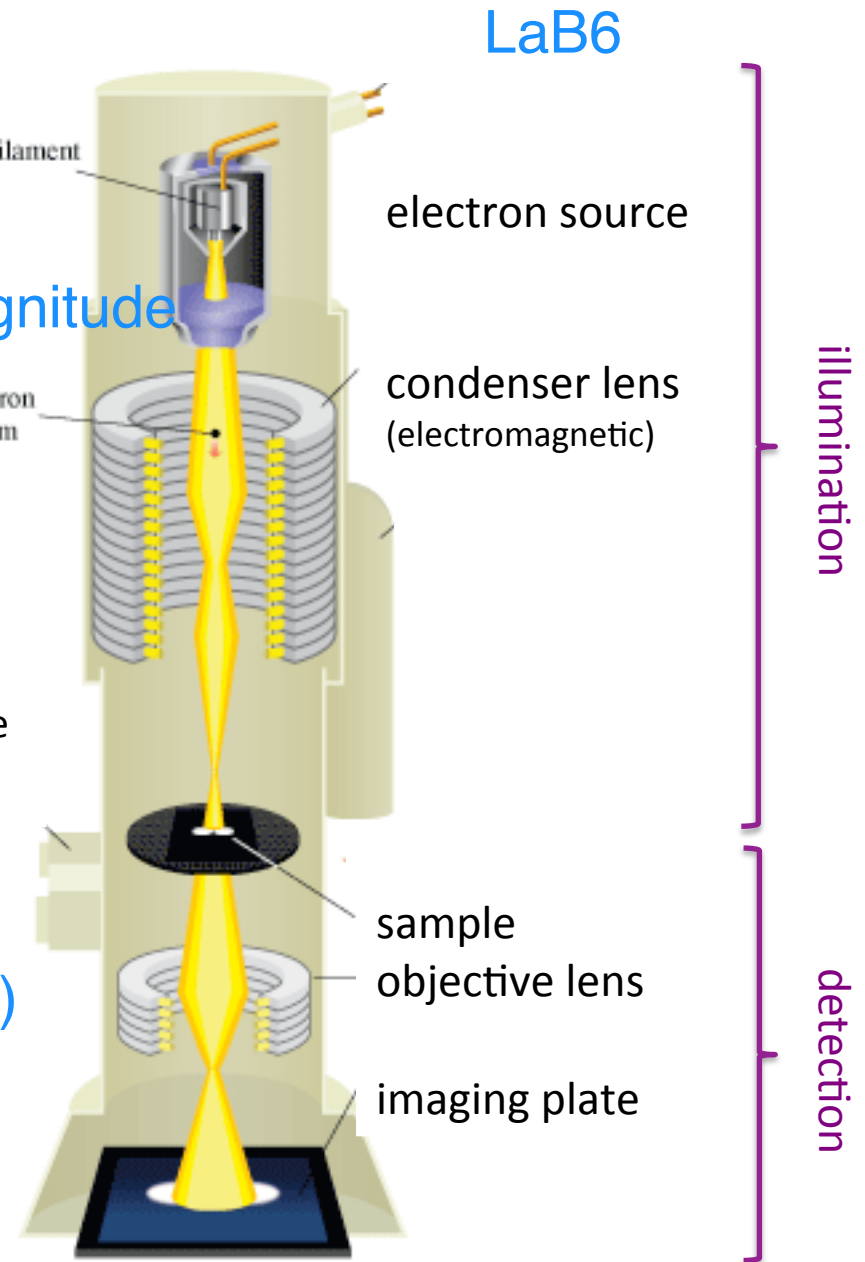
TEM: foundations

transmission electron microscopy

1931 Ernst Ruska (1986 Nobel Physics)

- High resolution \sim **0.14 nm**
 - compare to $\lambda_{\text{(blue light)}} \sim 400 \text{ nm}$
 - Rayleigh $R_{\text{light}} = 0.61 * \lambda / \text{NA} \sim$ **250 nm**
 - de Broglie wavelength $\lambda_{(e^-)} \sim$ **5 pm**
- Electron source: 200 kV **0.005 nm**
 - thermionic emission by lanthanum hexaboride
 - vacuum and focusing lenses
- Sample preparation
 - thin and sturdy **10 nm - 100 um**
 - grid: **copper + formvar (carbon)**
 - biology: not *in situ*
- Image \approx sample *density*
 - e^- pass through & are also scattered
 - phosphor screen, YAG-coupled CCD

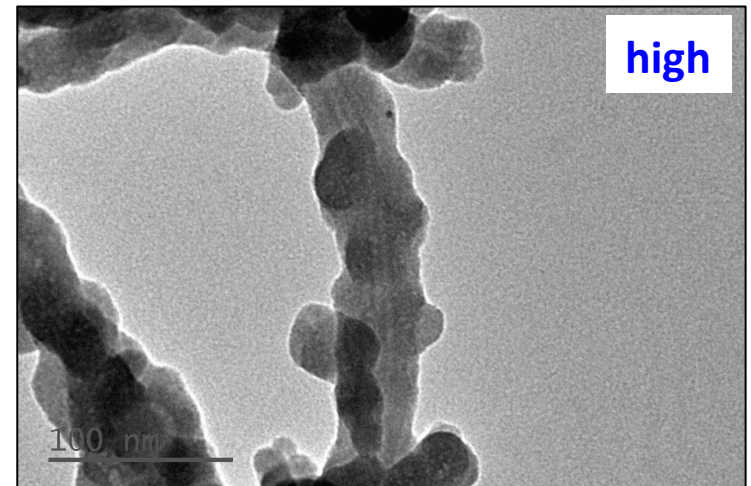
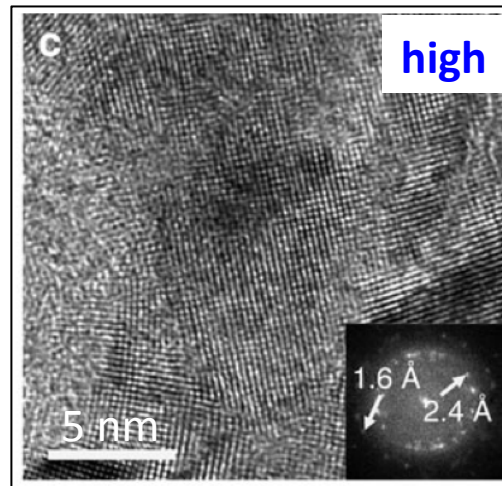
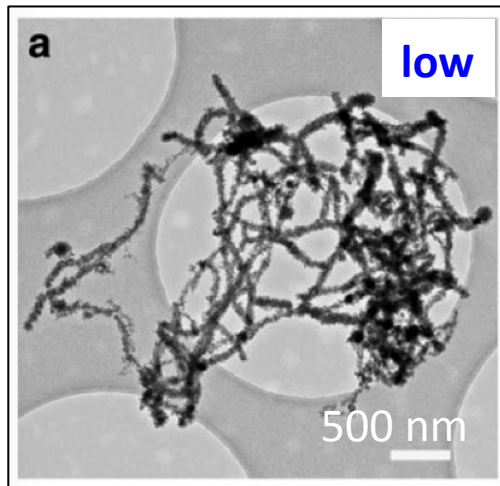
electrons to photons



TEM: your experiments, your mini-report

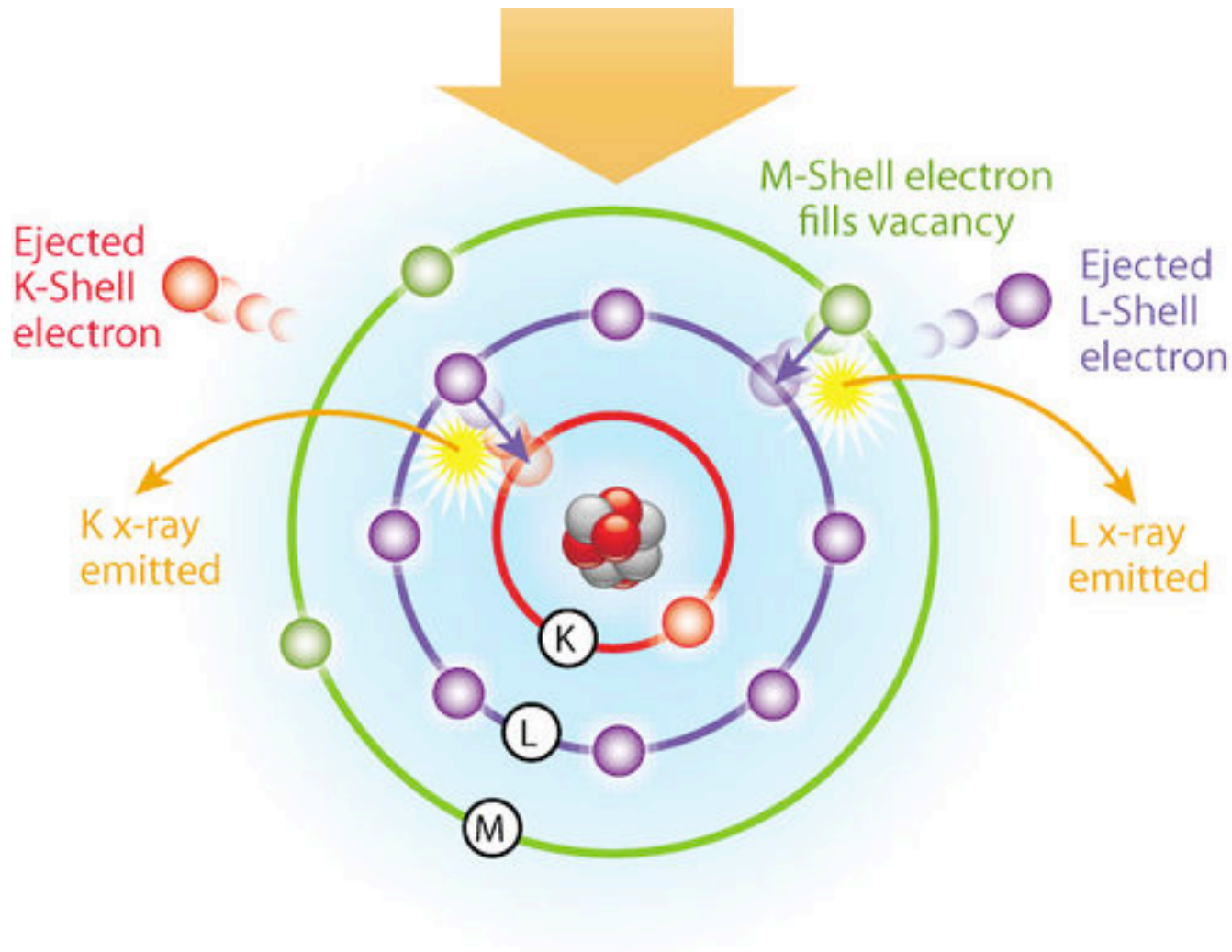
➤ What will you learn?

- at low magnification: overall structure, bundling/clustering, precipitation (biomineralization), length, "cross linking"
- at high magnification: crystal gold, amorphous vs. crystal Fe(III)PO₄, diameter of nanowires, exact diameter of AuNP



Elemental mapping by EDX

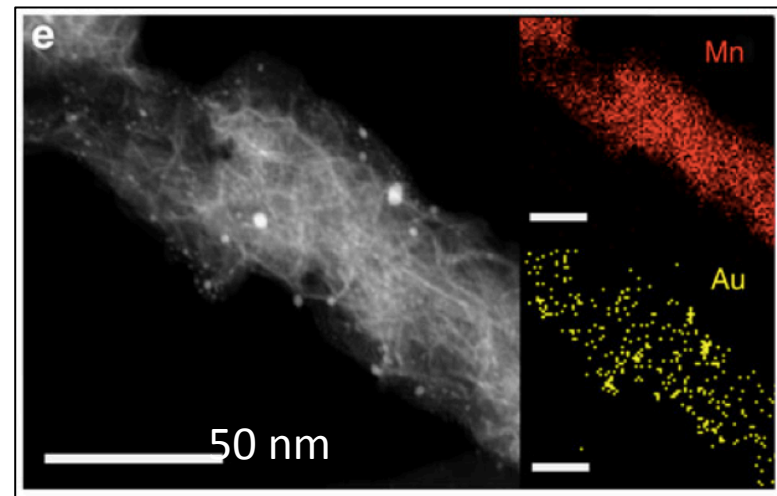
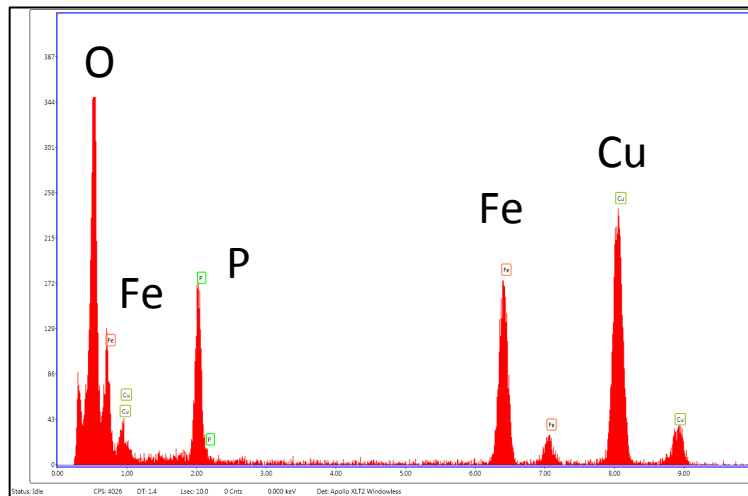
- X-ray emission spectrum is characteristic of unique atomic structure of element



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, (C),
 - contamination: S (from $\text{SO}_4 [2-]$), (NH_4), Na (from Na^+)



energy (eV)

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

Today in lab

- TEM in 13-1012:
 - 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