

M3D4: Transmission Electron Microscopy (TEM)

5/5/2017

1. *Quick* Prelab Discussion
2. Half of class goes to TEM (Koch)
3. Half of class works on research proposal
(presentations in one week!)

Only three 20.109 days left (?!#?)

- **M3 major assignments**

- Research proposal (20%) Friday May 12th 1pm

- upload slides to Stellar by deadline
- bring 1 print-out of your slides to 16-336

- Mini-report (5%) Monday May 17th 10pm **2-3 pages**

- No abstract, no methods section
- Background/Motivation, Figures and combined Results/Discussion

- Final blog post May 11th at 10pm

Figures:
EDX
TEM images
capacity

- **Extra Office Hours in 56-322:**

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

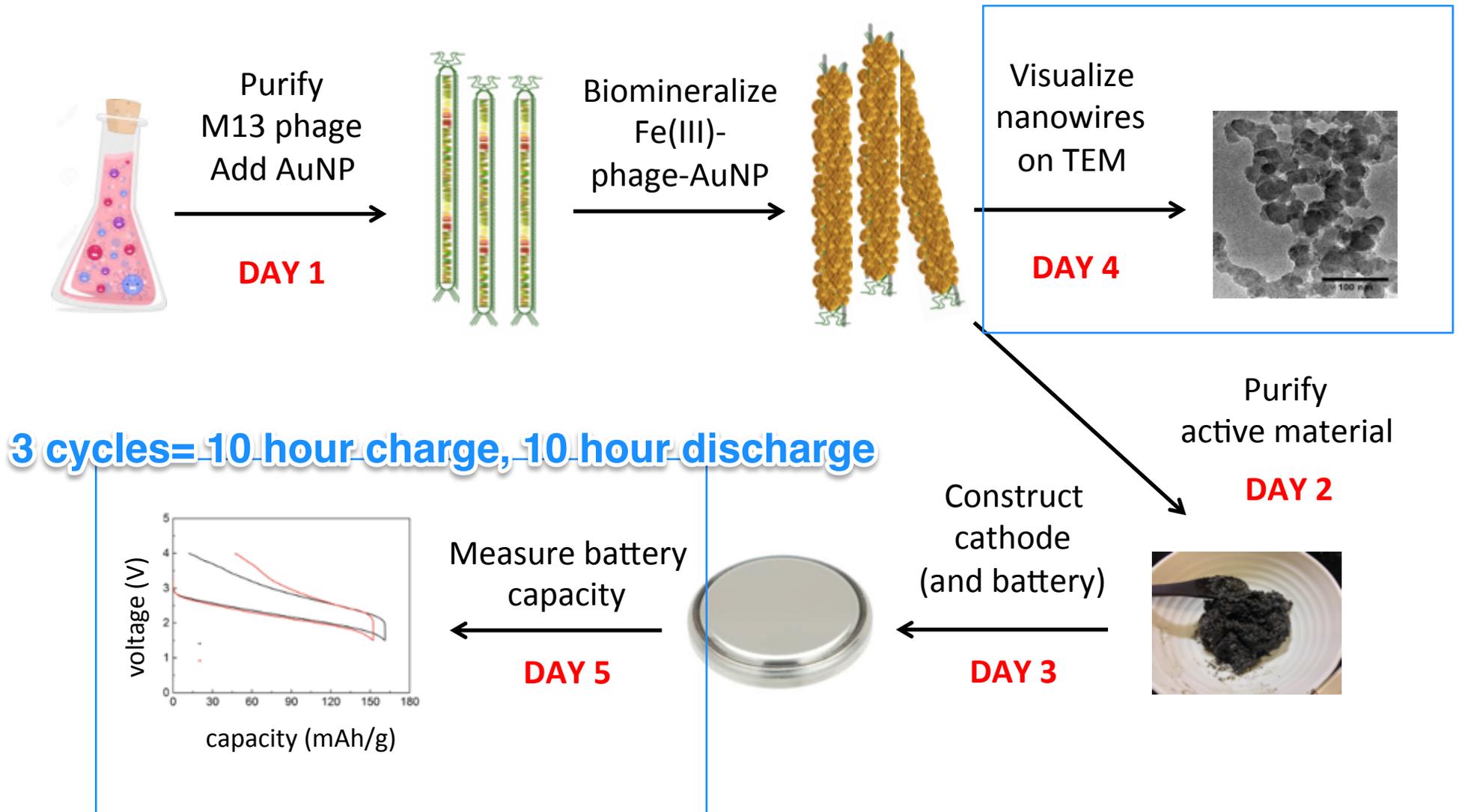
MIT **BE**
BIOLOGICAL ENGINEERING

Communication Lab

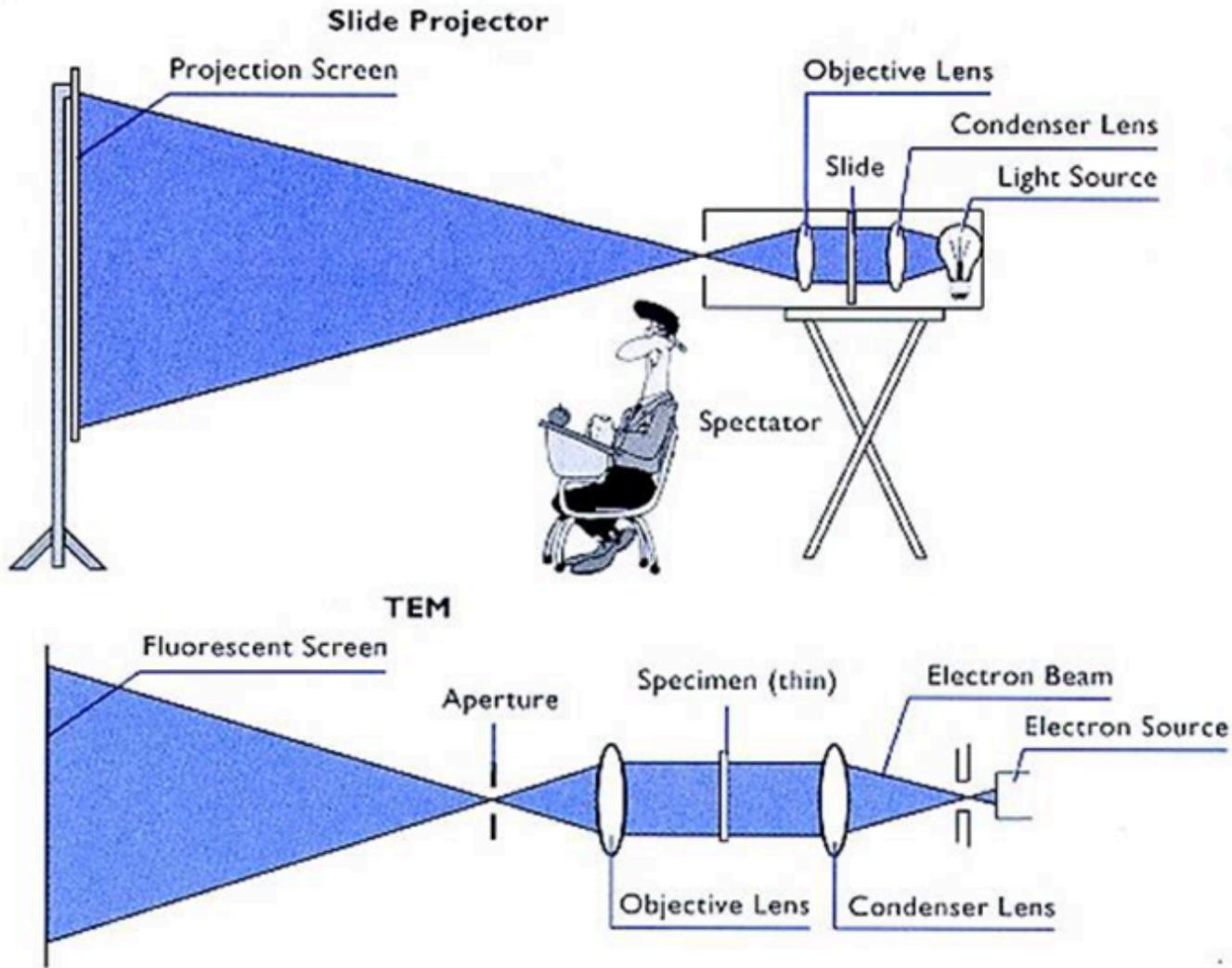
Make Comm Lab appointments!

Module 3: biomaterials engineering

How does gold quantity affect battery capacity?



TEM: basics

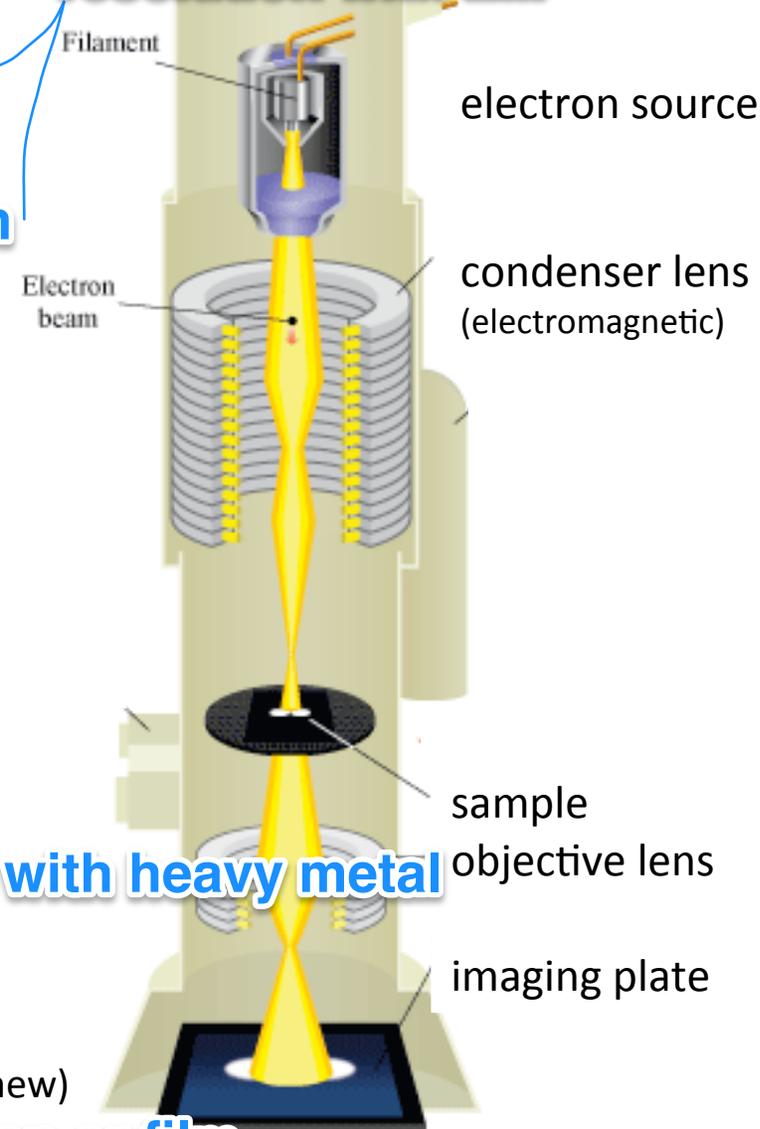


TEM: foundations

1931 Ernst Ruska (1986 Nobel Physics)

- High resolution \sim **0.2nm**
 - de Broglie wavelength $\lambda_{(e^-)} \sim$ **0.005nm**
 - compare to $\lambda_{(blue\ light)} \sim 400\text{ nm}$ **$\sim 250\text{nm}$**
 - Rayleigh $R_{light} = 0.61 * \lambda / NA$
- Electron source:
 - thermionic emission by tungsten, heated to $\sim 200\text{ kV}$
 - focusing lenses **electromagnetic**
 - vacuum **gas diffuses e-**
- Sample preparation
 - thin and sturdy **10nm-100um**
 - grid **copper**
 - **biomaterials must be coated with heavy metal**
- Image \approx sample *density*
 - e^- pass through & are also scattered
 - phosphor screen (old), YAG-coupled CCD (new)
 - **e- to photons=image on screen or film**

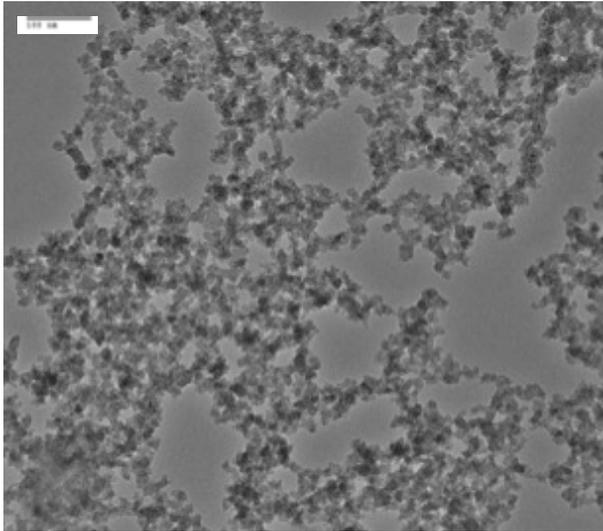
5 order of magnitude better resolution with EM



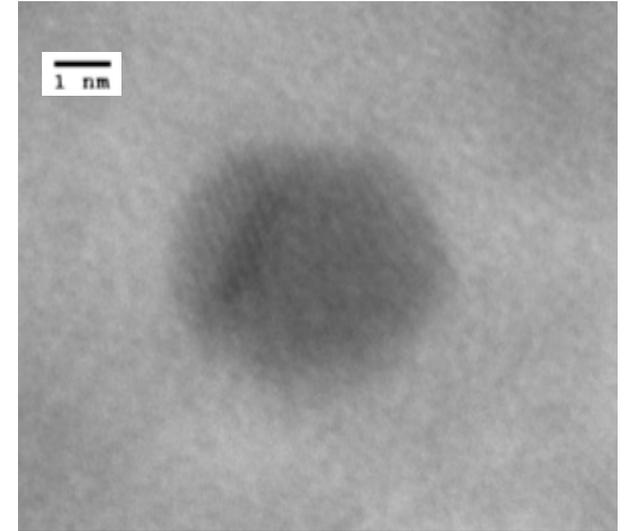
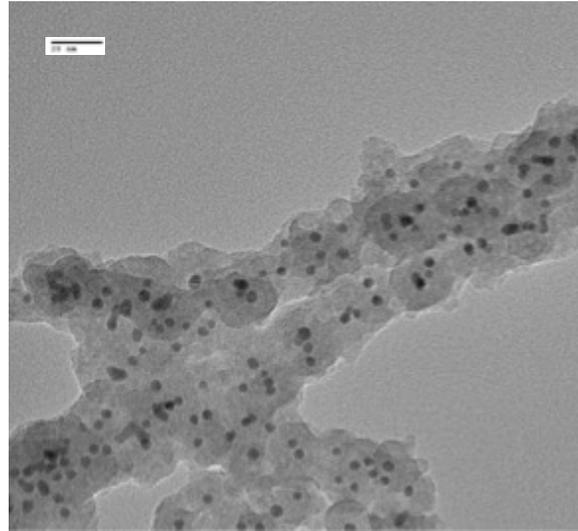
TEM micrographs

➤ What will you learn?

- at low resolution: **general morphology, density, uniformity, length**
- at high resolution: **diameter of nanowire, aFePO₄ or crystals, size of AuNP**



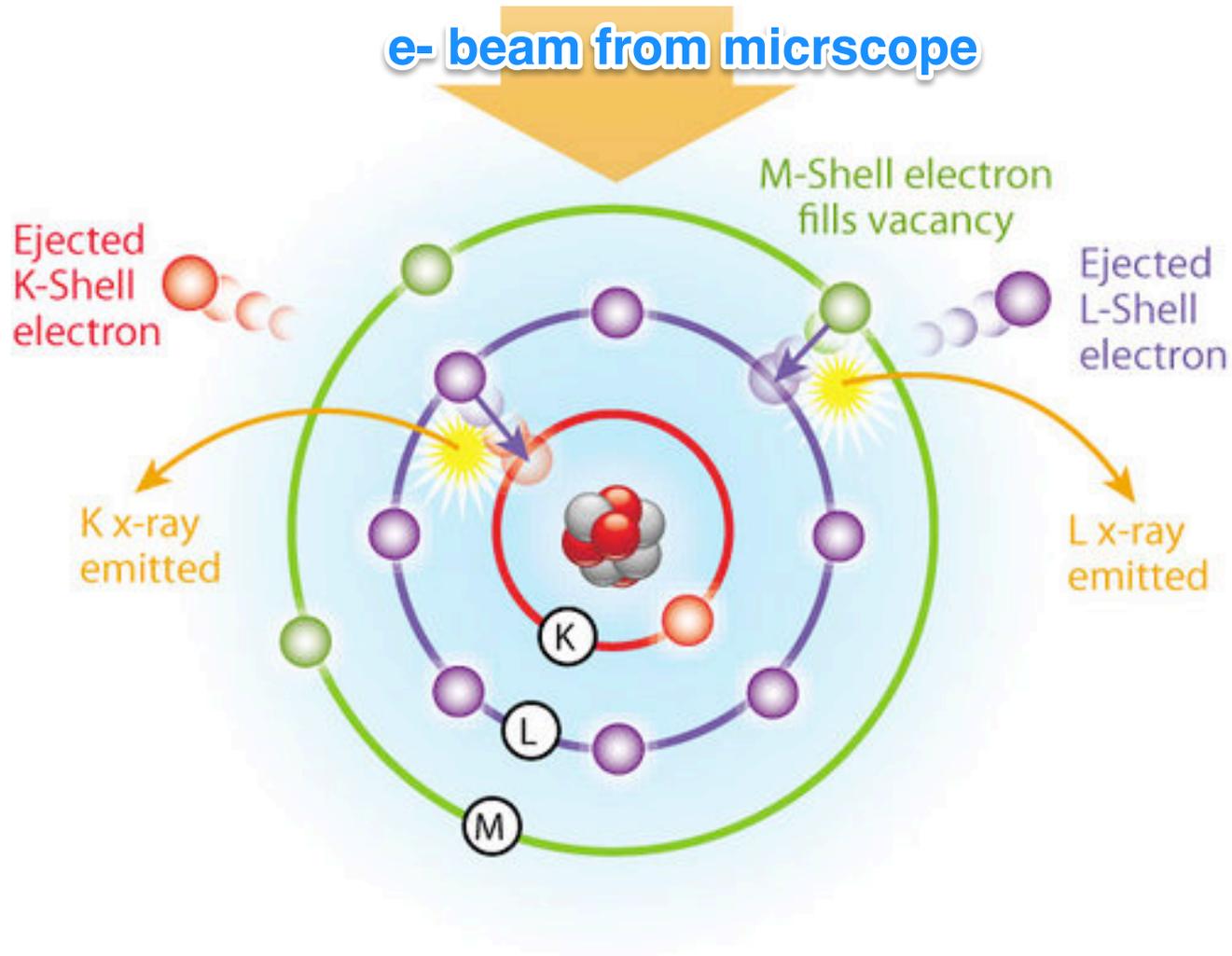
low



high

Elemental mapping by EDX

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

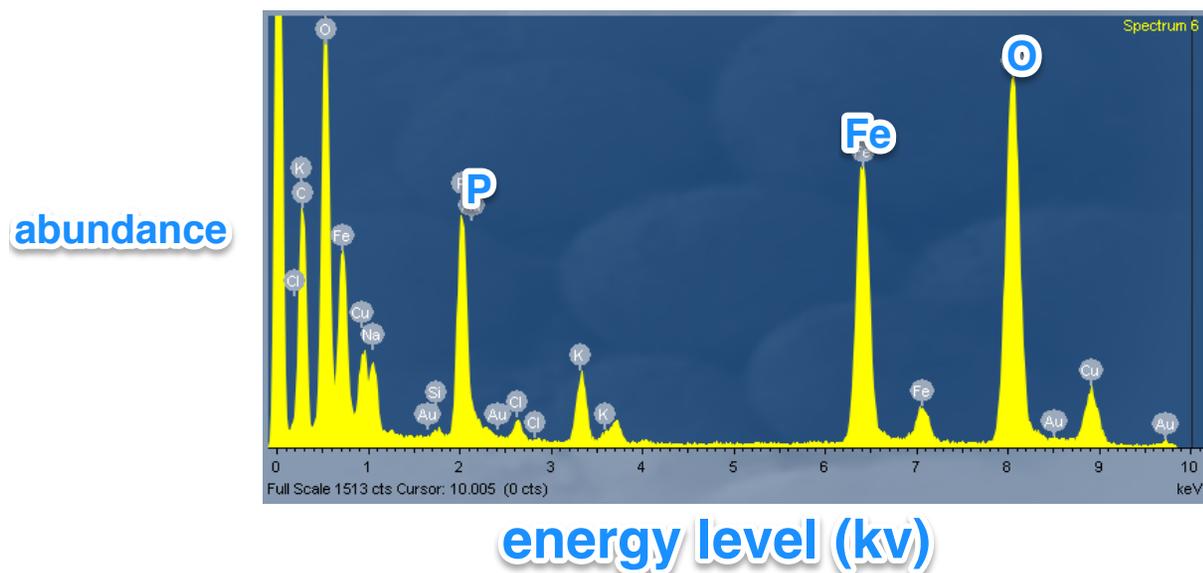


EDX analysis on JEOL, JEM2100

➤ What will you learn?

Ratios of elements

- EDX: energy-dispersive X-ray spectroscopy analysis
 - atomic composition of heavier elements in material
 - X-ray emission spectrum is characteristic of unique atomic structure of element
 - expected: **gold, iron, phos, copper, oxygen**
 - contamination: **sodium, sulfur**
silicon



Today in lab

- TEM in **Koch basement**
 - 1:30pm: pink/green
 - 2:15pm: red/yellow
 - 3:00pm: purple/blue
 - What can your TEM images suggest about the phage biomineralization and AuNP binding? Are the AuNP the correct size?
- M3D5HW: Calculate mA needed to discharge battery in 10hrs, handwritten or emailed calculations are fine, turn in individually
- Reminder: Quiz M3D5
- *Use your time wisely:*
 - draft your research proposal slides
 - discuss how the presentation speaking parts will be shared
 - draft talking point notes for presentation
 - review rubric on wiki to make sure you are including all components necessary