M3D4: Transmission Electron Microscopy (TEM)

11/30/2017

1. *Quick* Prelab Discussion
2. Two groups at a time go to TEM (Koch)
3. Class works on research proposal (**presentations in one week! 20% of your grade!**)

Only three 20.109 days left (?!#?)

- **M3 major assignments**
  - Research proposal (20%) Thursday Dec. 7th 1pm
    - upload slides to Stellar by deadline
    - bring **1** print-out of your slides to 16-336
  - Mini-report (5%) Monday Dec 11th 10pm
    - No abstract, no methods section
    - Background/Motivation, Figures and combined Results/Discussion

TEM, capacity, EDX

  - Final blog post: Dec. 8th by 10pm;Bonus blog: Dec 12th at 10pm
- **Extra Office Hours (find us in our offices):**

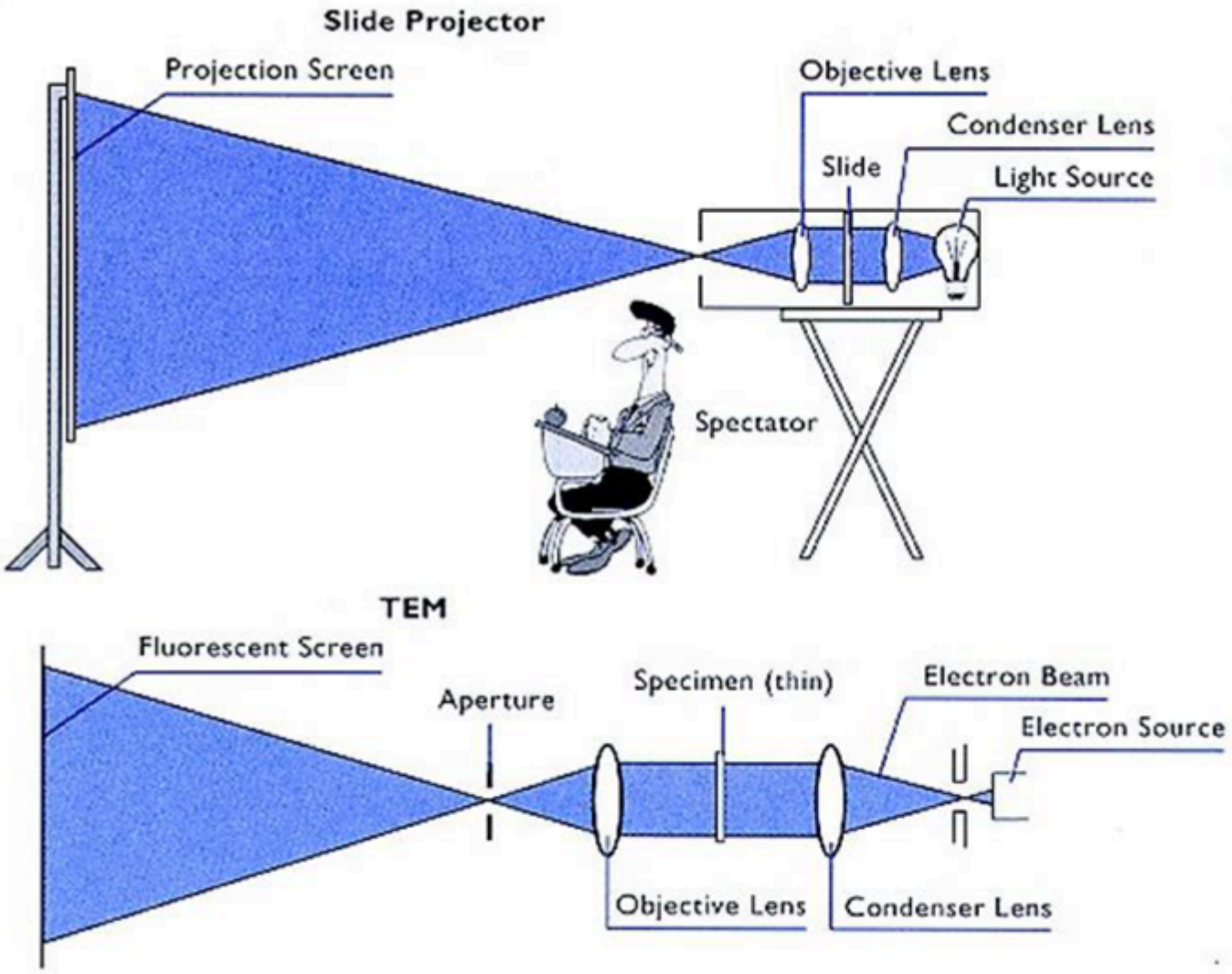
– Monday 11/4	1-5pm	Josephine, Noreen
– Tuesday 11/5	5-7pm	Noreen
– Wednesday 11/6	5-7pm	Noreen
– Thursday 11/7	2-3pm	Josephine
– Friday 11/8	10:30-12:30pm	Leslie

  - Email us to make appointments!

MIT BE BIOLOGICAL ENGINEERING | Communication Lab

Make Comm Lab appointments!

TEM: basics



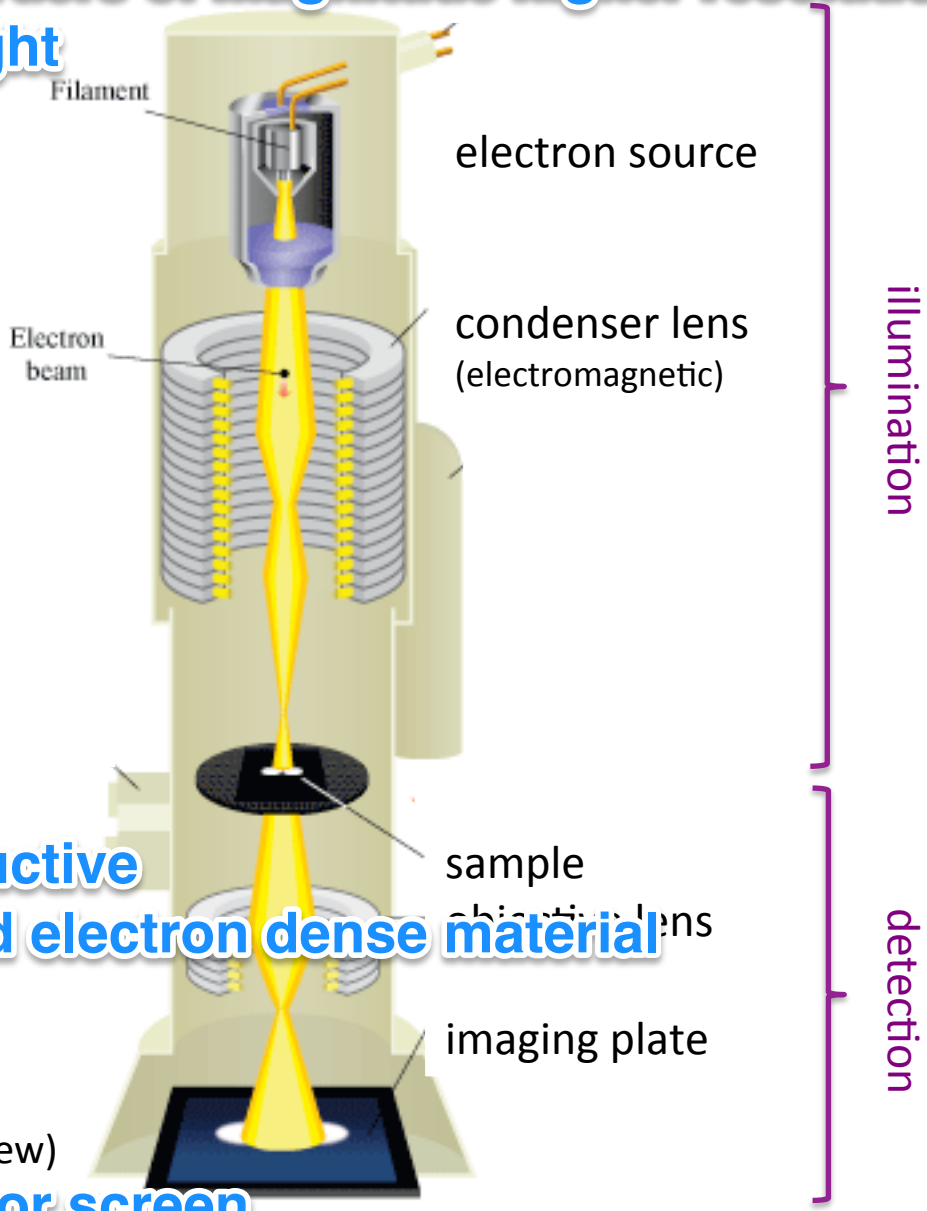
http://labs.mete.metu.edu.tr/tem/TEMtext/philips.jpg

TEM: foundations

EM 5 orders of magnitude higher resolution than light

1931 Ernst Ruska (1986 Nobel Physics)

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

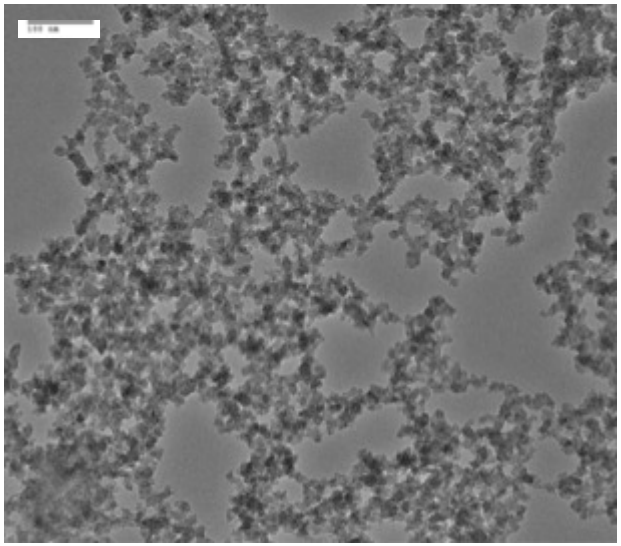


TEM micrographs **results, discussion text**

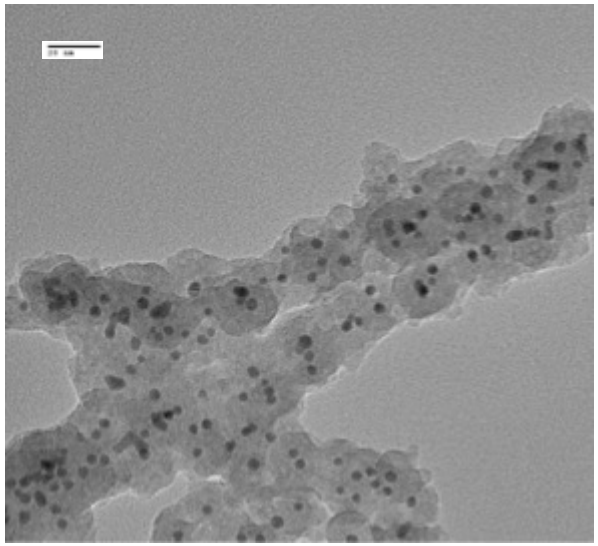
- What will you learn?

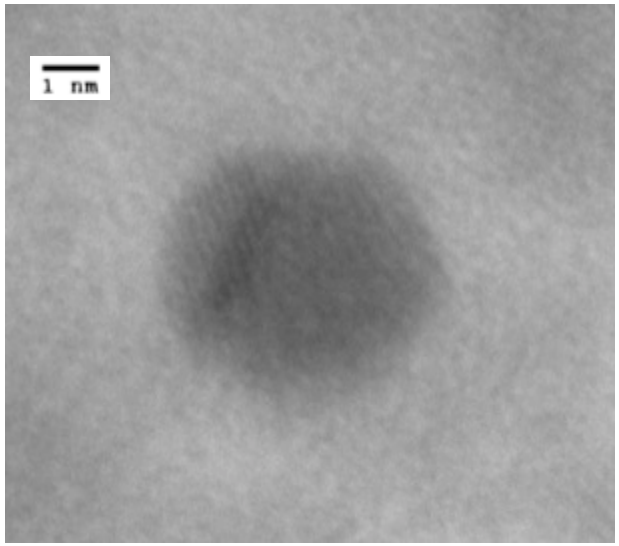
- at low resolution: **length of nanowire, general morphology, # of np, diameter of nanowire, uniformity, density**
- at high resolution:

  size of nanoparticle, amorphous vs. crystalline FePO4



low



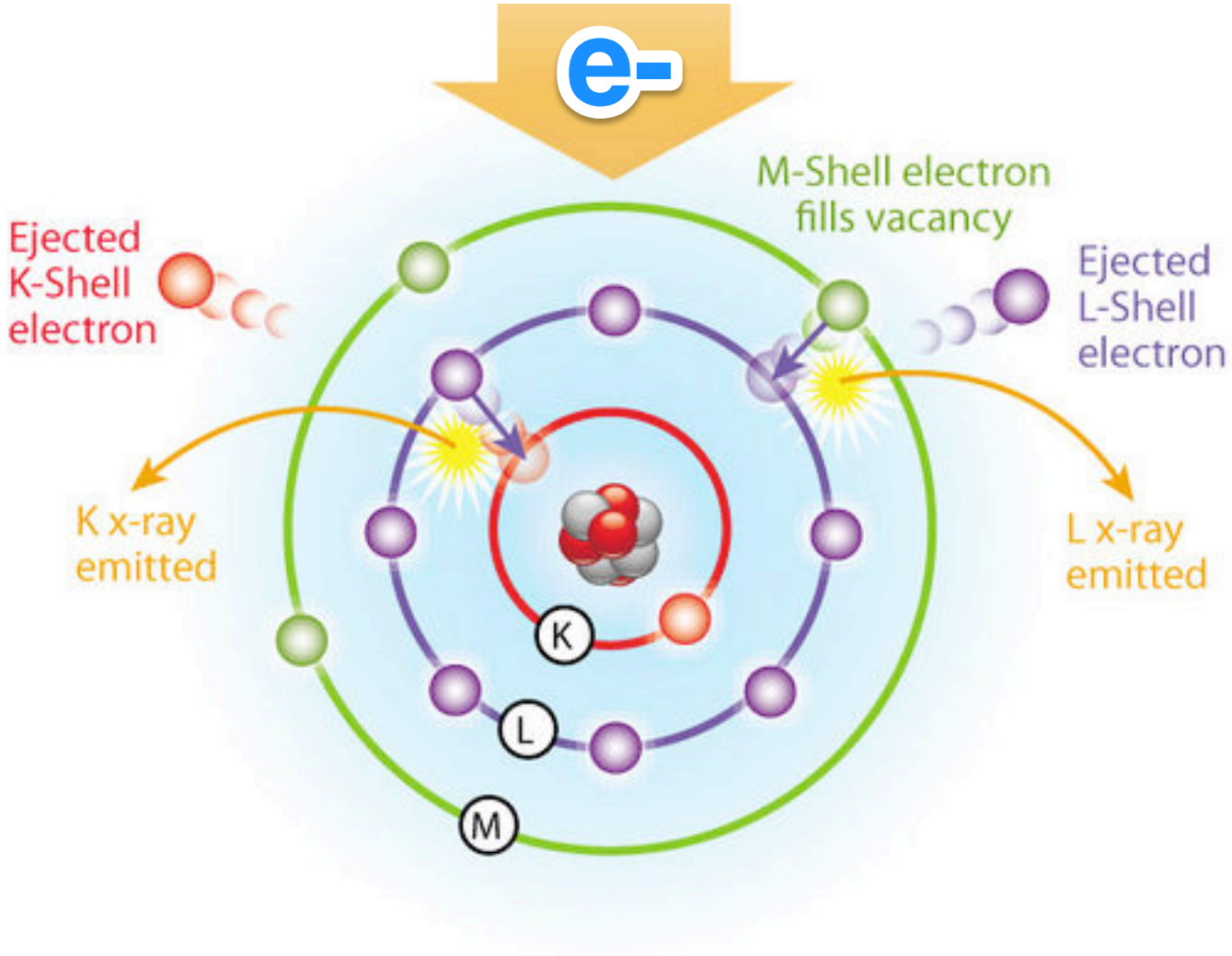


high

from Spring 2016 20.109

Elemental mapping by EDX

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

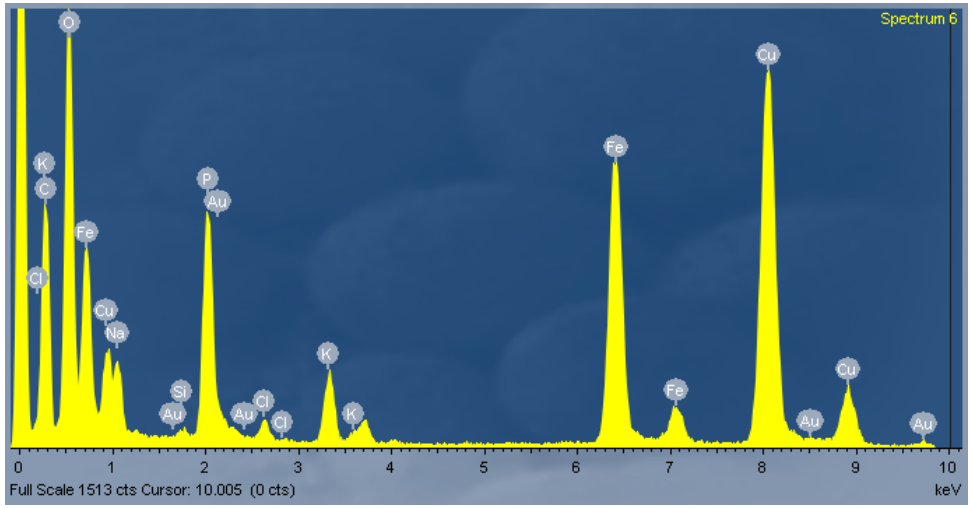


EDX analysis on JEOL, JEM2100

- What will you learn? at what ratios?

- 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: iron, gold, nickel, phosphate, oxygen, carbon, copper
  - contamination: sodium, silicon

abundance



energy level

Today in lab…

- TEM in **Koch basement**
  - 1:30pm: Yellow/ Green
  - 2:15pm: Blue/ Pink
  - 3:00pm: Purple/White
  - 3:45pm: Red/Orange
  - ➢ What can your TEM images suggest about the phage biomineralization, AuNP and NiNP binding? Are the NP the size expected?

- M3D5HW: Calculate mA needed to discharge your experimental battery (choose 1 cathode weight) 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