M3D4: Transmission Electron Microscopy (TEM)

12/1/2017

1. *Quick* Prelab Discussion
2. One group 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 assignments**
  - Research proposal (20%) Friday Dec. 8th 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
  - Final blog post about Mod 3: Dec. 8th by 10pm
  - Bonus blog: Dec 12th at 10pm *Note this is a slight change from wiki

TEM, capacity, EDX

- **Extra Office Hours (find us in our offices):**

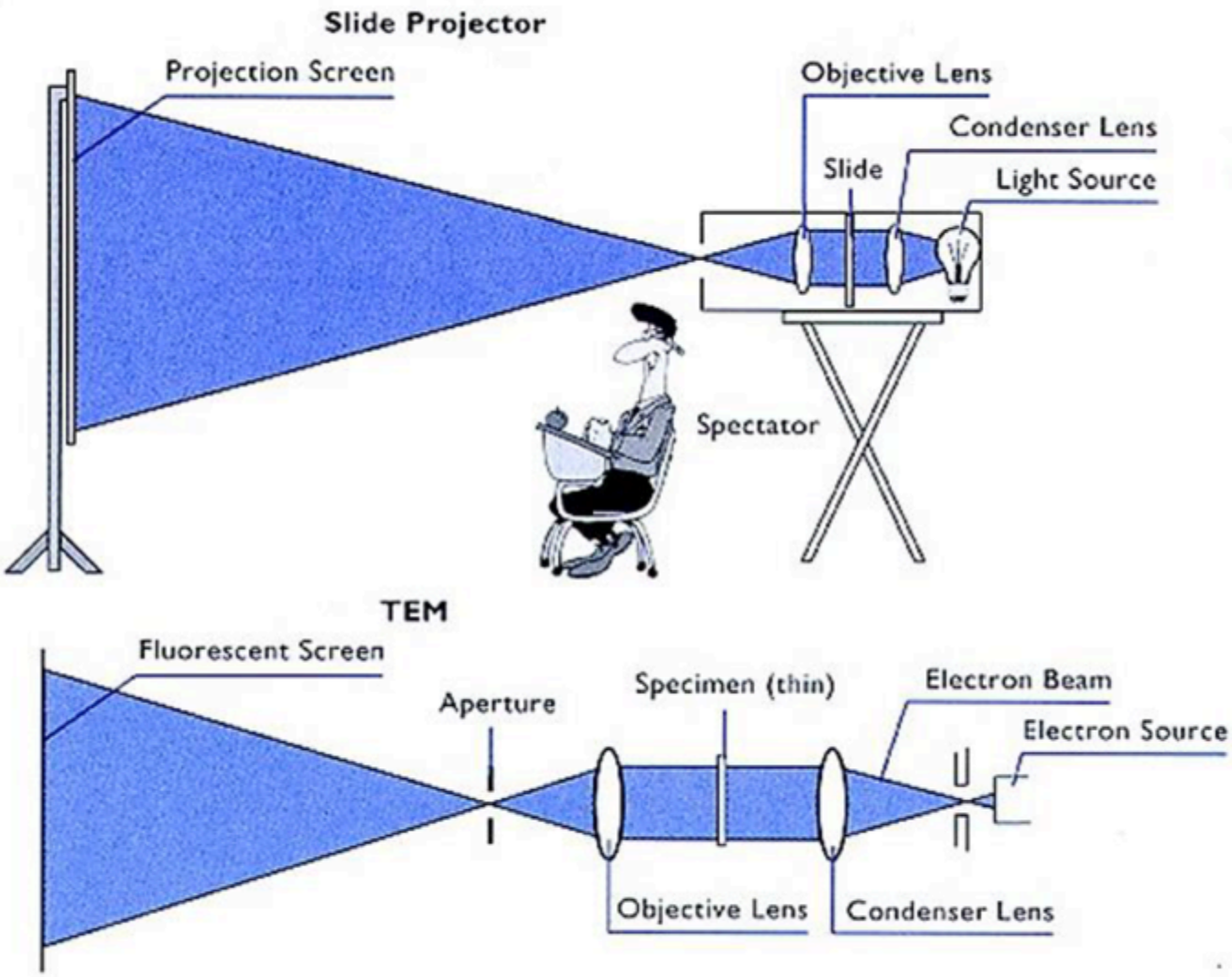
– Monday 11/4	1-5pm	Josephine, Noreen
– Tuesday 11/5	5-7pm	Noreen
– Wednesday 11/6	5-7pm	Noreen
– Email me		Josephine
– Friday 11/8	10:30-12:30pm	Leslie

  - Email us to make appointments!

MIT BE BIOLOGICAL ENGINEERING | Communication Lab

Make Comm Lab appointments!

TEM: basics

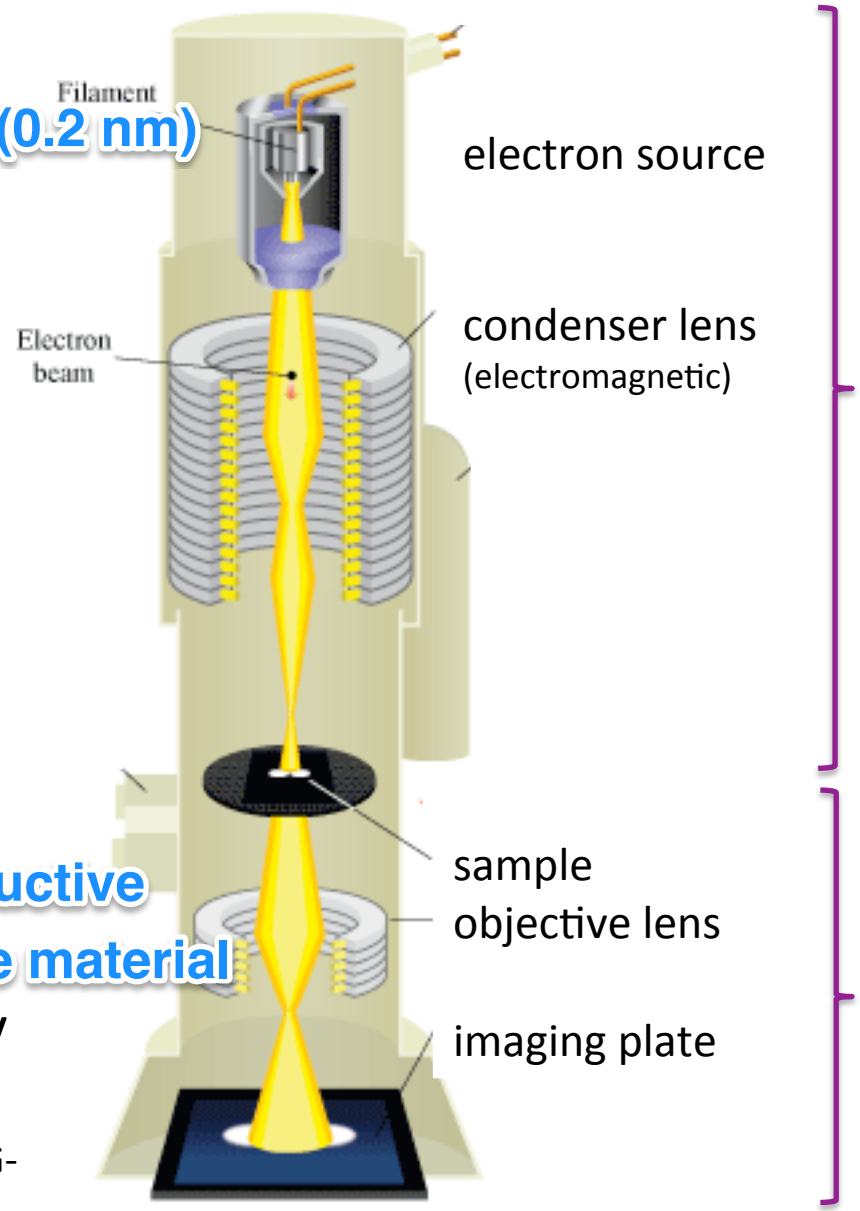


http://labs.mete.metu.edu.tr/tem/TEMtext/philips.jpg

TEM: foundations

1931 Ernst Ruska (1986 Nobel Physics)

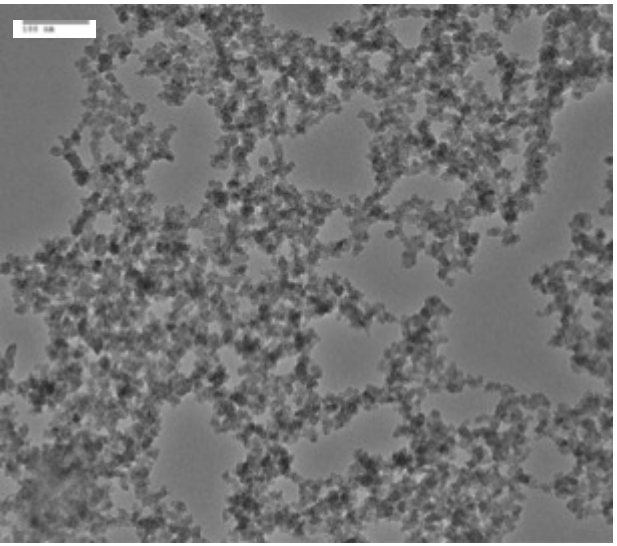
- High resolution ~ **~2 Angstroms (0.2 nm)**
  - de Broglie wavelength $\lambda_{(e-)}$ ~ **0.05 A**
  - Compare to $\lambda_{(\text{blue light})}$ ~ 400 nm
  - Rayleigh $R_{\text{light}} = 0.61 * \lambda / NA$
- Electron source:
  - Thermionic emission by tungsten
  - Accelerating voltage ~ 200 kV
  - Focusing lenses **electromagnetic**
  - Vacuum **gas scatter e-**
- Sample preparation
  - Thin and sturdy **10nm-100um**
  - grid **copper: sturdy and conductive**
  - **biomaterial coated in e- dense material**
- Image ≈ sample electron density
  - e^- pass through & are also scattered
  - phosphor screen (visualization by eye), YAG-coupled CCD (capture image)
  - **e- to photons --> imaged on film/screen/camera**



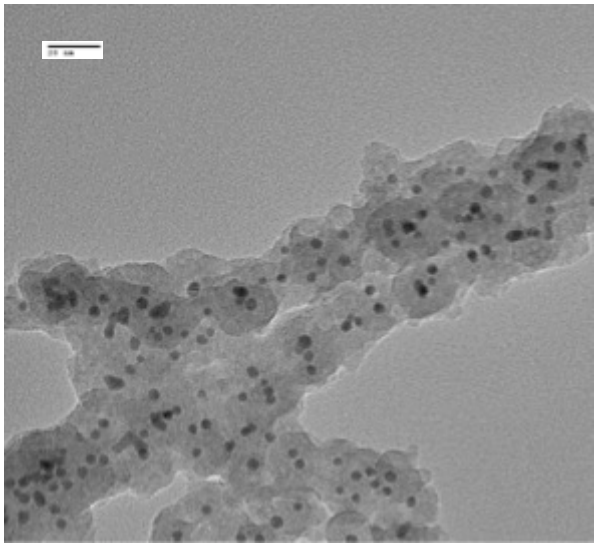
TEM micrographs

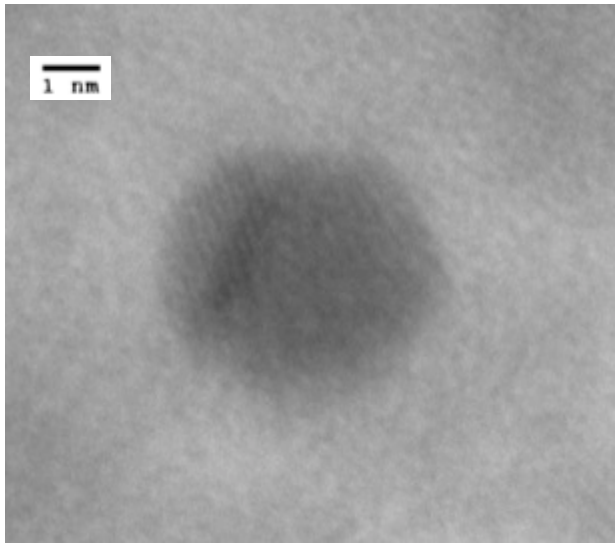
➢ What will you learn?

- At low resolution: **morphology, length of nanowires, diameter, uniformity, mineralization, # NP**
- At high resolution: **amorphous vs crystalline, crystal plane, size nanoparticles**



low



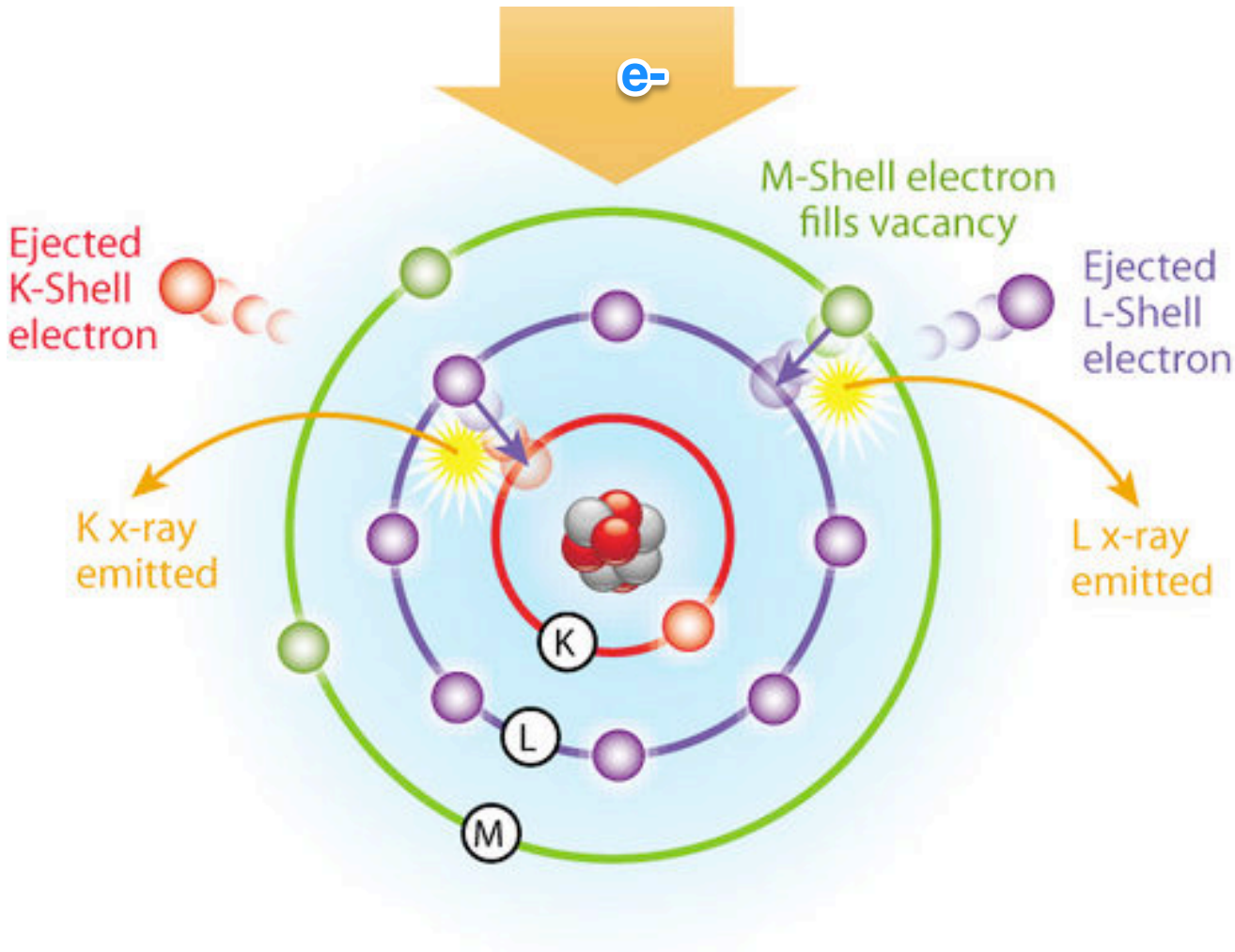


high

from Spring 2016 20.109

Elemental mapping by energy dispersive x-ray spectroscopy (EDX)

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

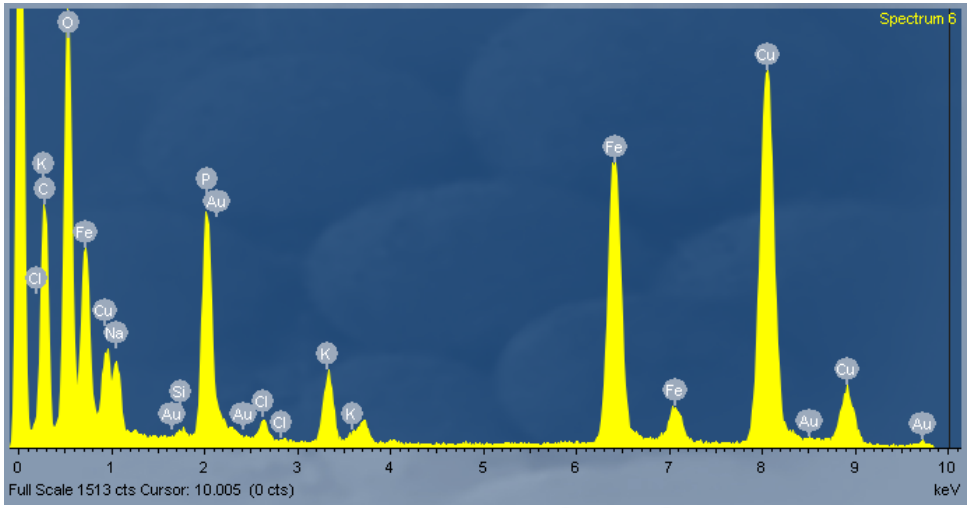


EDX analysis on JEOL, JEM2100

➢ What will you learn?

- 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: **Au, Ni, Fe, P, O, C, Cu**
  - Contamination: **Na**

abundance



energy (keV)

Today in lab…

- TEM in Koch basement—meet Eric in lobby by elevators
  - ➢ 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