M3D4: Transmission Electron Microscopy (TEM)

5/03/2016

1. Prelab Discussion
2. Half of class goes to TEM (building 13)
3. Half of class works on report or research proposal

- Quiz on M3D5!

Only three 20.109 days left (?!#?)

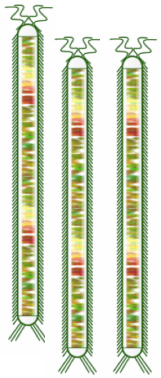
- **Reminder: visit Comm. Lab for 5pts M3 HW credit**
- **M3 mini-report (5%)**
  - **OH Thursday (5/5) 6-10pm 16-220** (lecture room) with pizza
  - No abstract, no methods section, combined results and discussion
  - Figures: TEM images, EDX, capacity, class data
- **M3 research proposal (20%)**
  - feedback on your M3D4 homework on May 4th (tomorrow) via email
  - Office hours on Sunday (5/8) 11am – 5pm in 56-302
  - slides due Tuesday, May 10th at 1pm
  - bring **1** print-out of your slides to 16-336
- **M3 Blog and extras**
  - Mod3 blog due May 11th 5pm
  - all other blogs due May 14th 11am

Module 3: biomaterials engineering

How does gold size/quantity affect battery capacity?

Purify
M13 phage
Add AuNP

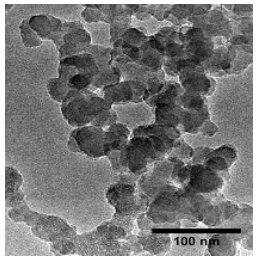
DAY 1



Biomineralize
AuNP-Fe(III)-
phage

Visualize
nanowires
on TEM

DAY 4



Purify
active material

DAY 2

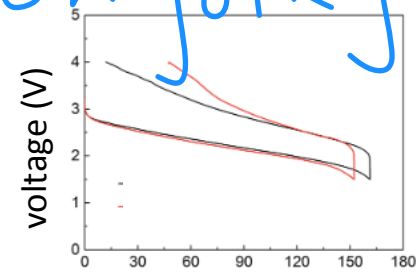
Construct
cathode
(and battery)

DAY 3

Measure battery
capacity

DAY 5

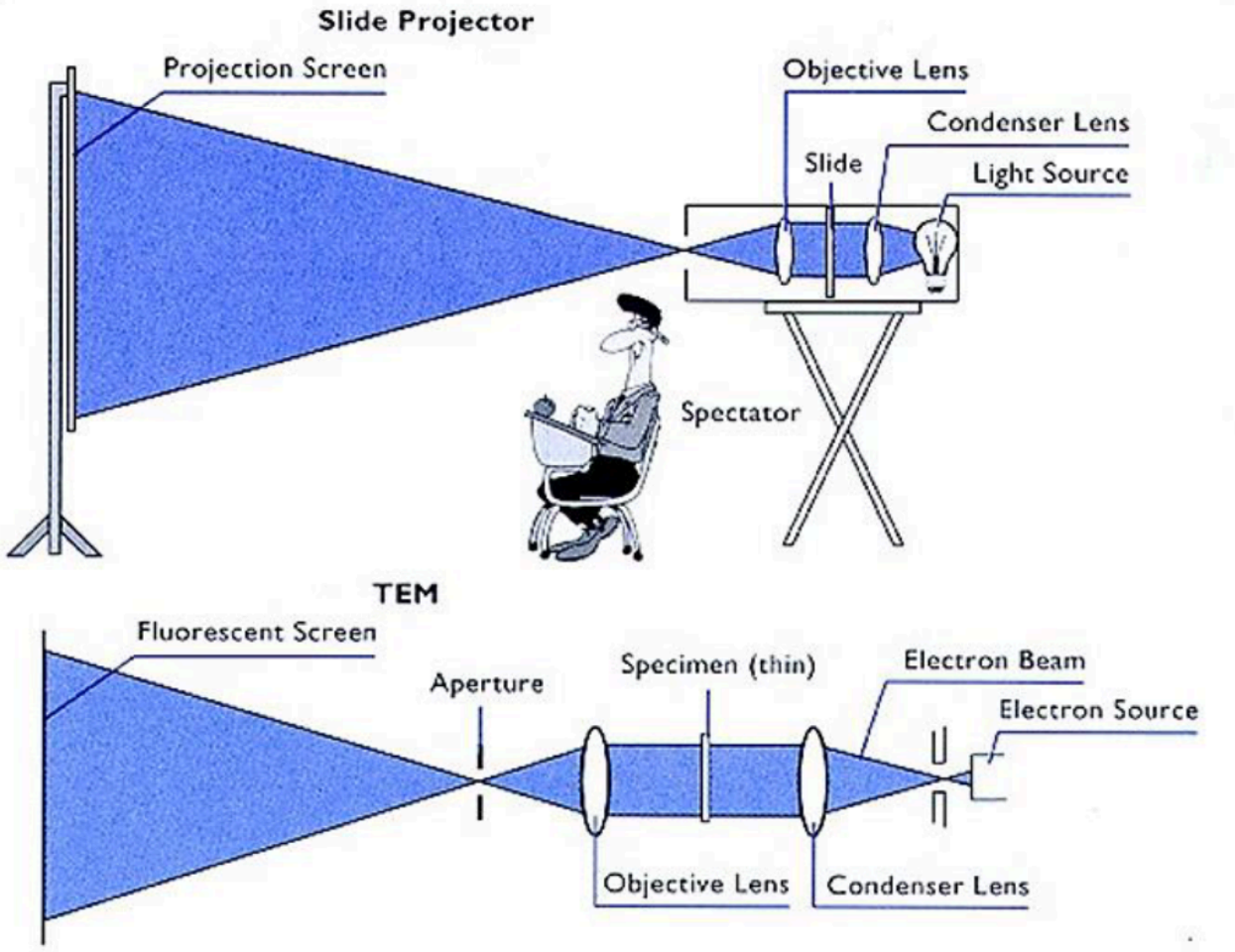
Ongoing



charge and discharge 5 times
each cycle 10 hours

TEM: basics

transmission electron microscopy



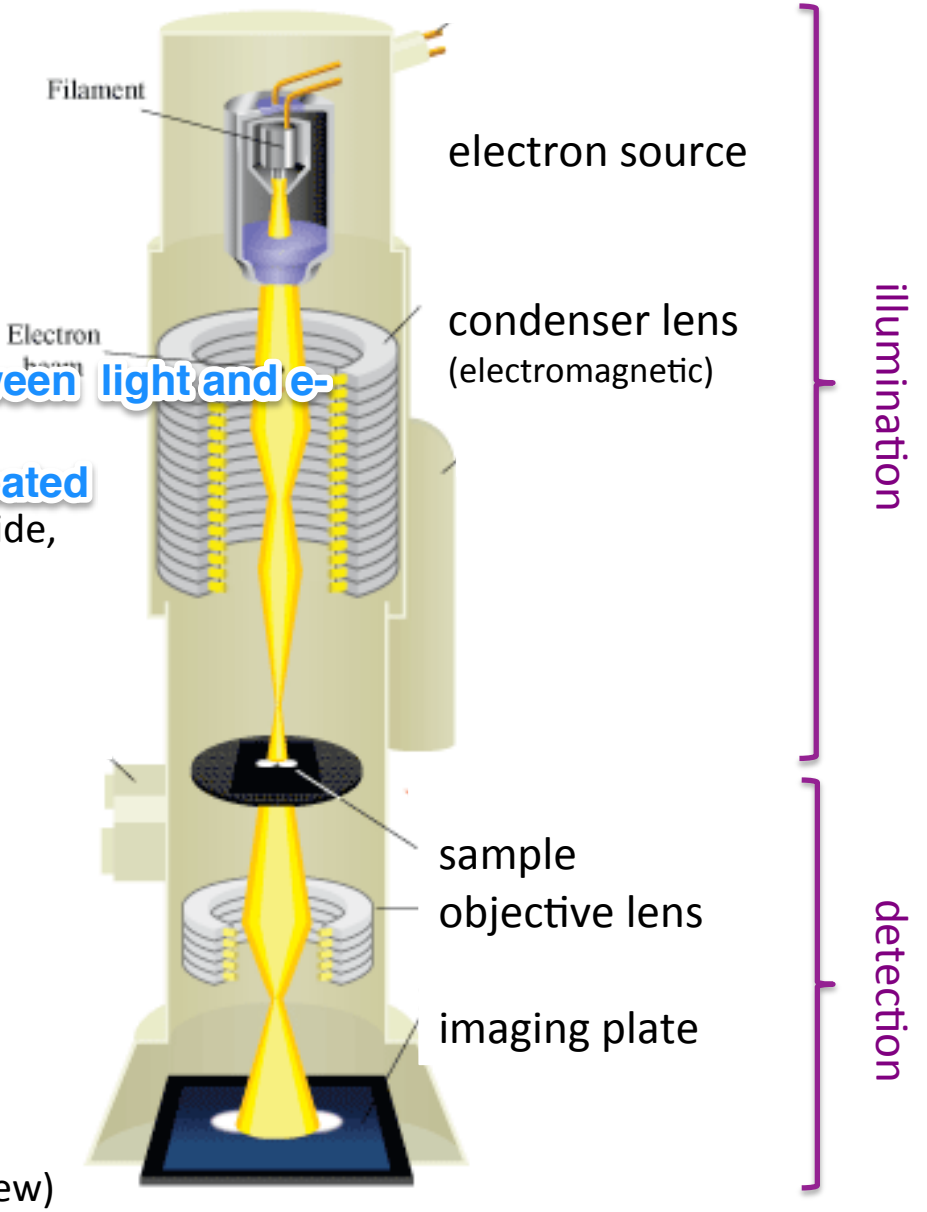
http://labs.mete.metu.edu.tr/tem/TEMtext/philips.jpg

TEM: foundations

transmission electron microscopy

1931 Ernst Ruska (1986 Nobel Physics)

- High resolution ~ 0.14nm
  - de Broglie wavelength $\lambda_{(e-)}$ ~ 0.005nm
  - compare to $\lambda_{(blue\ light)}$ ~ 400 nm
  - 5 orders of magnitude difference between light and e-
- Electron source: e- emitted when heated
  - thermionic emission by lanthanum hexaboride, heated to ~ 200 kV
  - focusing lenses electromagnetic
  - vacuum gas diffuses e-
- Sample preparation
  - thin and sturdy 10nm-100um
  - grid copper
  - sturdy, conductive
- Image ≈ sample *density*
  - e^- pass through & are also scattered
  - phosphor screen (old), YAG-coupled CCD (new)
  - e- translated to photons



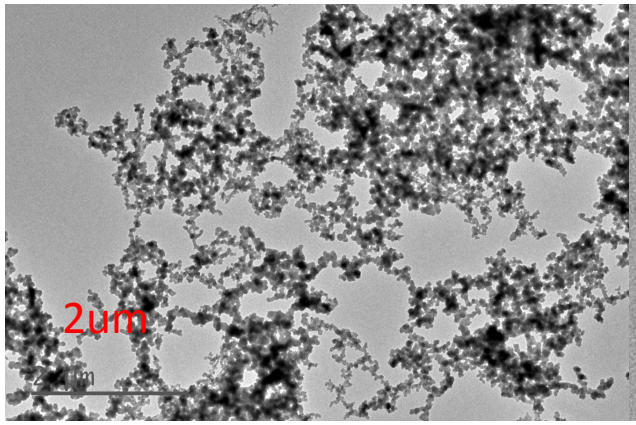
For today: TEM JEOL 2010

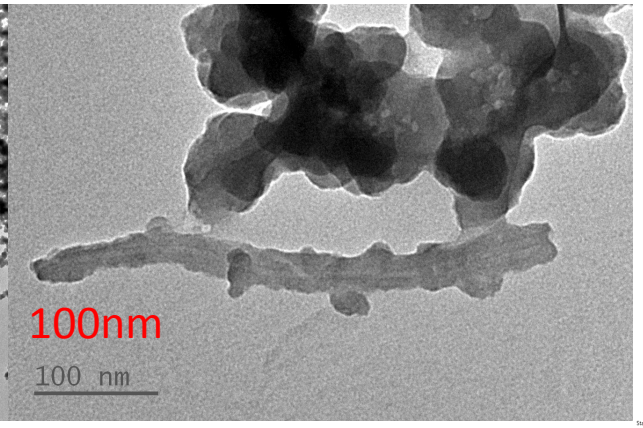
➢ What will you learn?

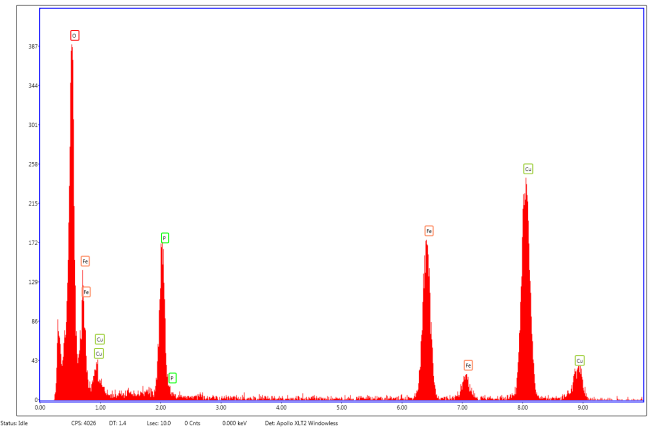
- at low resolution: morphology
- at high resolution: diameter of wire, amorphous vs. crystalline (both, lattice planes of gold
- EDX: elemental mapping

energy-dispersive X-ray spectroscopy analysis (EDX)

- atomic composition of heavier elements in material (> Na^{11})
- X-ray emission spectrum is characteristic of unique atomic structure of element
- expected: oxygen, iron, phosphate, gold, copper
  contaminate: sodium







from Fall 2015 20.109

Today in lab

- TEM in **13-1012**
  - 1:25pm: pink/green /yellow
  - 2:45pm: red/orange/purple/blue teams
  - ➢ How do TEM images relate to AuNP size/phage number ?

- Use your time wisely:
  - M3 research proposal
  - M3 mini-report
  - Blog (even if late!)