

M3D4: Transmission Electron Microscopy (TEM)

12/01/2016

1. *Quick* Prelab Discussion
2. Half of class goes to TEM (building 13)
3. Half of class works on research proposal
(presentations in one week!)

Only three 20.109 days left (?!#?)

- ***M3 major assignments***

- Research proposal (20%) Thursday Dec. 8th 1pm

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

- Mini-report (5%) Monday Dec. 12th 10pm

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

- *Final blog post Dec. 14th at 10pm*

- **M3 Extra Office Hours and Feedback**

- Visit:

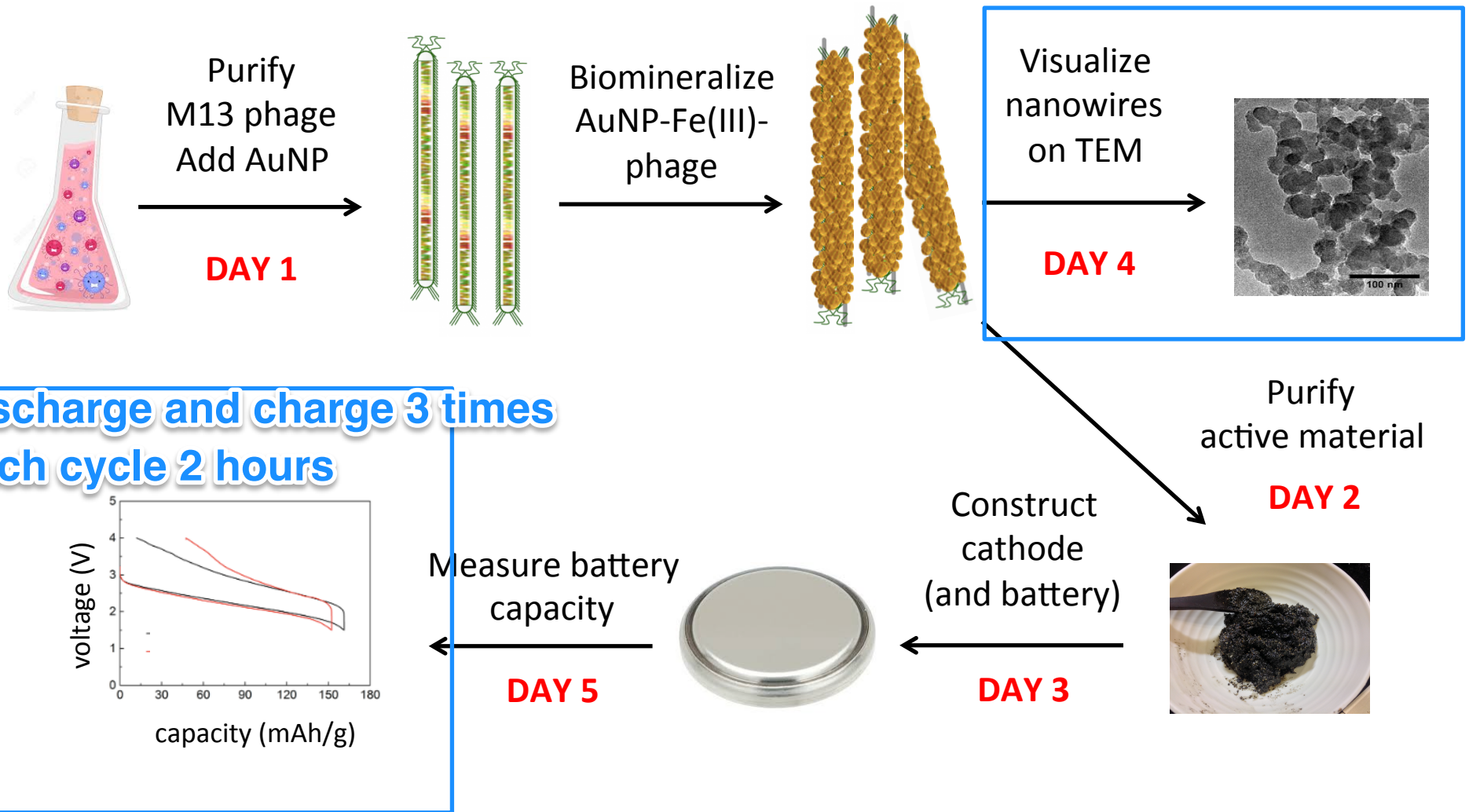


- Instructor extra office hours poll

EM images
EDX analysis
capacity data
class data

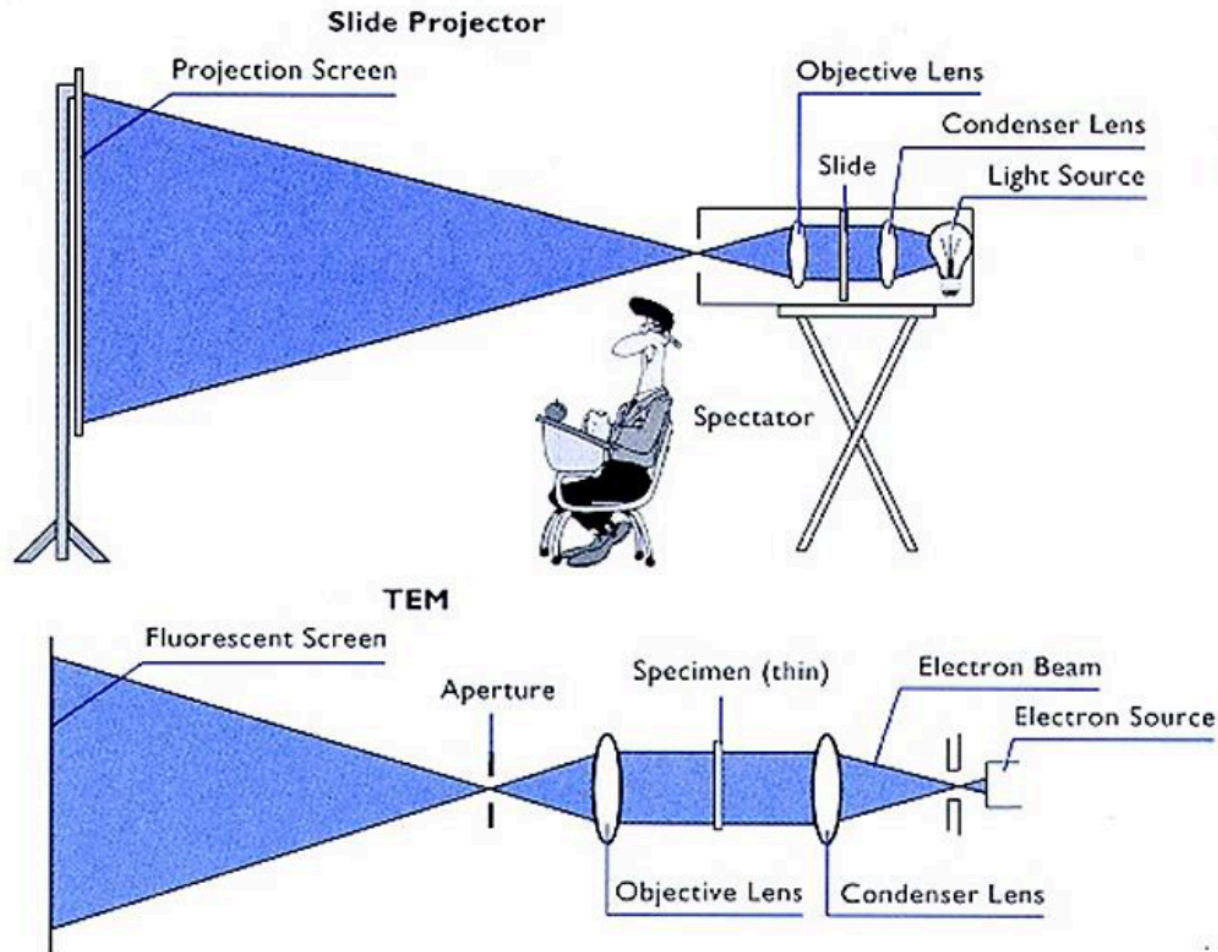
Module 3: biomaterials engineering

How does AuNP size affect battery capacity?



TEM: basics

transmission electron microscopy

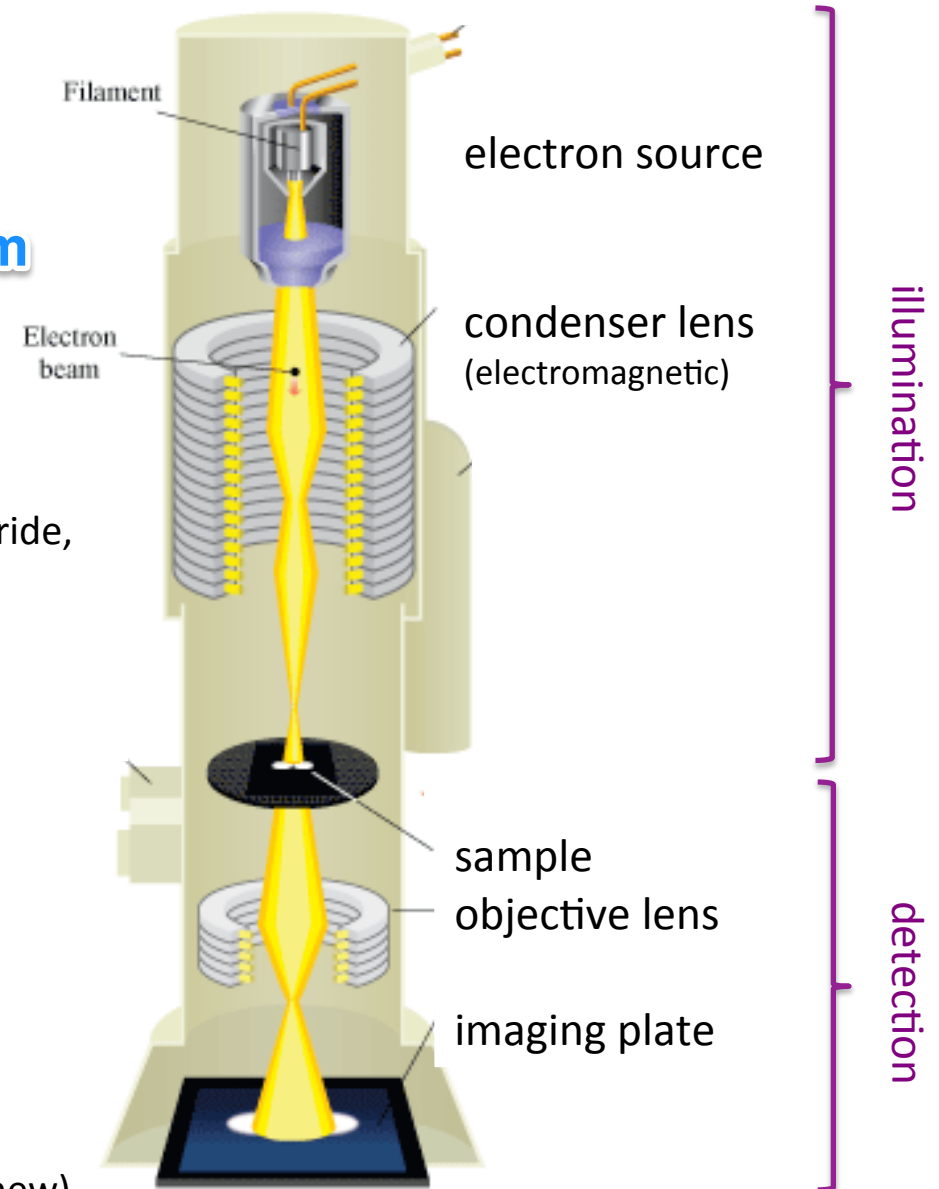


TEM: foundations

transmission electron microscopy

1931 Ernst Ruska (1986 Nobel Physics)

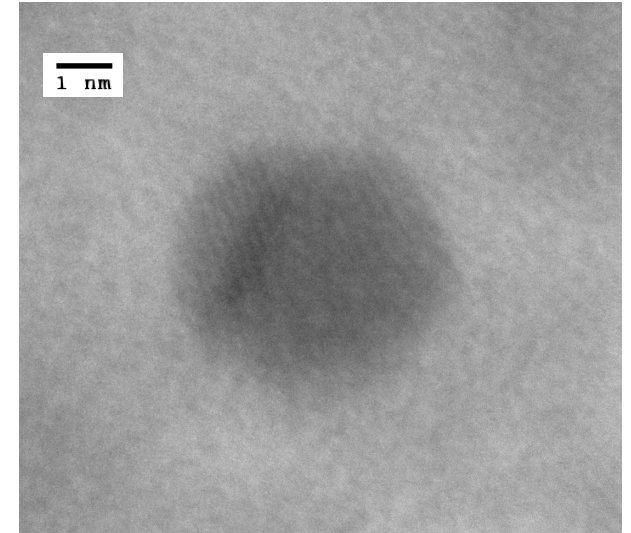
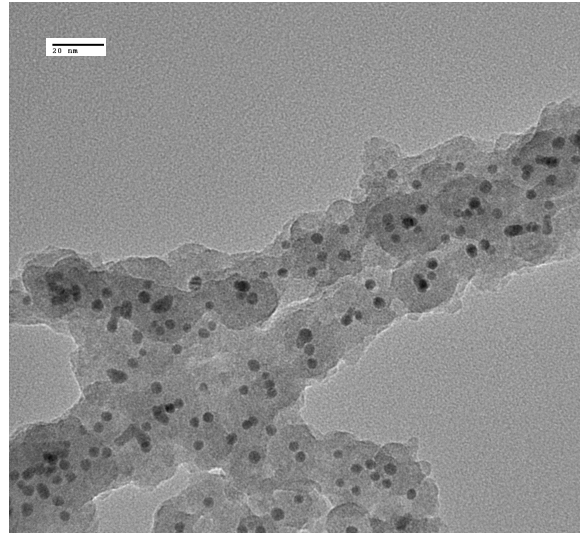
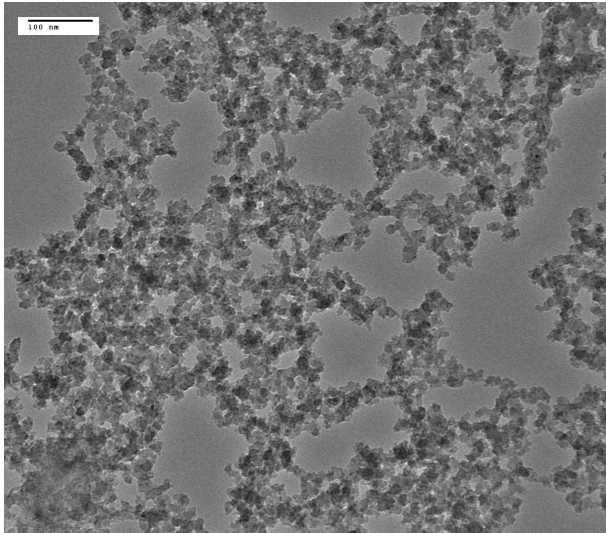
- High resolution ~ **0.14nm**
 - de Broglie wavelength $\lambda_{(e^-)} \sim$ **0.005nm**
 - compare to $\lambda_{(blue\ light)} \sim 400\text{ nm}$
 - **5 order of mag difference**
- Electron source:
 - thermionic emission by lanthanum hexaboride, heated to $\sim 200\text{ kV}$
 - focusing lenses **electromagnetic**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



TEM JEOL 2010 micrographs

➤ What will you learn?

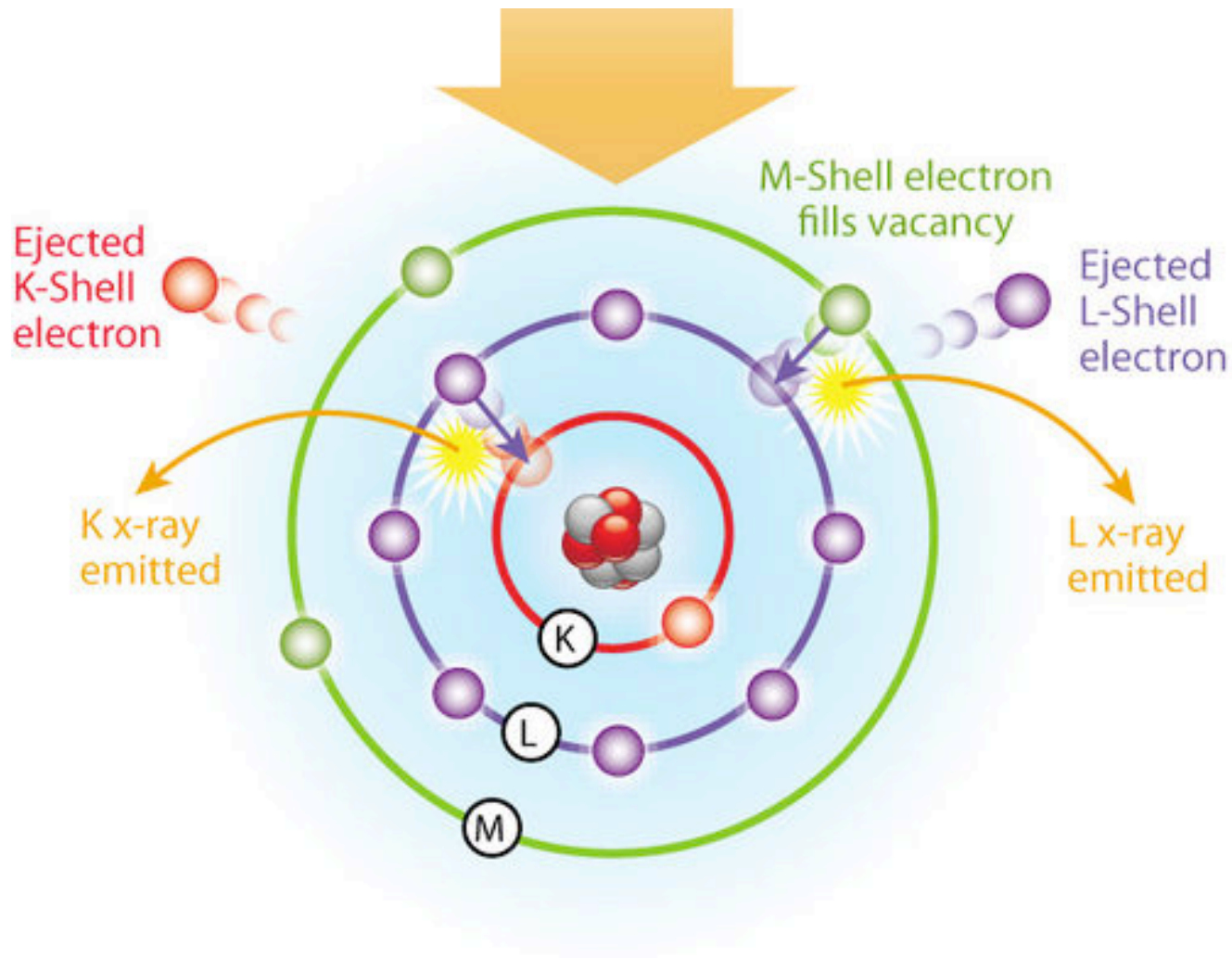
- at low resolution: **general morphology, uniformity, length, concentration**
- at high resolution: **diameter, aFePO₄ vs crystal, size of AuNP**



from Spring 2016 20.109

Elemental mapping by EDX

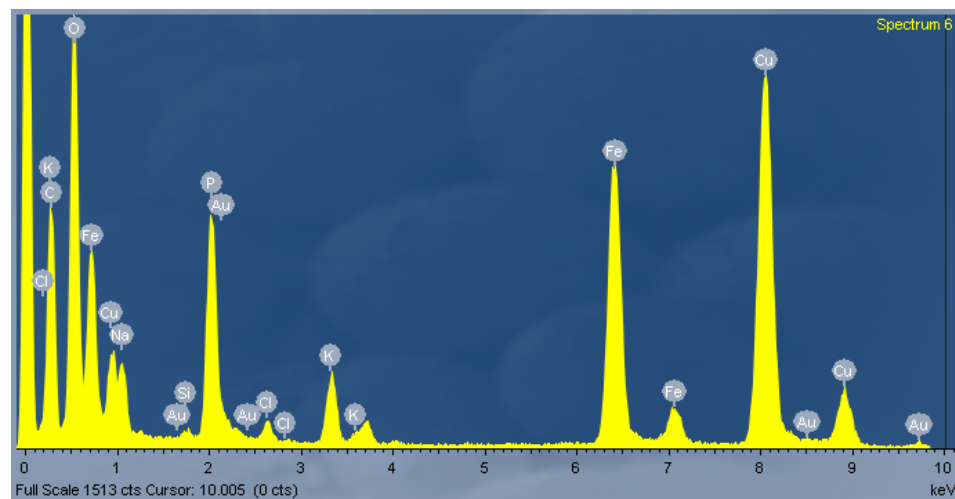
- X-ray emission spectrum is characteristic of unique atomic structure of element



EDX analysis on JOEL 2010

➤ 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: **iron, phosphate, copper, gold, oxygen**
 - contamination: **sodium**



Today in lab

- TEM in **13-1012**
 - 1:25pm: pink/green /yellow
 - 2:45pm: purple/blue teams
 - What can your TEM images suggest about the phage biomineralization and AuNP binding? Are the AuNP the correct size?
- *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