

# M3D4: TEM

12/02/2015

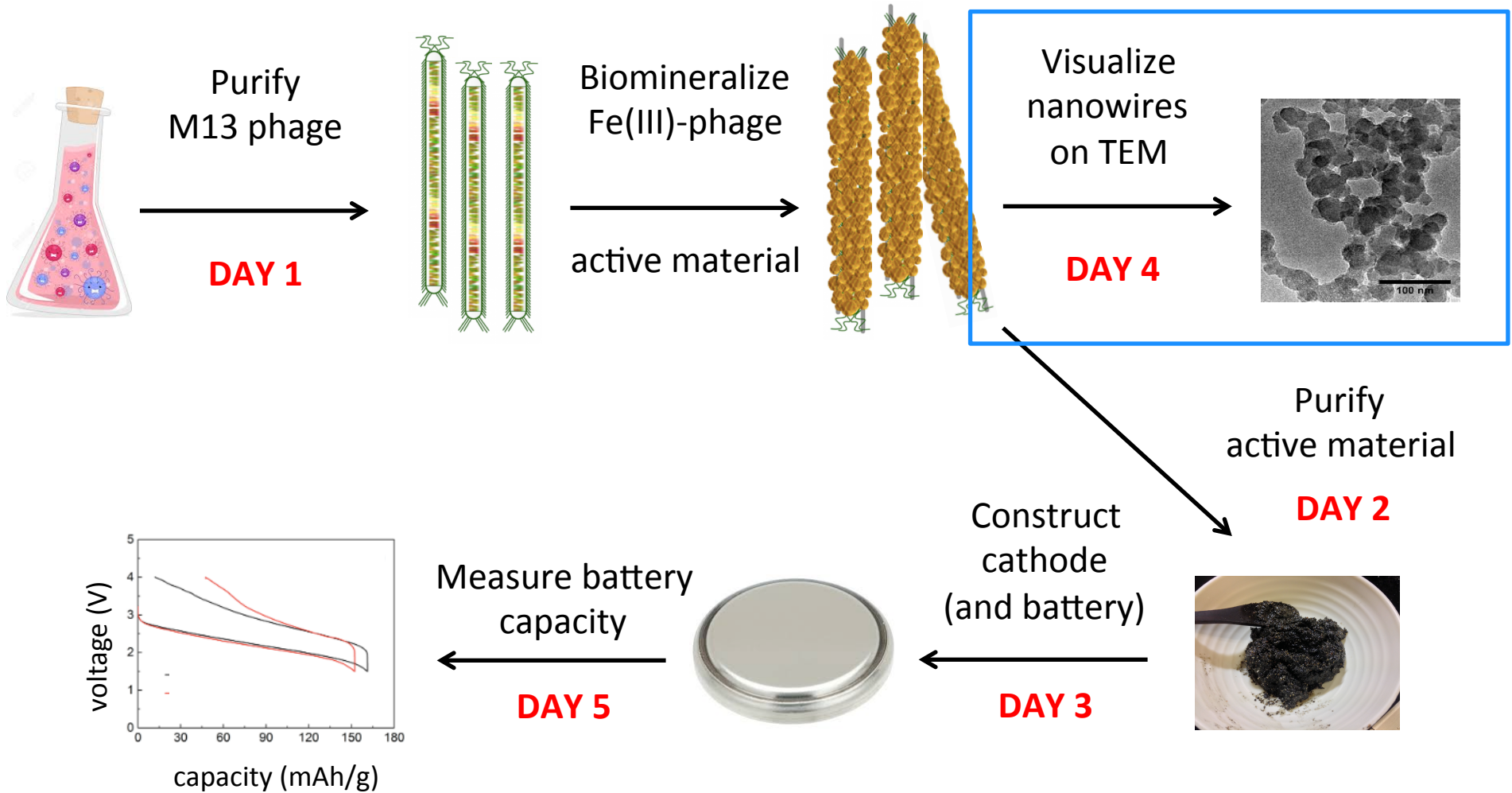


# Only 3 days left ?!#?



- M3 mini-report **as a TEAM**
  - *officially* due Friday, Dec. 4<sup>th</sup> at 10pm
  - **practically, we'll check Stellar on Monday 7am**
- M3 research proposal
  - feedback on your M3D4 homework on Dec. 4<sup>th</sup>
  - office hours on Sunday, Dec. 6<sup>th</sup> 10am – 5pm in 56-302
  - slides due Wednesday, Dec. 9<sup>th</sup> at 1pm
  - bring **two** print-outs of your slides
- Quiz on M3D5
- Blog
  - due Saturday, Dec. 12<sup>th</sup> at 5pm

# Module 3: biomaterials engineering

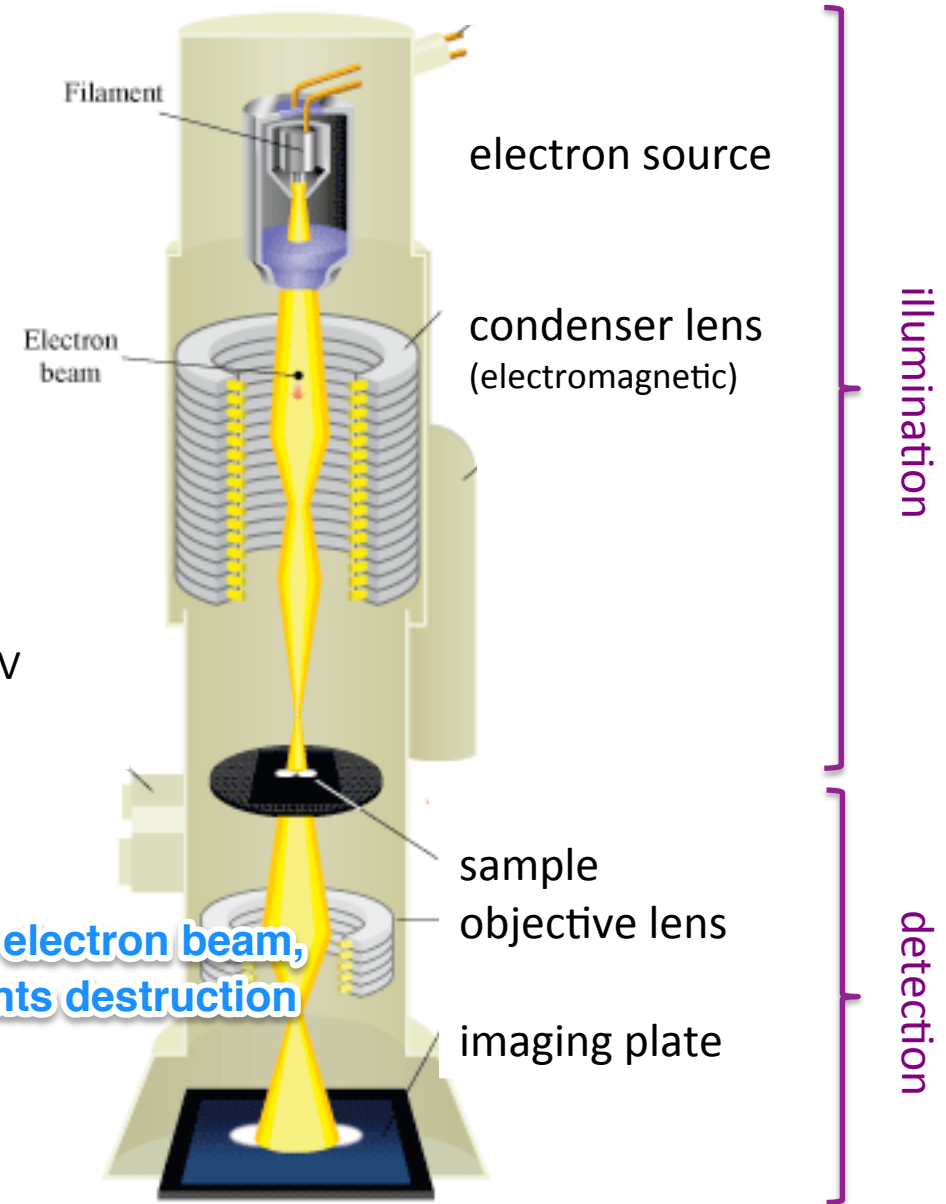


# TEM: foundations

transmission electron microscopy

1931 Ernst Ruska (1986 Nobel Physics)

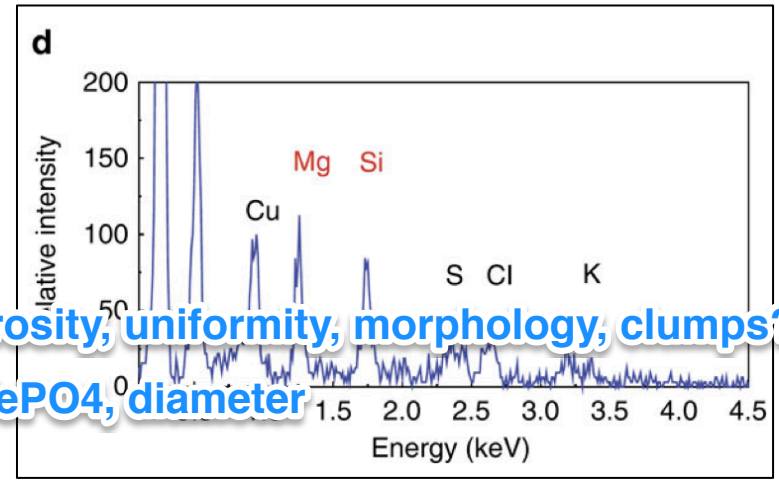
- High resolution  $\sim 0.1 \text{ nm} \sim 1 \text{ \AA}$ 
  - de Broglie wavelength  $\lambda_{(e^-)} \sim 5 \text{ pm}$
  - compare to  $\lambda_{(\text{blue light})} \sim 400 \text{ nm}$
  - Rayleigh  $R_{\text{light}} = 0.61 * \lambda / \text{NA}$
- Electron source:
  - thermionic emission by tungsten,  $\sim 100 \text{ kV}$
  - vacuum and focusing lenses
- Sample preparation
  - thin and sturdy  $10 \text{ nm} - 100 \text{ um}$
  - grid: **conductive copper disperses electron beam, prevents destruction**
  - biology: not *in situ*
- Image  $\approx$  sample *density*
  - $e^-$  pass through & are also scattered
  - phosphor screen, YAG-coupled CCD



# TEM: your experiment

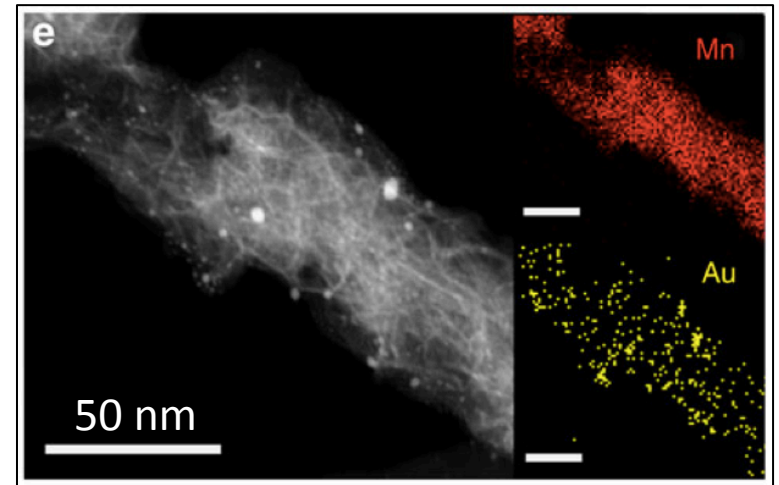
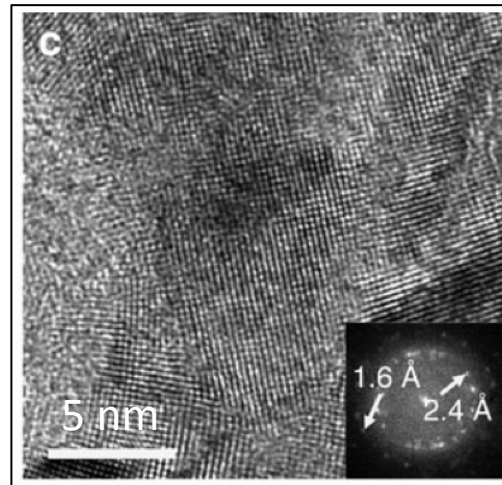
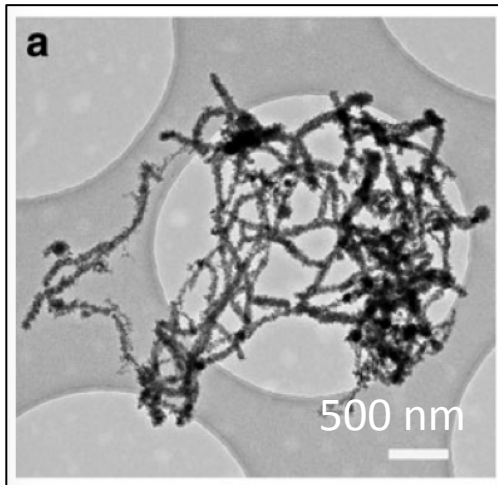
## ➤ What will you learn?

- at low resolution: **length, concentration, porosity, uniformity, morphology, clumps?**
- at high resolution: **crystal vs. amorphous FePO<sub>4</sub>, diameter**
- 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: **Fe, P, (Cu)**



# Today in lab

- TEM in 13-1012
  - 1:45pm: pink/blue/yellow
  - 3:15pm: red/green teams
  - How do TEM images relate to phage number ?  
M3D1: you chose  $2 \times 10^{11}$ , or  $2 \times 10^{12}$ , or  $2 \times 10^{13}$  M13 bacteriophage
- Get ahead!
  - M3 research proposal
  - Blog
  - M3 mini-report
  - Any other class in life?

