M3D4: Transmission Electron Microscopy (TEM)

- 1. Prelab Discussion
- 2. One group at a time to TEM(Koch)
- 3. Class works on research proposal (**Presentations in one week!**)

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Only three 20.109 days left!

M3 Assignments

- Research proposal (20%) 12/7 by 1pm
 - Upload slides to Stellar by deadline
 - Bring 1 print-out of your slides to 16-336
- Mini-report (5%) 12/10 by 10pm
 - No abstract, no methods section
 - Background/Motivation, Figures and combined Results/Discussion
- Final blog post 12/8 by 10pm
- Extra Office Hours:
 - Sat and Sun (12/1-2): I will schedule 1 hour time slots, by appointment only
 - M 2-5pm Noreen
 - Tu 10-11am Josephine
 - W 11am-1pm Josephine
 - W 3-5pm Noreen
 - Th 2-3pm Leslie
 - Th 3-5pm Noreen
 - Email us to set up a time outside of these



Make Comm Lab appointments!

TEM mages capacity data elemental mapping

Electron microscopy pushes past a fundamental limit of light microscopy



TEM: foundations

1931 Ernst Ruska (1986 Nobel Physics)

- High resolution ~ $\lambda A = 0.1 0.2 \text{ nm}$
 - de Broglie wavelength $\lambda_{(e-)} \sim 0.1 \text{ hm} \left(\frac{\text{can be}}{1 \text{ measure}} \right)$
 - Compare to $\lambda_{(blue light)}^{purple} \sim 400 \text{ nm}$
 - Rayleigh R_{light} = 0.61 * λ / NA
- Electron source:
 - Thermionic emission by tungsten
 - Accelerating voltage ~ 200 kV
 - Focusing lenses electro magnetic
 - Vacuum gas d'Muses e-



TEM: foundations

1931 Ernst Ruska (1986 Nobel Physics)

- Sample preparation
 - Thin and sturdy (10nm –100μm)
 - Grid: <u>Copyer</u>-sturdy and <u>conductive</u>
 - Biomaterials 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)
 - $-e^{-} \rightarrow \frac{\text{photons}}{\text{photons}}$, image on film or screen



Results/

What information do you learn from TEM micrographs? Discussion

- At low resolution: unifonity, morphology, length or width of nemoure estimate NP per phage (or length of phage)
- At high resolution:
 Jianeter of NP, anorphous vs. crystalline felog









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

Results/ Discussion

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 elements: ron, phosphate, gold, copper, oxygen Contaminating elements: sodium, calcium, carbon, silicon



X-ray emission spectra can be used for elemental mapping





Today in lab...

- TEM in Koch basement
 - What can your TEM images suggest about the phage biomineralization and AuNP binding? Are the NP the size expected?
- 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
- M3D5HW: Calculate mA needed to discharge your experimental battery (choose 1 cathode weight if had more than 1 cathode) battery in 10 hrs, handwritten or emailed calculations are fine, **turn in individually**
- Reminder: Quiz M3D5