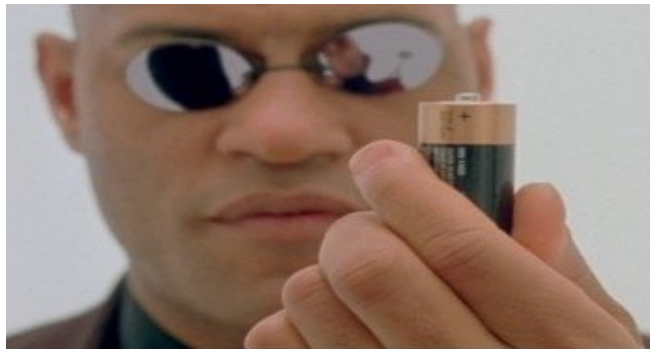


M3D3: Cathode construction

1. ½ class: Construct cathode material (Belcher Lab)
2. Quiz
3. Prelab Discussion
4. Research Proposal Peer Review Exercise

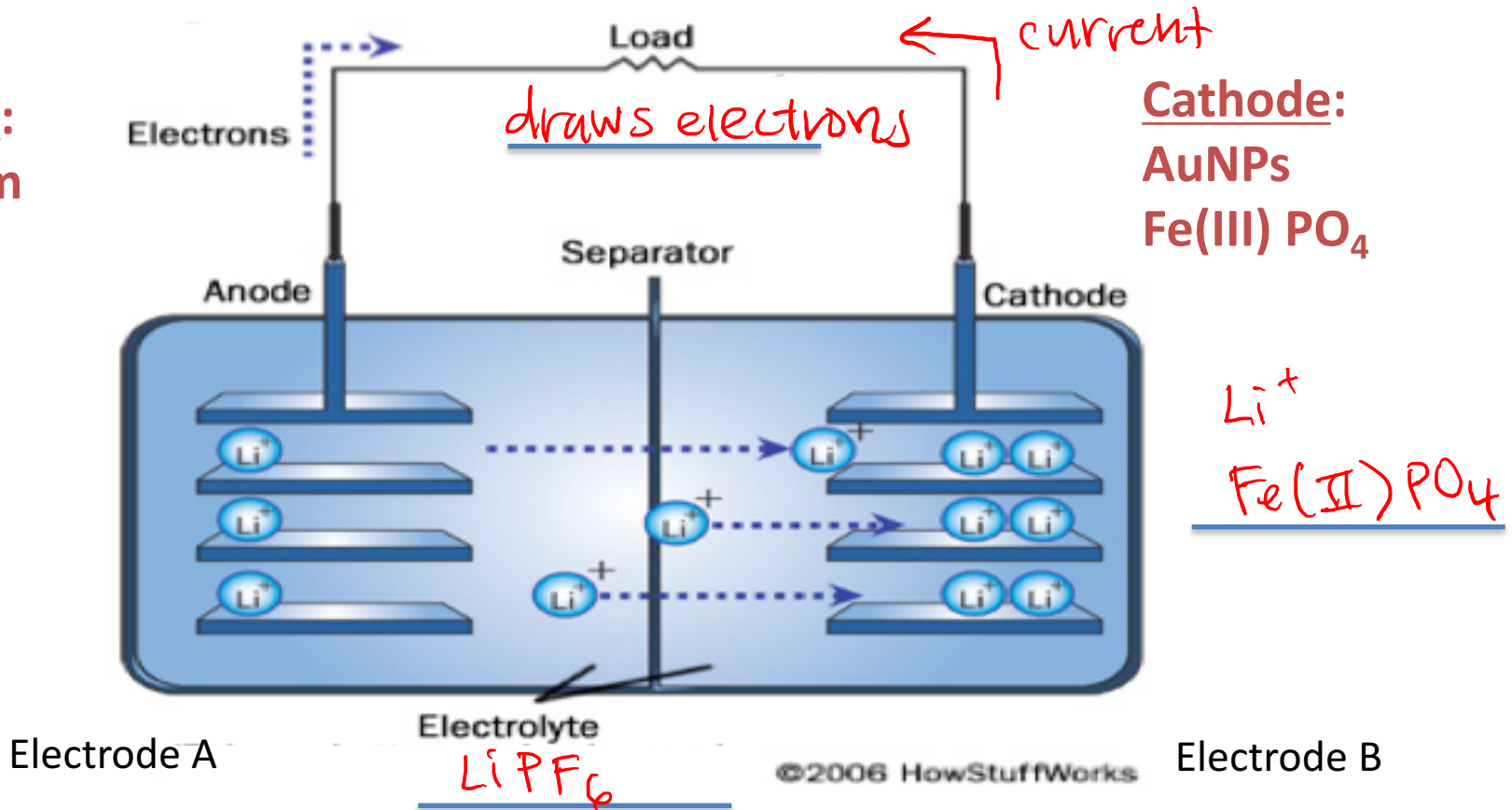


- **M3 major assignments**
 - Research proposal (20%), slides due 5/11 at 1pm
 - This is two weeks away
 - Work on this Today!
 - Mini-report (5%), due 5/14 at 10pm
- **M3D4 Homework, Both parts submitted as a team**
 - Research Proposal Presentation outline (wiki, google doc, benchling)
 - ***Address topics in HW prompt for full credit***
 - Outline Background and Approach for mini-report ***with references***
 - <http://belcherlab.mit.edu/publications/>

Is this battery discharging or charging?

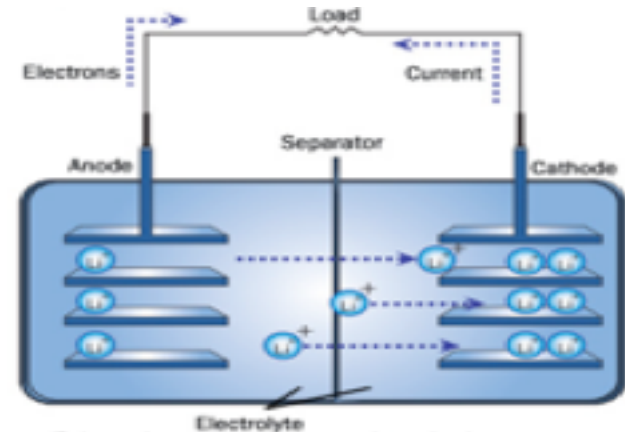
Anode:
Lithium

Cathode:
AuNPs
Fe(III) PO₄



Cathode is (+) During Spontaneous Discharge

- Oxidation/Reduction occurs at the cathode (accepts e-)
- Oxidation/Reduction occurs at the anode (donates e-)
- *Electrons* flow from + / \ominus to \oplus / - *electrode*
- During discharge, Electrode B is the cathode and is positively charged.



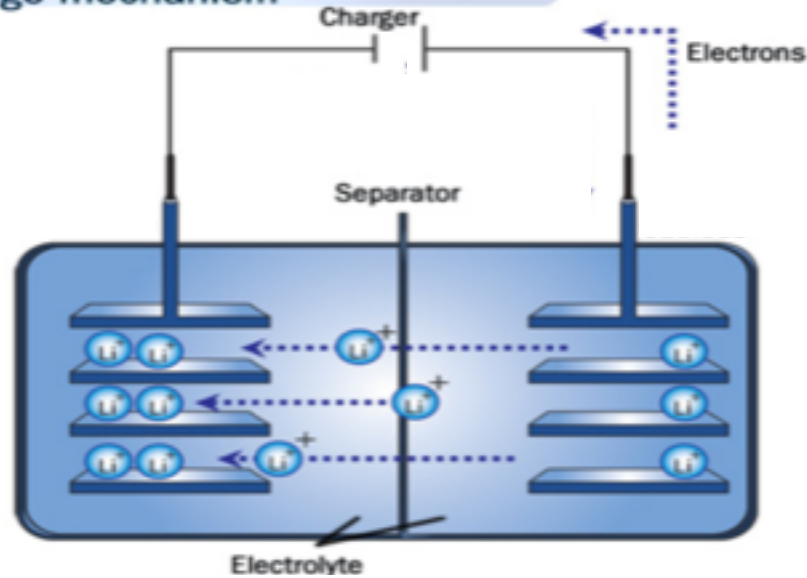
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Electrode A

Electrode B

During (re)charge, electron flow is reversed

Lithium-ion rechargeable battery
Charge mechanism



Reduction
(cathode)

oxidation
(anode)

\ominus

Electrode A

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\oplus

Electrode B

NOVA documentary:
“Search for the Super Battery”

<https://youtu.be/a4McN9OYDwg?t=770>

What is battery capacity?

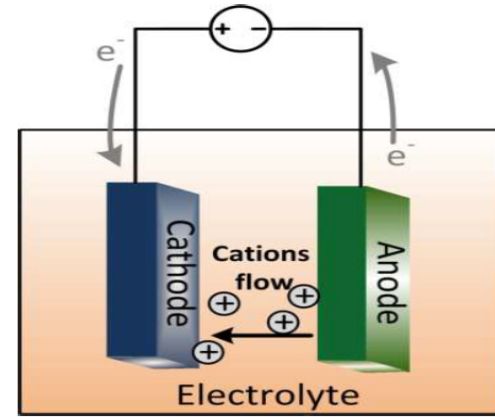
- Quantity of electricity (charge) involved for the electrochemical reaction between the active materials in the battery
- For our Fe(III)-phage batteries, the theoretical (gravimetric) specific capacity is 178 mA*h/g

• Units:

$$\left(\frac{\text{charge}}{\text{time}} \right) \left(\frac{\text{time}}{\text{mass}} \right) = \frac{\text{charge}}{\text{mass}}$$

- Capacity calculated from
 - total # of electrons that can be accepted
 - charge of those electrons
 - and atomic mass
- Why will our batteries not achieve theoretical specific capacity?

additional mass from additives:
(teflon, gold, phage)



from Dr. Maryam Moradi

How do phage scaffolds improve batteries?

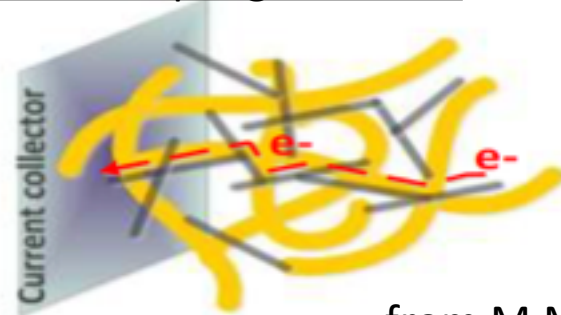
- Ion diffusivity → nano structuring active material
 - What is the advantage of nano structures?

higher surface area: volume ratio

- Electronic Conductivity → integrating additives
 - How do phage improve integration of additives?

- *phage act as structural material for binding additives*
- *phage display: find & select phage for binding additives*

Example: Adding carbon nanotubes to phage cathode

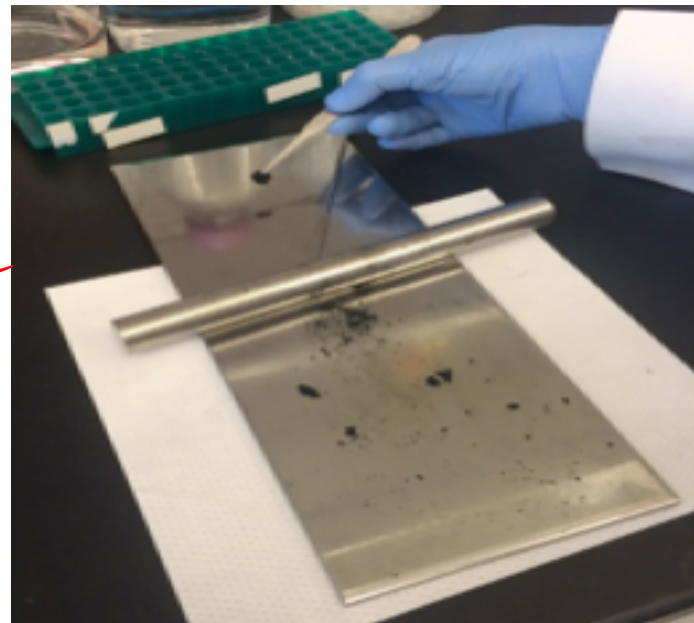


from M.Moradi

How will you construct your cathode?

1. Weigh AuNP-Fe(III)-phage nanowires (active material)
2. Mix with Super P - carbon material, and PTFE - *teflon, binder* increase conductivity
3. Roll cathode material into thin sheet
4. 'Punch out' cathode disc
5. Weigh cathode_(why?) - calculate specific capacity
6. Dry cathode_(why?)

↳ remove solvents & water, improve binding



Today in lab...

Note: Likely to choose M3D3 for notebook grading:
Include cathode weights & notes from peer review

1. Construct cathode Belcher lab
 - Bring lab coat and eye protection
 - Bring a notebook and something to write with
 2. Research proposal peer exercise
 - Everyone must be the “presenter” and “listener” at least once
 - Partner assignments will depend on timing of cathode construction
- M3D4HW: (see slide 2) You cannot make major changes to your research proposal idea after Friday(5/4)!