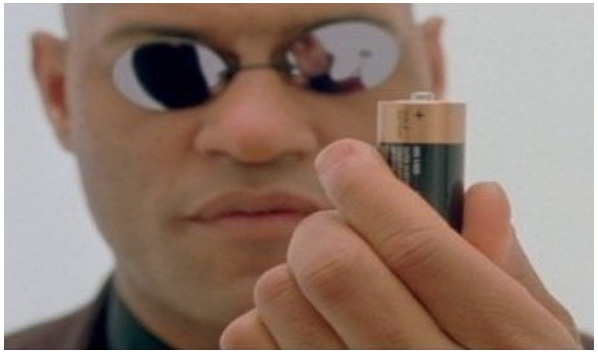
M3D3: Cathode construction

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



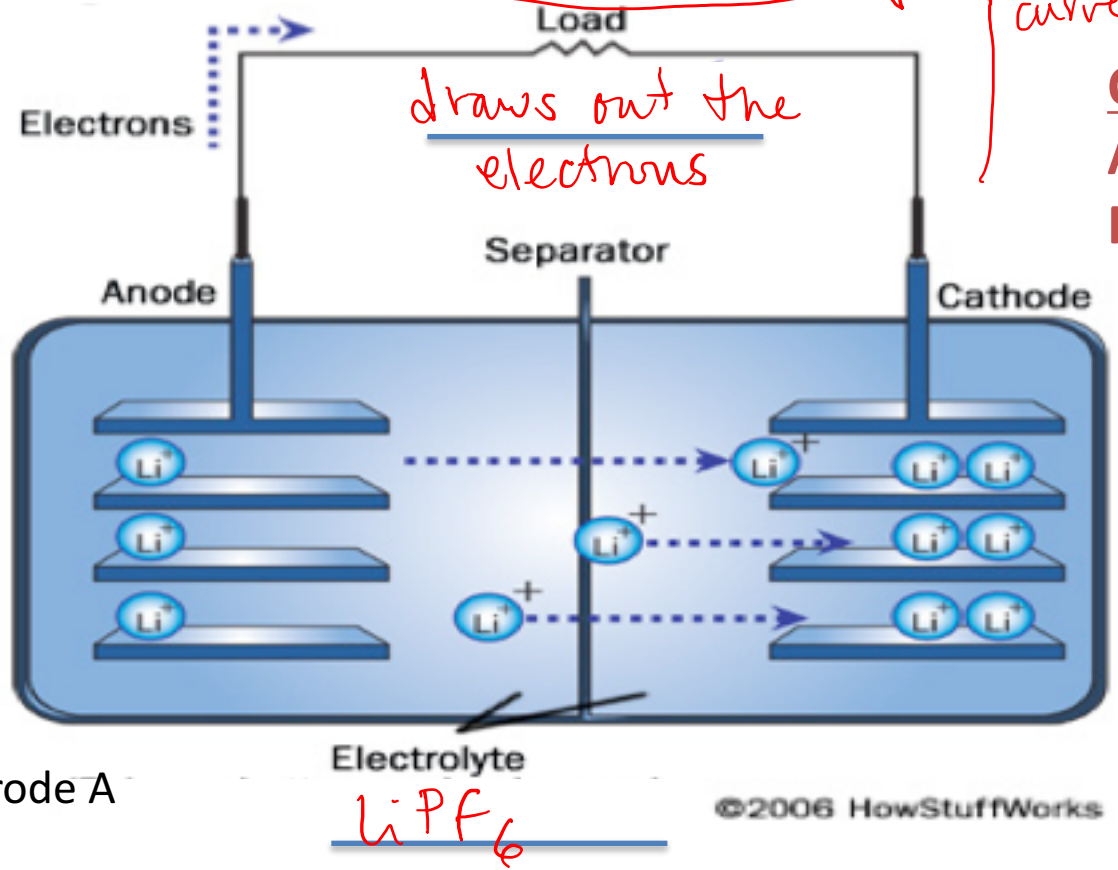
- ***M3 major assignments***
  - Research proposal (20%), slides due 12/7 at 1pm
    - **This is <1.5 weeks away**
    - **Work on this Today!**
  - Mini-report (5%), due 12/10 at 10pm

- **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?

current

Anode:
Lithium
(metal)



Cathode:
AuNPs
Fe(III) PO_4

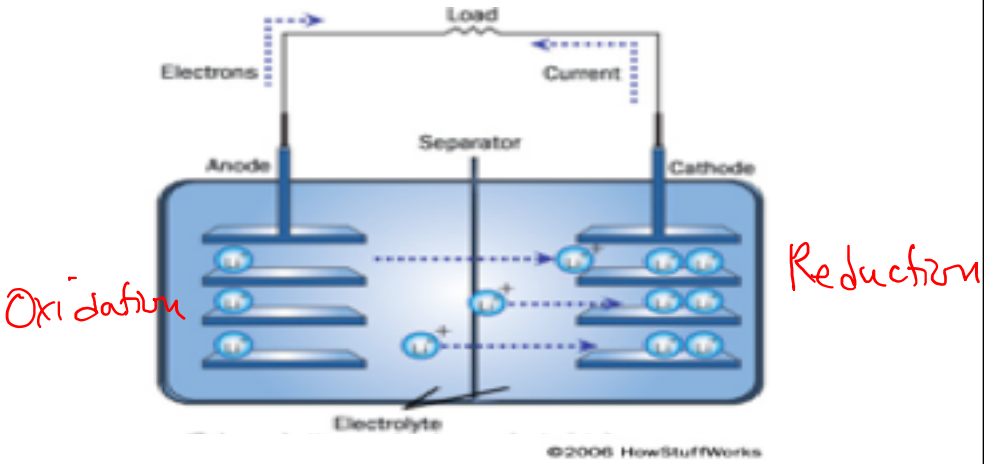
Li+
Fe(III)PO4

Electrode A

Electrode B

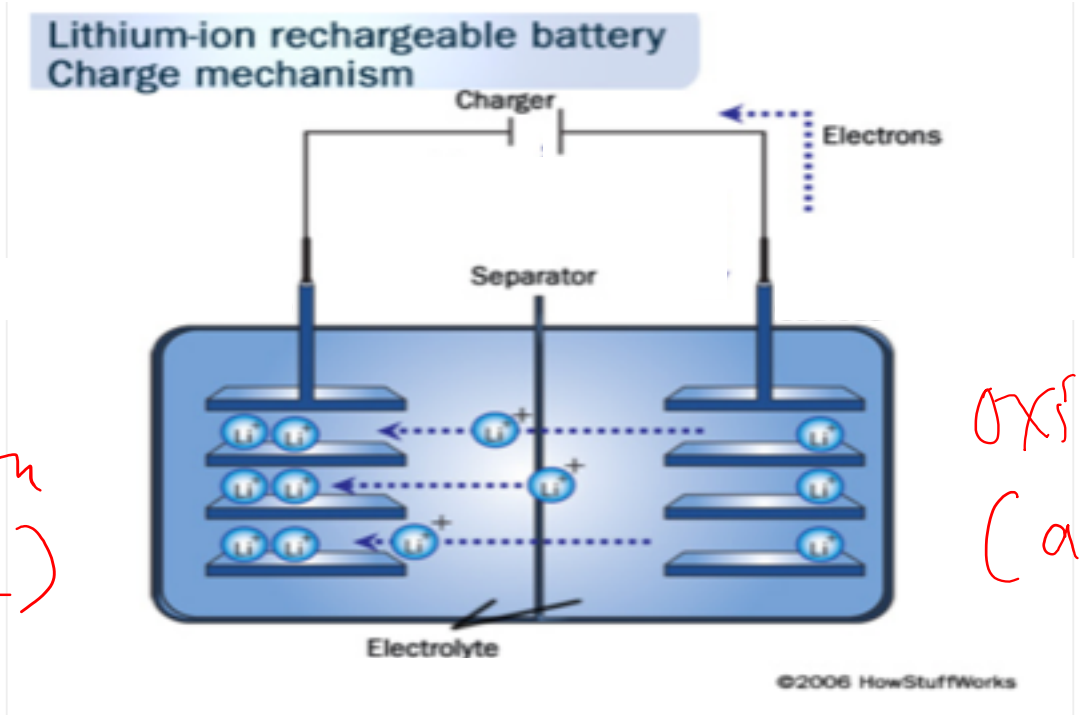
Cathode is (+) During Spontaneous Discharge

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



Electrode A Electrode B

During (re)charge, electron flow is reversed



Reduction (cathode)

Oxidation (anode)

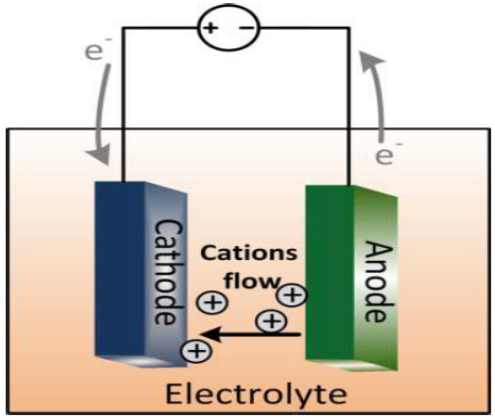
Electrode A

Electrode B

NOVA documentary:
“Search for the Super Battery”

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

What is battery capacity?



from Dr. Maryam Moradi

- 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: $\left(\frac{\text{charge}}{\text{time}}\right) \cdot \left(\frac{\text{time}}{\text{mass}}\right) = \frac{\text{charge}}{\text{mass}}$ (cathode)
- 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 in denominator from additives (phage, gold, teflon)

$LiFe(II)PO_4$

How do phage scaffolds improve batteries?

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

    amorphous, higher surface:volume ratio
- Electronic Conductivity → integrating additives
  - How do phage improve integration of additives?

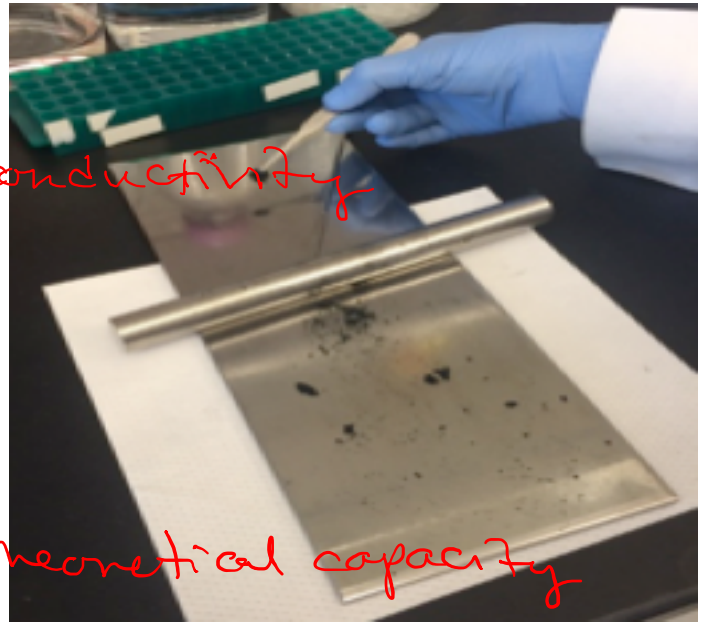
    phage display: ability to find + select phage for binding additives (iron, gold, nanotubes)

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, increase conductivity and PTFE : teflon, binder
3. Roll cathode material into thin sheet
4. 'Punch out' cathode disc
5. Weigh cathode (why?) control mass, theoretical capacity
6. Dry cathode (why?) improve binding, remove unwanted solvents



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 (11/30)!