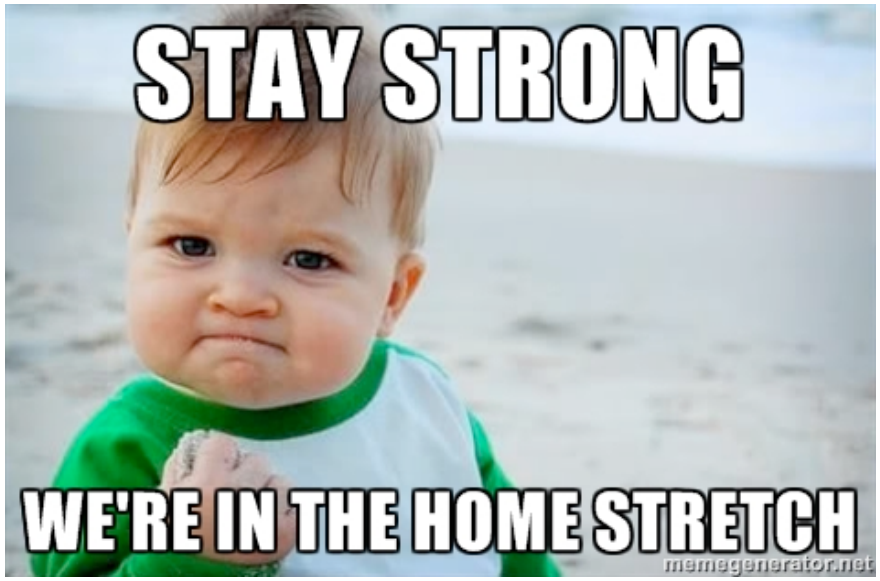
M3D1:Growth of phage materials

11/14/17

1. Purify M13 bacteriophage (phage)
2. Prelab during 60min incubation
3. Finish M13 purification and measure concentration of M13 phage
4. Incubate phage with nanoparticles (AuNP/NiNP)



Thank you, Jifa Qi (Belcher Laboratory) !

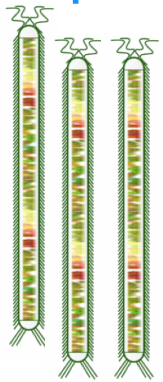
Module 3: biomaterials engineering

How do material choice and nanoparticle size affect battery capacity?

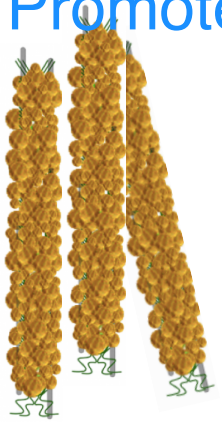
PEG/NaCl - hydrophillic, polymer. Promote phage aggregation

Purify
M13 phage
Add AuNP/NiNP

DAY 1

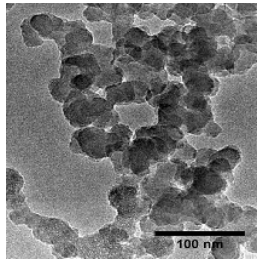


Biomineralize
Fe(III)-
phage-AuNP



Visualize
nanowires
on TEM

DAY 4



Purify
active material

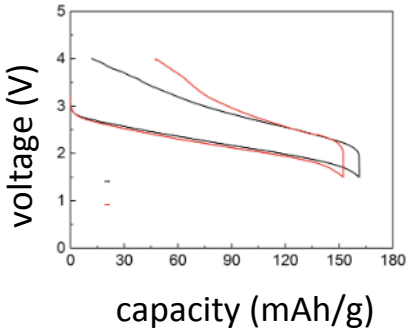
DAY 2

Construct
cathode
(and battery)

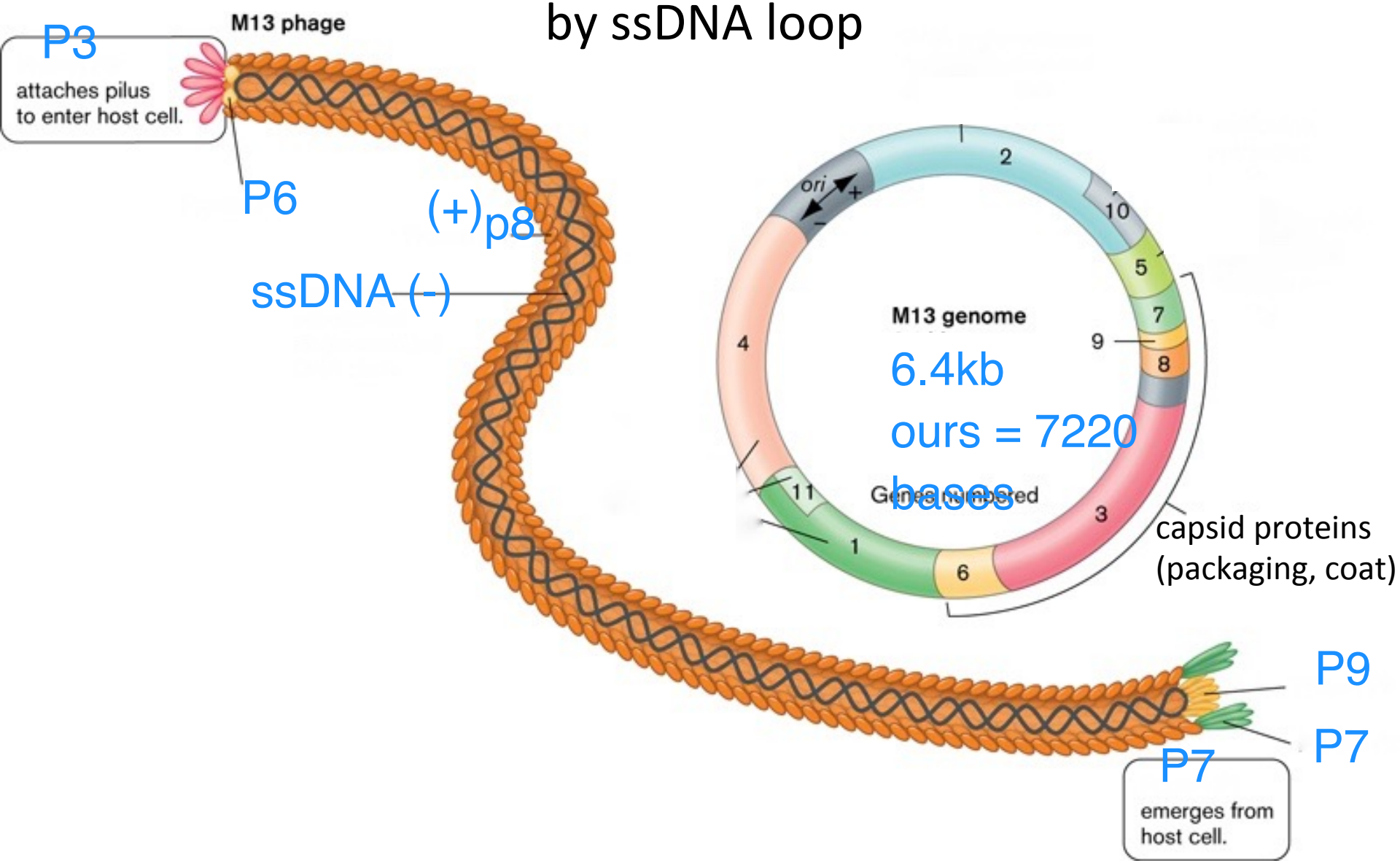
DAY 3

Measure battery
capacity

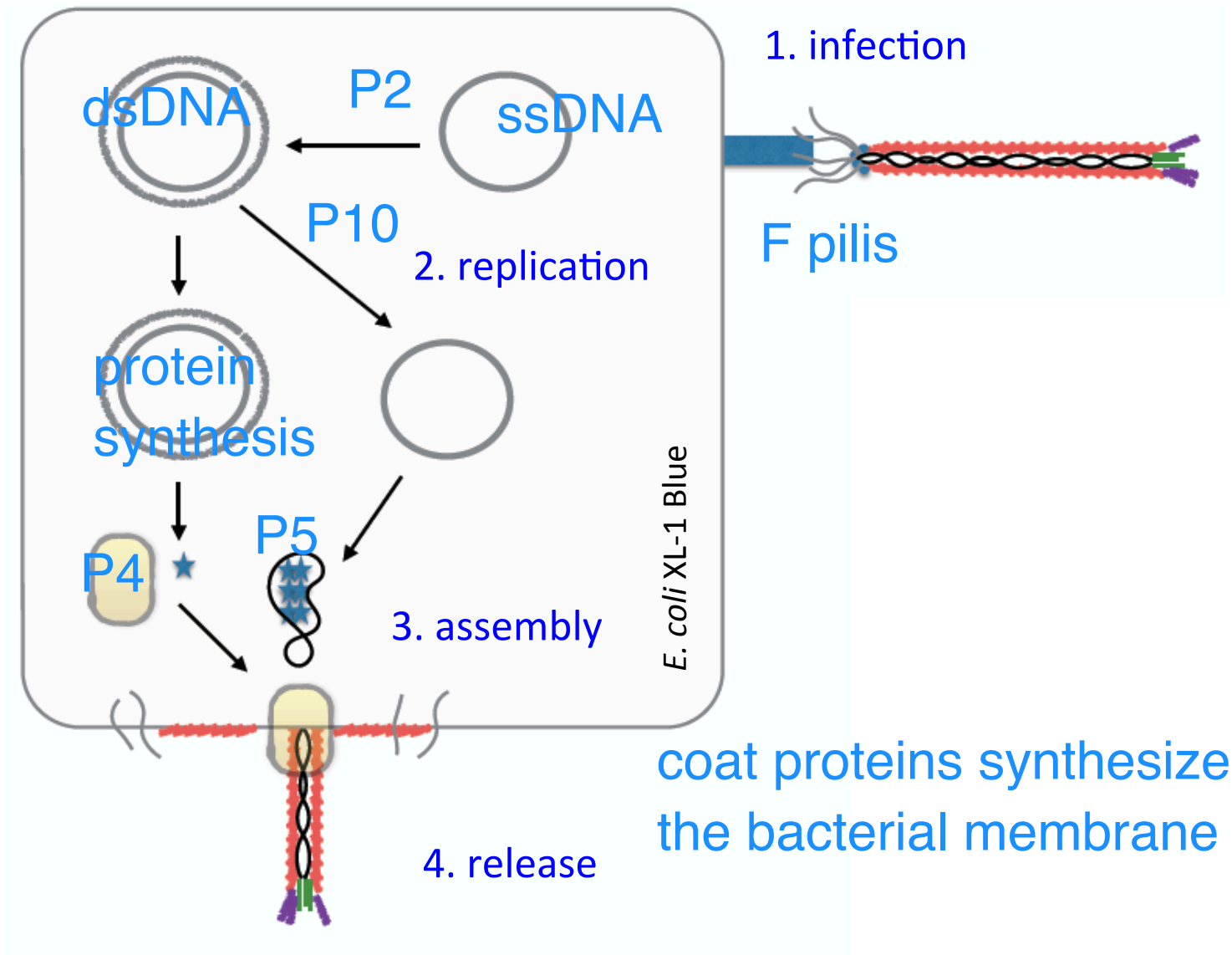
DAY 5



M13 is a high aspect ratio phage coated in proteins encoded by ssDNA loop



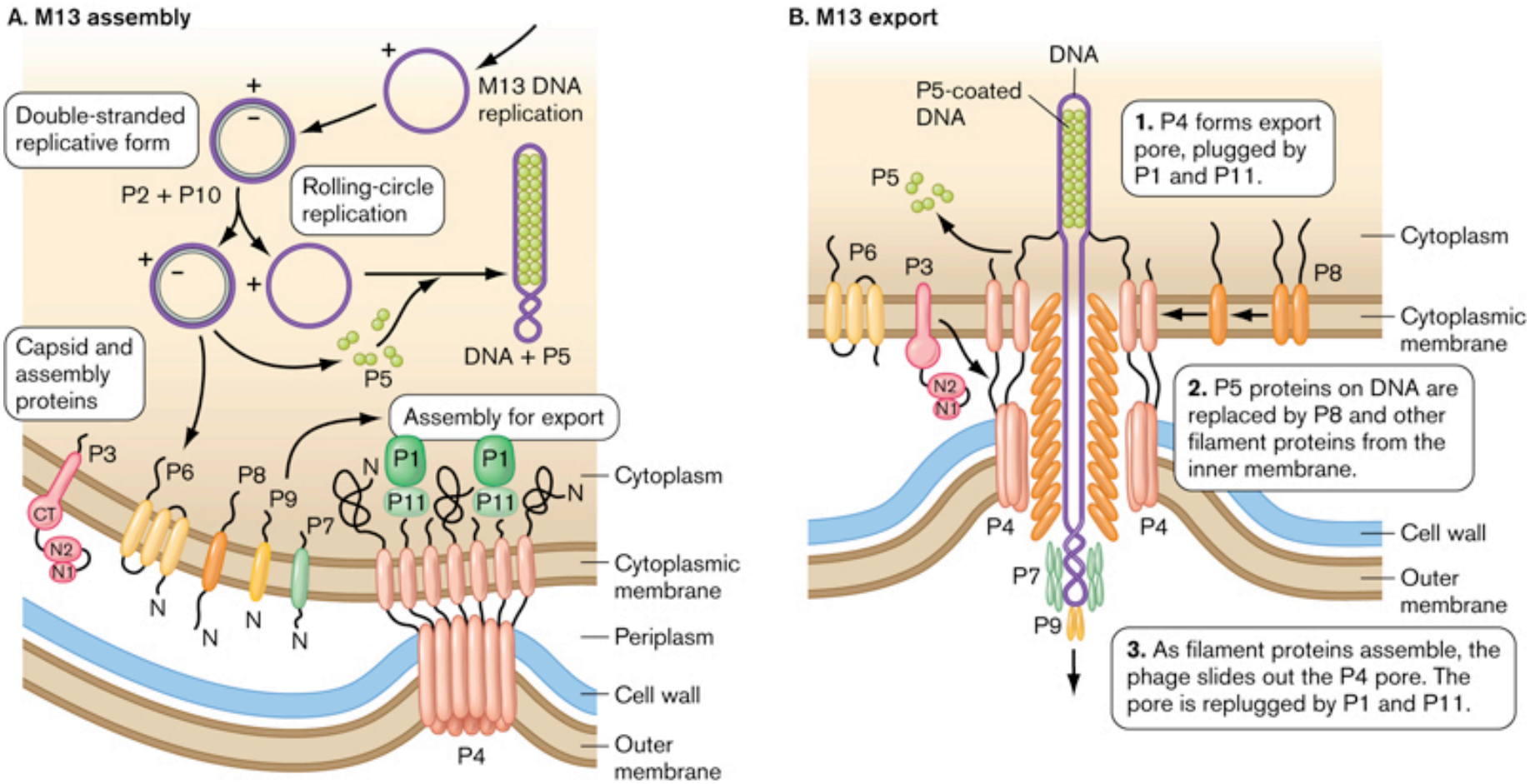
M13 virus life-cycle has four essential steps



coat proteins synthesized within the bacterial membrane

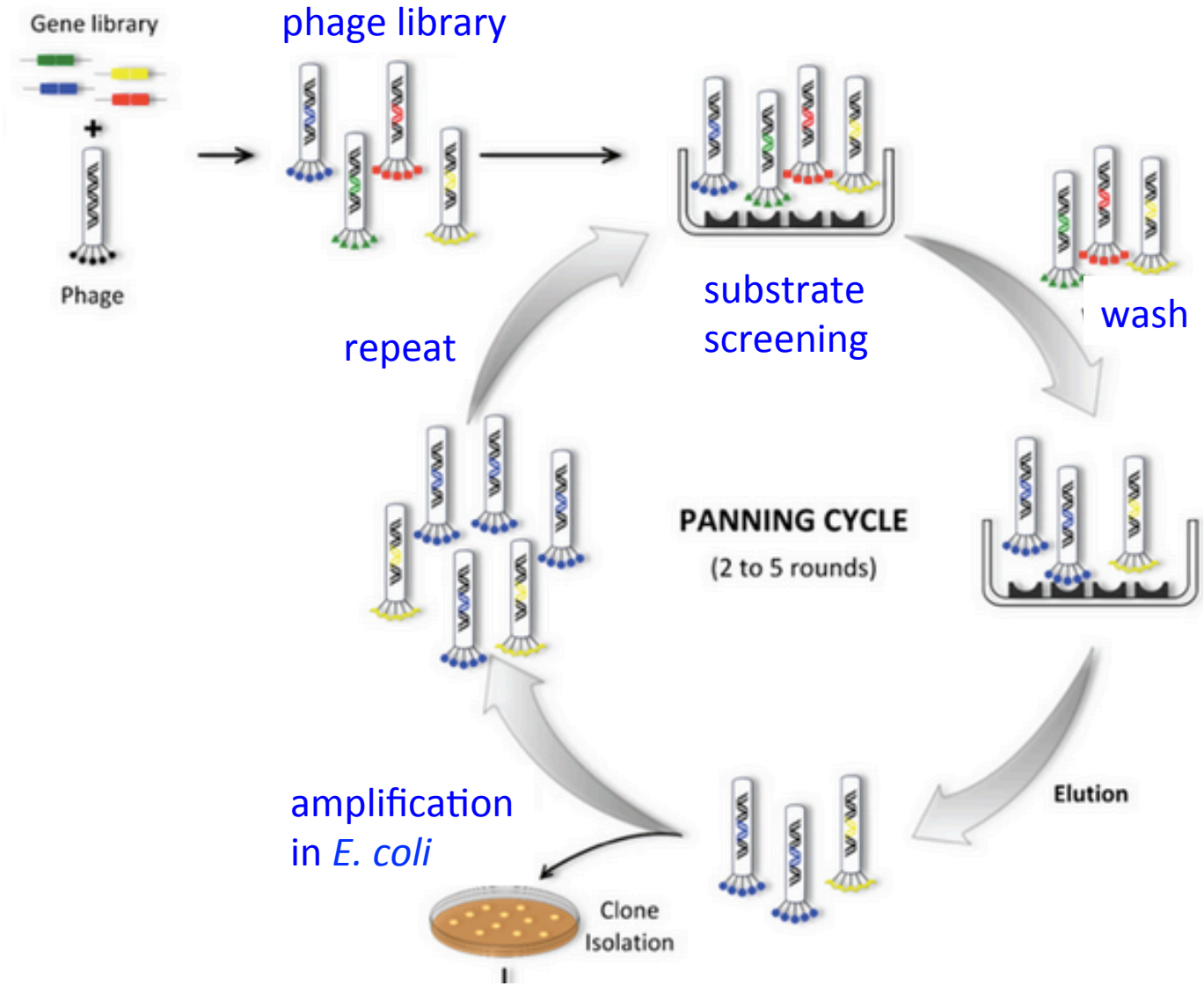
M13 is a nonlytic bacteriophage

(so we can easily get lots of it)



http://www.wwnorton.com/college/biology/microbiology2/ch/11/etopics.aspx

Phage display allows agnostic selection of useful peptide sequences (typically binding)

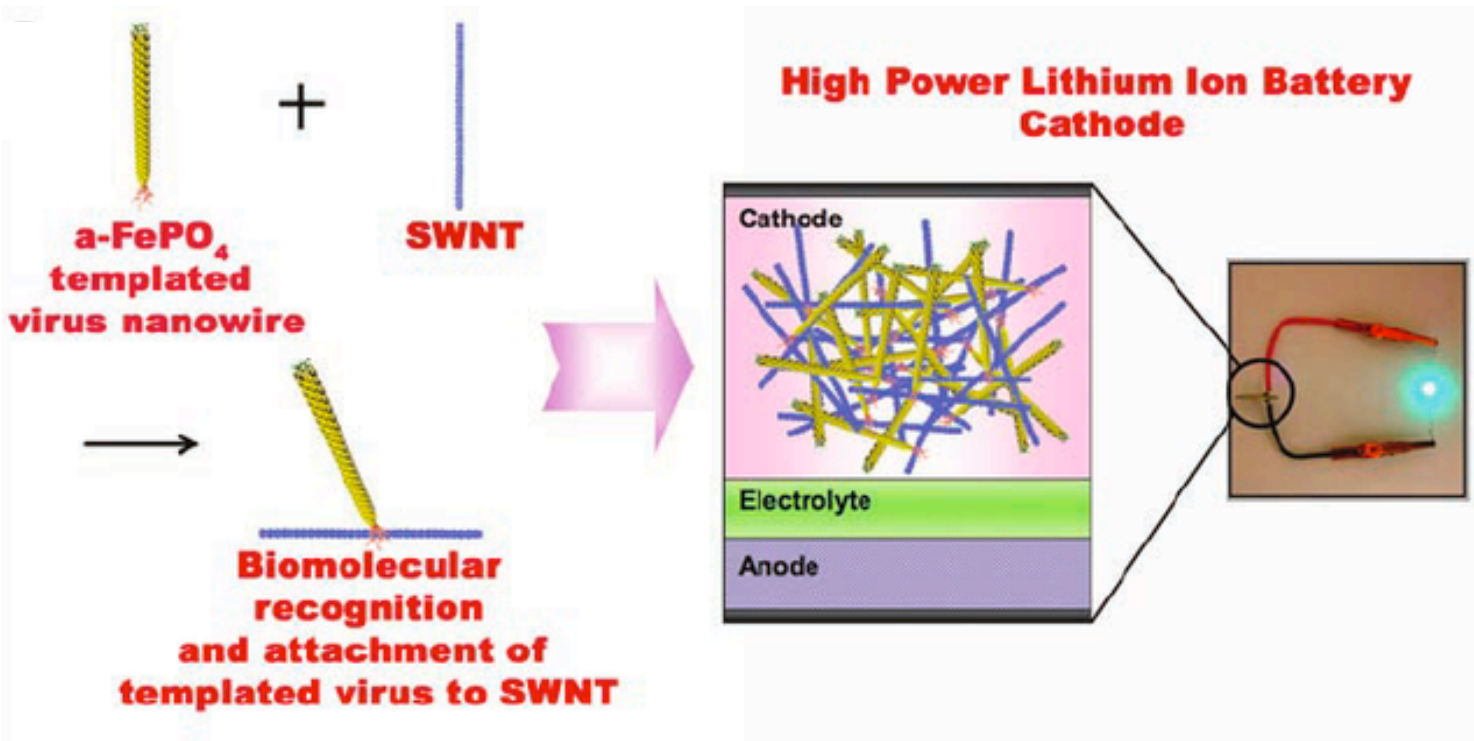


Biomolecules 2015, 5(3), 1783-1809; doi:10.3390/biom5031783

M13 are engineer-able biomaterials

negatively charged

- Our p8 coat protein was mutated to contain sequence DSPHTELP
- Modified p8 proteins bind single wall carbon nanotubes (SWCNT), iron and gold, and other cationic metals
- Example of this virus in literature (Science, 2009):



Lee et al. Fabricating Genetically Engineered High-Power Lithium-Ion Batteries Using Multiple Virus Genes. Science. 2009

M13 nanowires as battery cathode

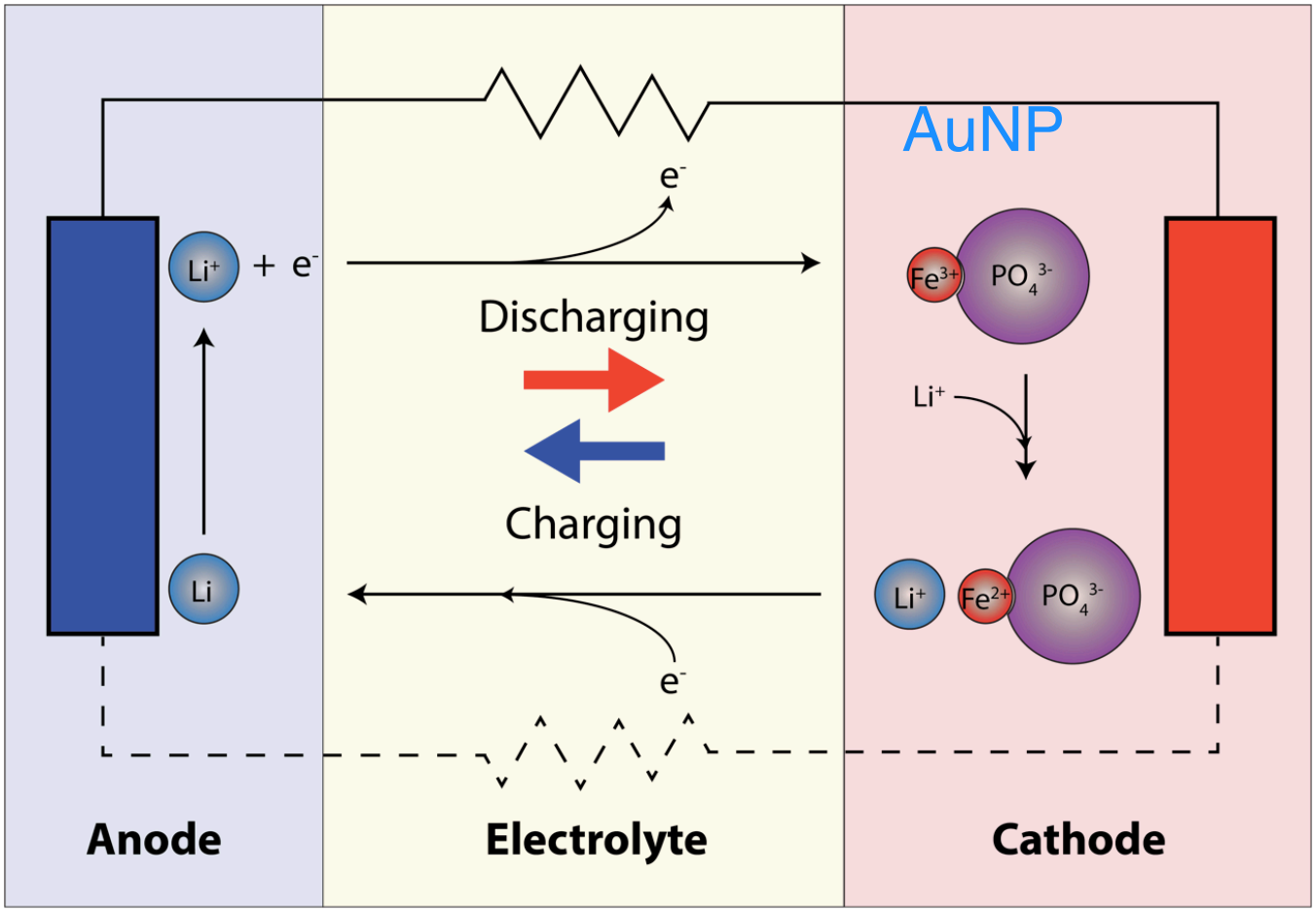
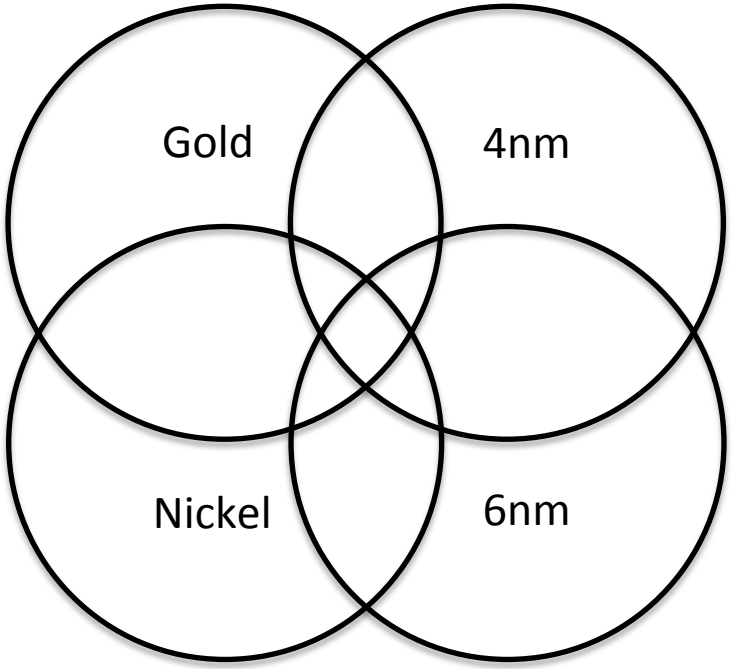


Image: George Sun

You will make a "Gold Standard" battery and an experimental battery

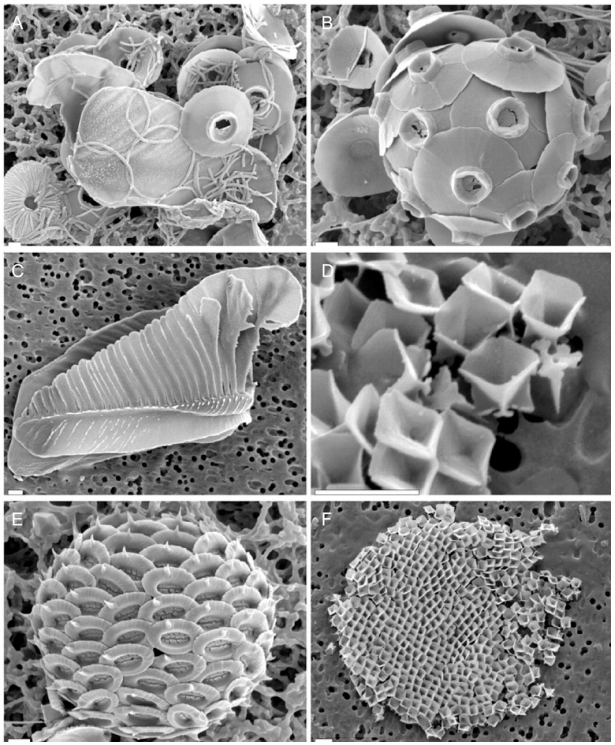
- Gold standard: 4nm AuNPs
- Choice of combination: 4/6nm, Au/Ni and ratio



Nanoparticle material and size may affect battery properties

- Redox coupling
  - Li / material interaction: Ni could oxidize at relevant voltage (Au will not)
- Conductivity
- Internal battery reaction catalysis
  - Li+ in solution → Li+ embedded
  - Surface to volume ratio with diameter

Examples of biomineralization from nature:



Engineering biomineralization using M13 phage:

- Environmental conditions

  4C, mild buffer, H2O

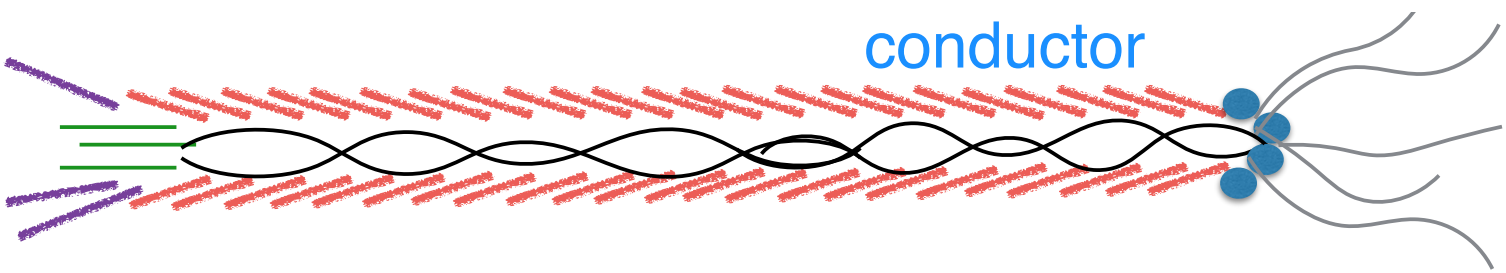
- Structural organization

  wire-like virus

- M13 provides scaffold for $Li(FePO_4)$ cathode construction

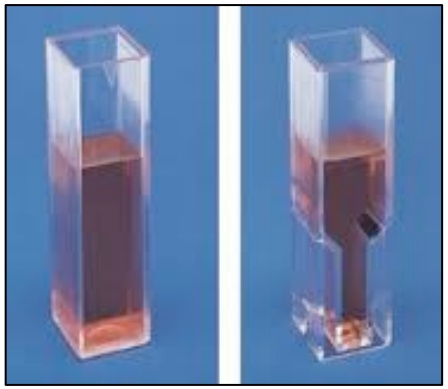
  iron = Li conductor / storage

  gold / nickel = electronic conductor



Determining Phage titer (number of virus):

- by plating: plaque assay
  - phage slows *E. coli* growth = plaque (cleared zone)
  - plaque-forming units: PFU/mL



- by spectrophotometry

$$\#\ \text{phage / mL} = \frac{(6 \times 10^{16})\ (A269 - A320)}{\#\ \text{bases in phage genome}}$$

❖ quartz cuvettes are expensive!

Today in lab

1. Finish phage purification
2. Calculate phage number
3. Begin construction of phage-NP-FePO4 nanowires (2 flasks, one per battery)
   - **Choose gold / nickel size, quantity and add to wiki**

- M3D2HW: Describe **FIVE** recent findings that could potentially define an interesting research question.
  - Formally cite the finding
  - Write 3-5 sentences summarizing the finding