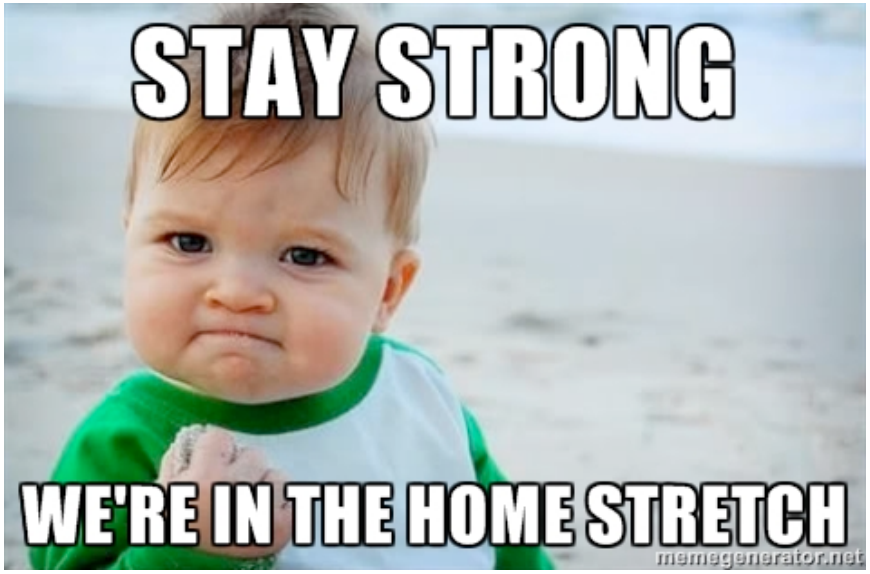
M3D1:Growth of phage materials

04/21/17

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



Thank you, Jifa Qi (Belcher Laboratory) !

As you know…

- Module 2 research article due 10pm on 04/22
- Blog post due 10pm on 04/23

M3 major assignments:

- Research proposal oral presentation (20%) on 05/11
  - Homework will build toward oral pres.
  - Discussions with Prof. Angie Belcher in lab
- Blog post due 10pm on 05/11
- Mini-report (5%) due 10pm on 05/16

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BIOLOGICAL ENGINEERING
Communication Lab

Keep using it!

We are in the homestretch!

		T/W Apr 18/19		Patriots' day holiday	
3	1	R/F Apr 20/21	AB	Grow phage active material	Homework due Research article due April 22 at 10 pm Blog post due Sun, Apr 23 at 10 pm
3	2	T/W Apr 25/26	AB	Purify phage active material	**Laboratory quiz** Homework due
3	3	R/F Apr 27/28		Construct cathode with phage active material	Homework due
3		T/W May 2/3	AB	Lecture, but no laboratory	
3	4	R/F May 4/5	AB	Visualize phage nanowires using TEM	Homework due
3	5	T/W May 9/10	AB	Assemble and test battery	**Laboratory quiz** Homework due
		R/F May 11/12	no lecture	Research proposal presentations	Blog post due Thu/Fri, May 11/12 at 10 pm
		T/W May 16/17		Open office hours	Mini report due Tue/Wed, May 16/17 at 10 pm
		R May 18		**Feedback and celebratory lunch**	

* (informal) elevator pitches for extensive feedback from Prof. Angie Belcher

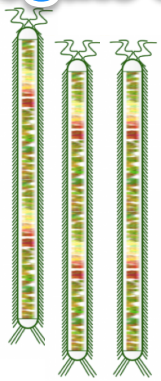
Module 3: biomaterials engineering

How does gold quantity affect battery capacity?

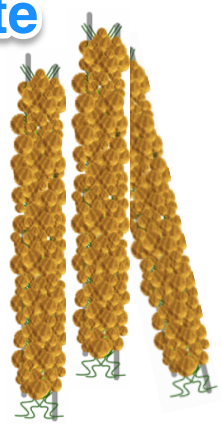
PEG: hydrophilic,
causes phage to aggregate and precipitate

Purify
M13 phage
Add AuNP

DAY 1

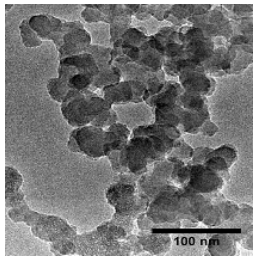


Biomineralize
Fe(III)-
phage-AuNP



Visualize
nanowires
on TEM

DAY 4



Purify
active material

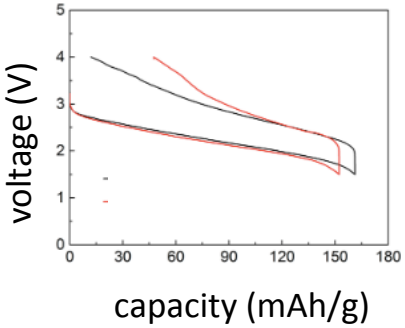
DAY 2

Construct
cathode
(and battery)

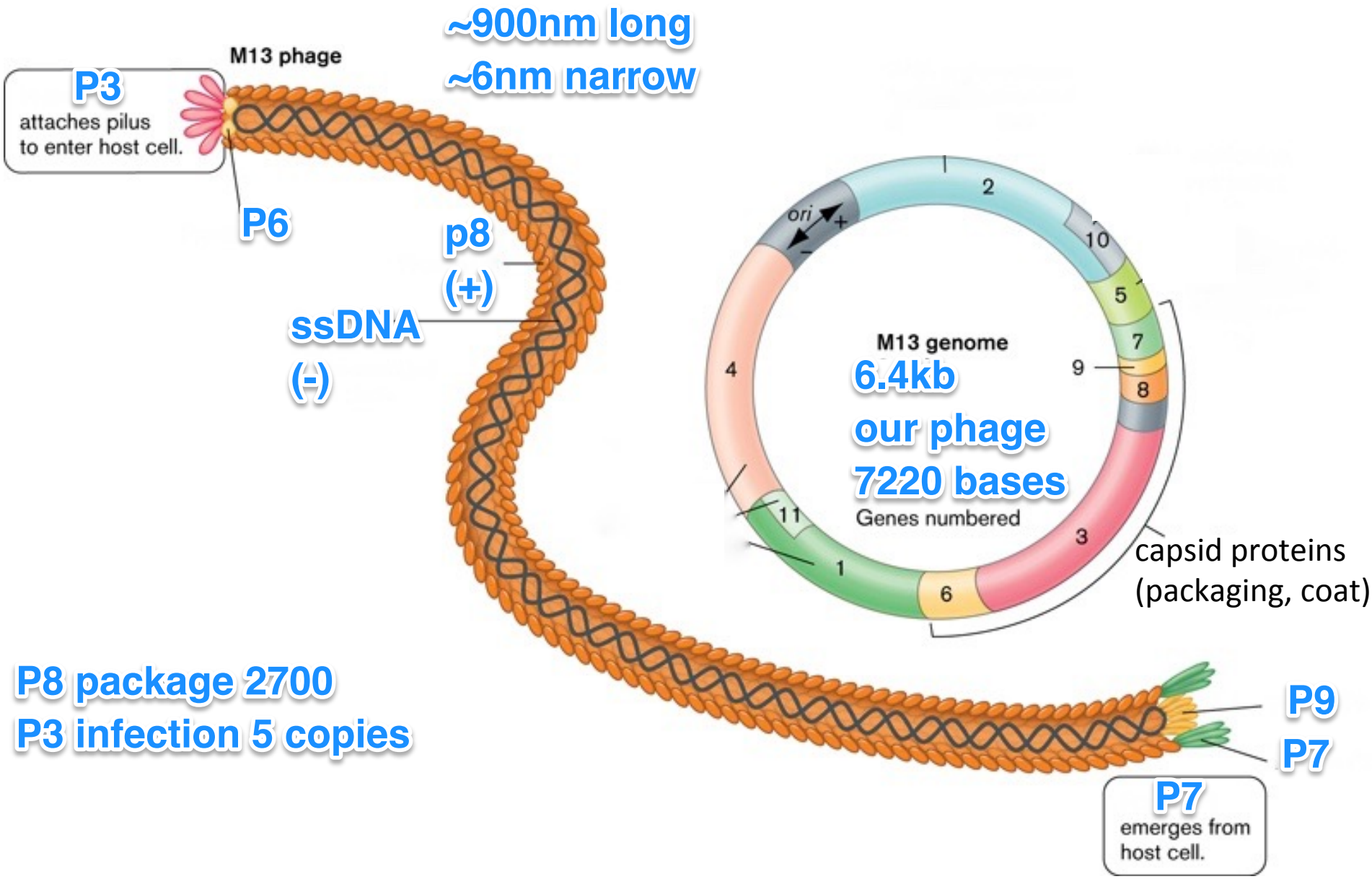
DAY 3

Measure battery
capacity

DAY 5

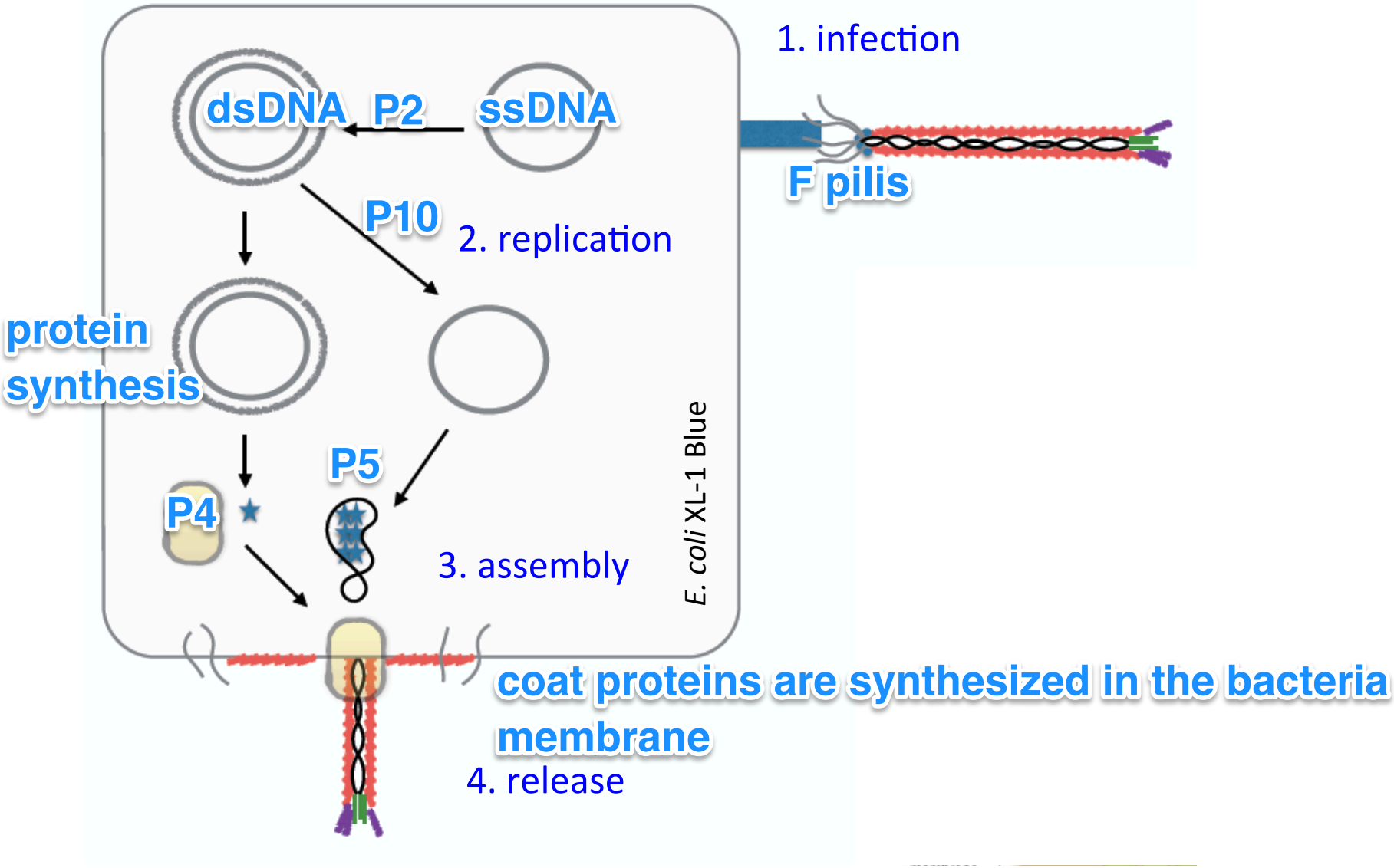


M13 phage genetics and structure

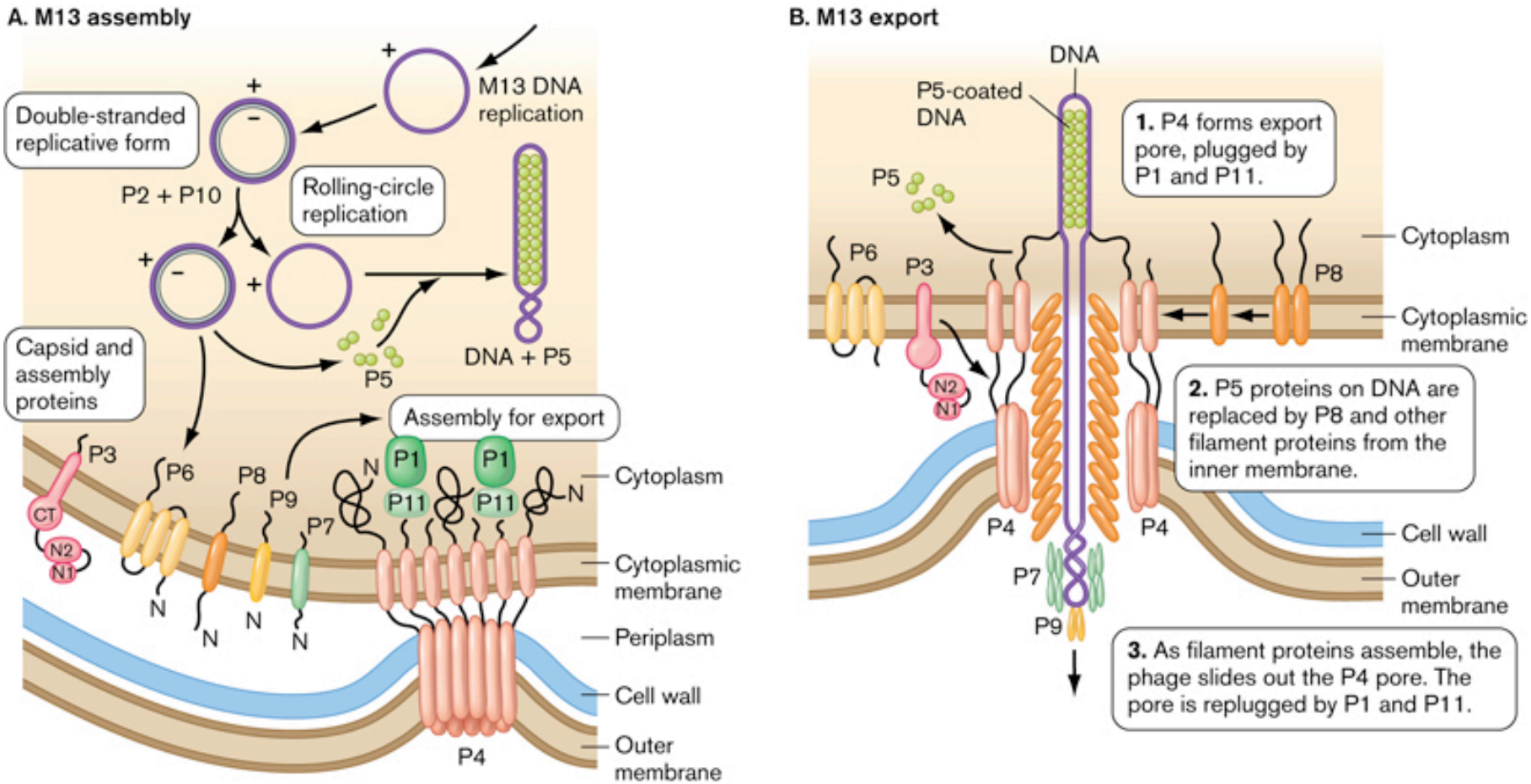


M13 uses host machinery to bring virus DNA into the cell and replicate

Overview of M13 virus life-cycle



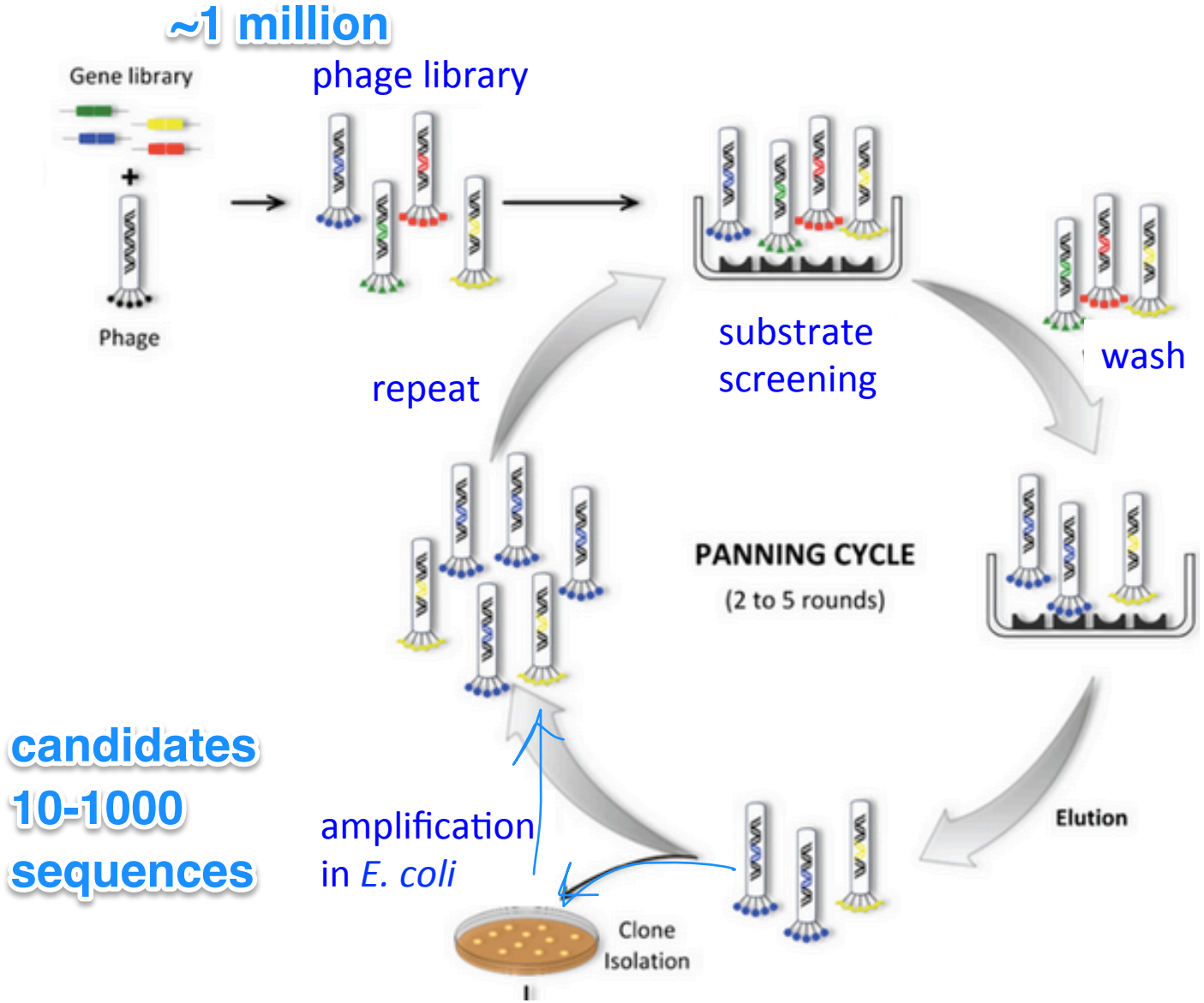
M13 is a nonlytic bacteriophage



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

Overview of phage display

P8 (2700) 4-6AA
P3 (5) 20-30 AA

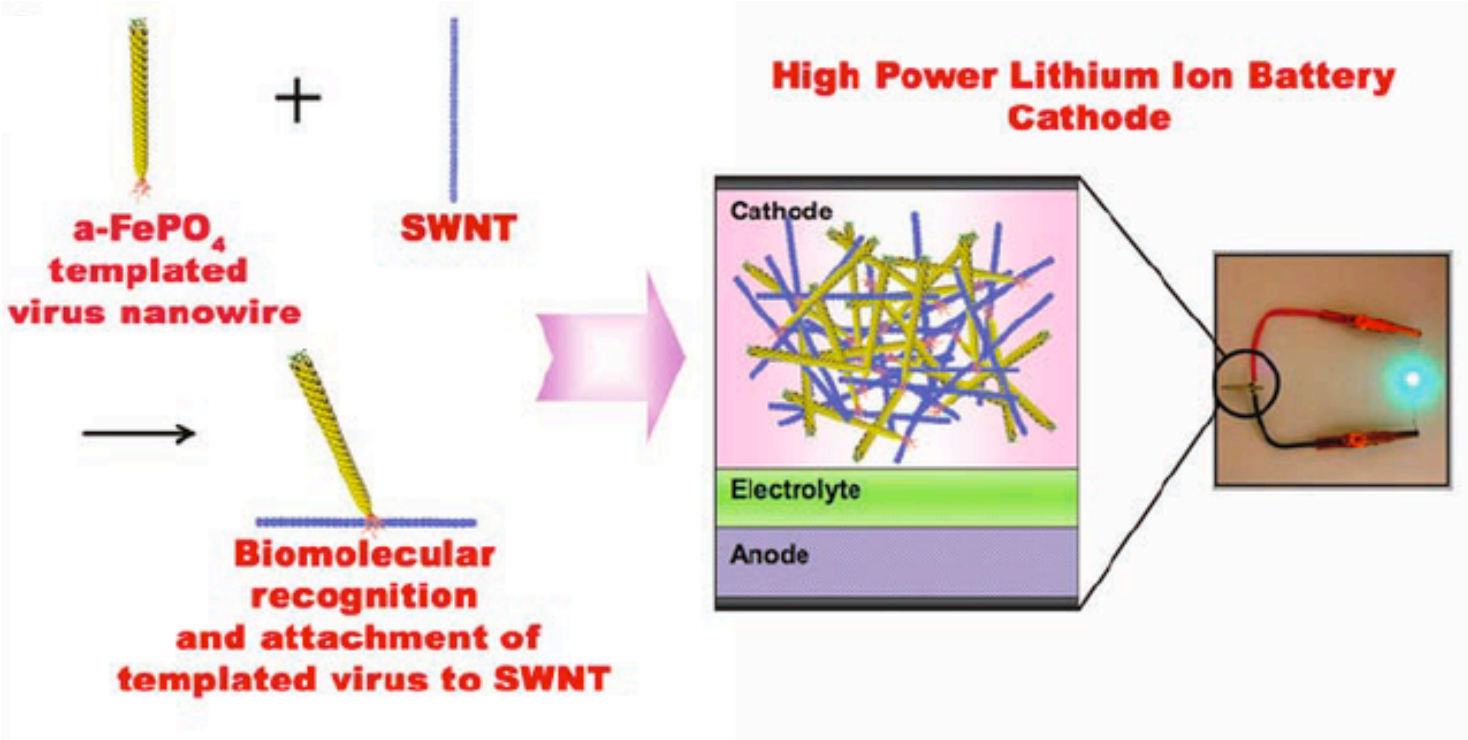


Biomolecules 2015, 5(3), 1783-1809; doi:10.3390/biom5031783

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
- 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

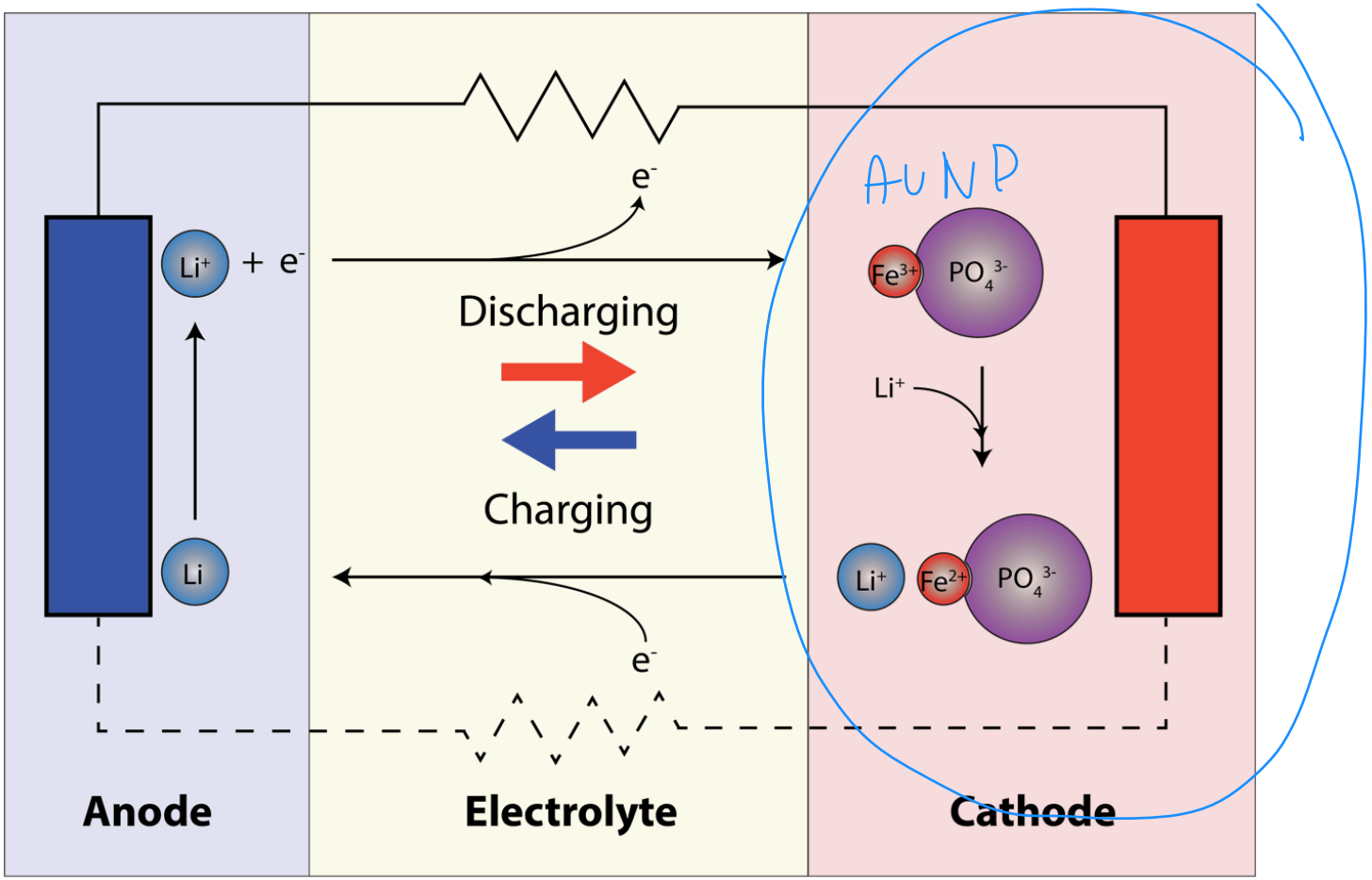
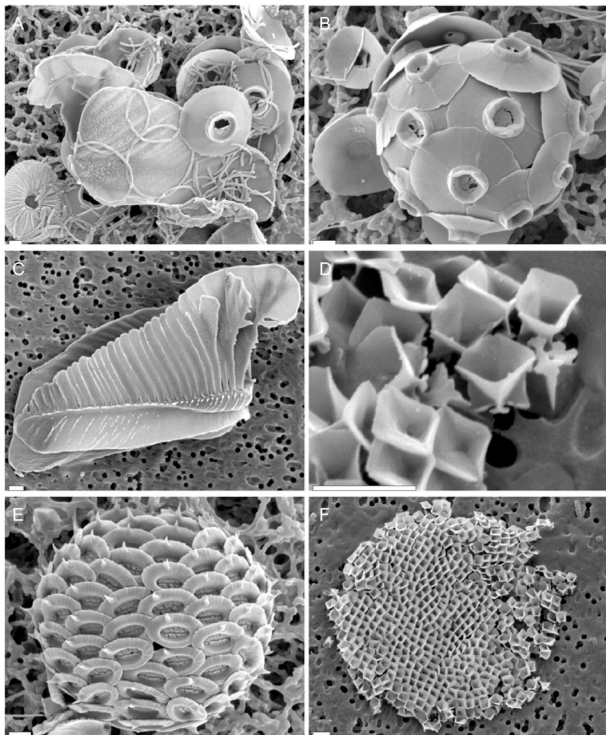


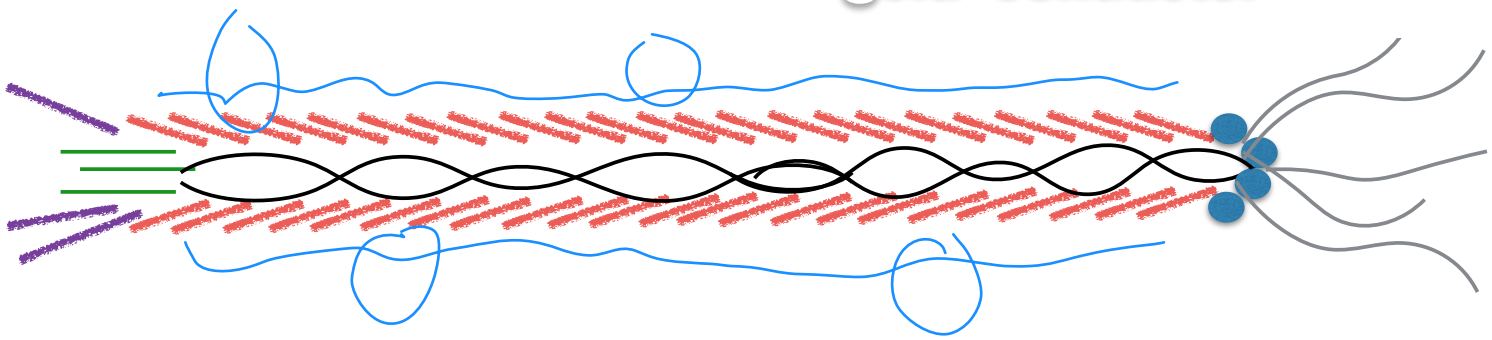
Image: George Sun

Examples of biomineralization from nature:



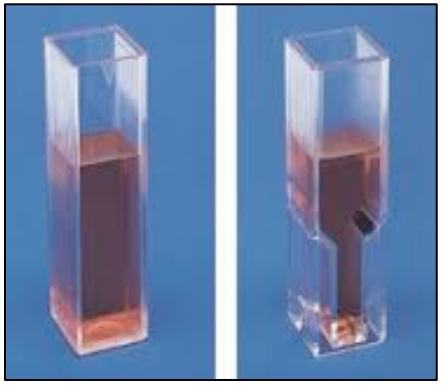
Engineering biomineralization using M13 phage:

- Environmental conditions
  4°C, **mild buffer, H2O**
- Structural organization
  wire-like virus
- M13 provides scaffold for Li($FePO_4$) cathode construction
  iron=storage
  gold=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-AuNP-FePO4 nanowires
   - **Choose gold 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