Double-dipping and connecting the dots: Integrating skill-building and inquiry-based research into a biochemistry lab curriculum

Melanie Berkmen
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Suffolk University

How to implement MIT's project lab…

Thank you!

Caterina Schweidenback
Suffolk

Edith Enyedy
Suffolk

HHMI Educ
Mandana Sassanfar
MIT

Thomas Schwartz
MIT

Phil Lessard
Project Lab
MIT

Mary Ellen Wiltrout
Harvard

Graham Walker
HHMI Educ Group
MIT

Celeste Peterson
Suffolk

Alan Grossman
MIT

Suffolk University
My students
Martha Richmond
Department of Chemistry and Biochemistry

Rick Gourse
UW-Madison

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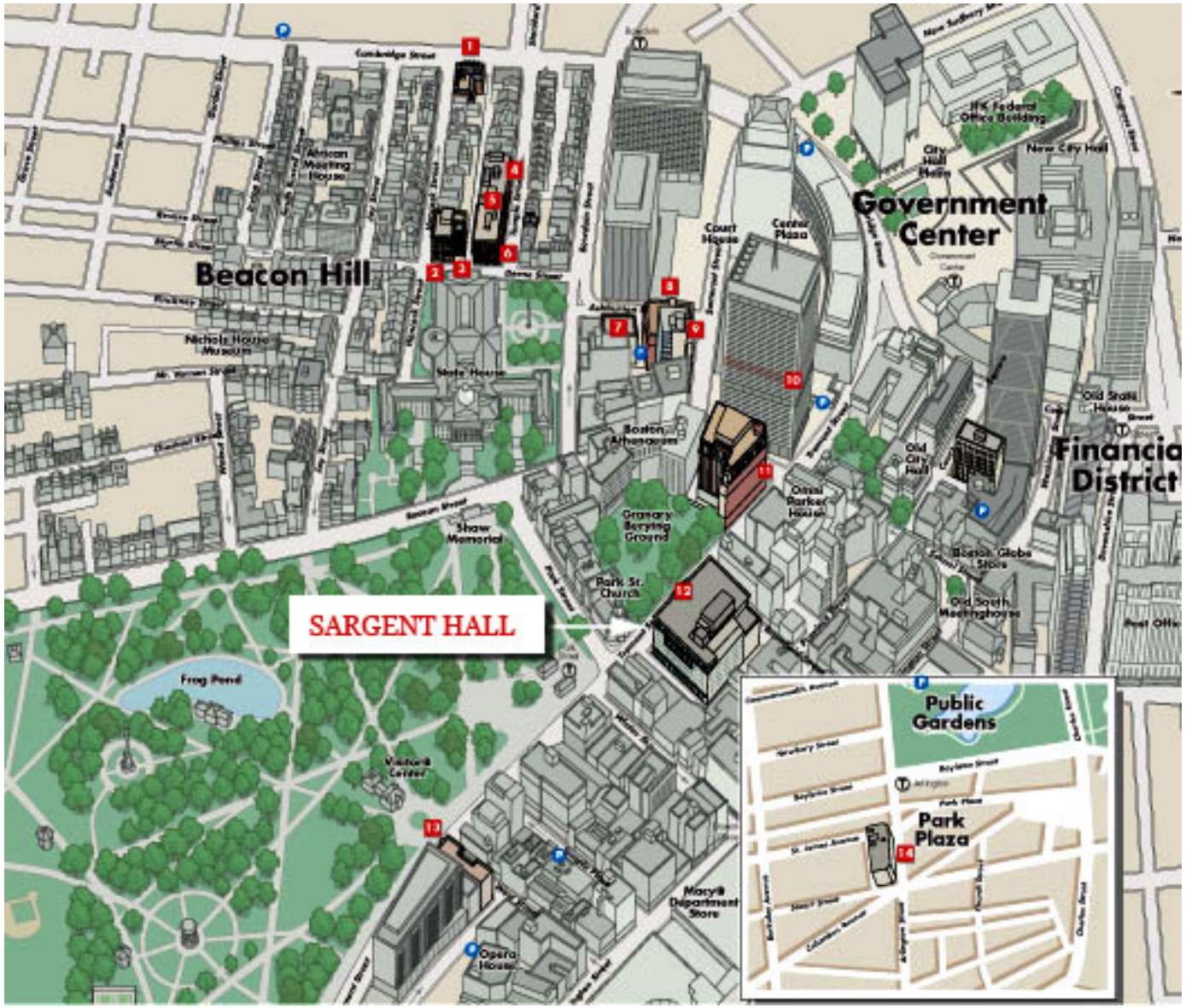
Outline

- About Suffolk and our students
- The prior biochemistry lab curriculum
- Lab 1: Basic biochemical techniques (Skill-building)
- Lab 2: Advanced biochemistry research (Application)
- Reflections

No, we are not just a Law School



Coming soon: 20 Somerset to house CAS

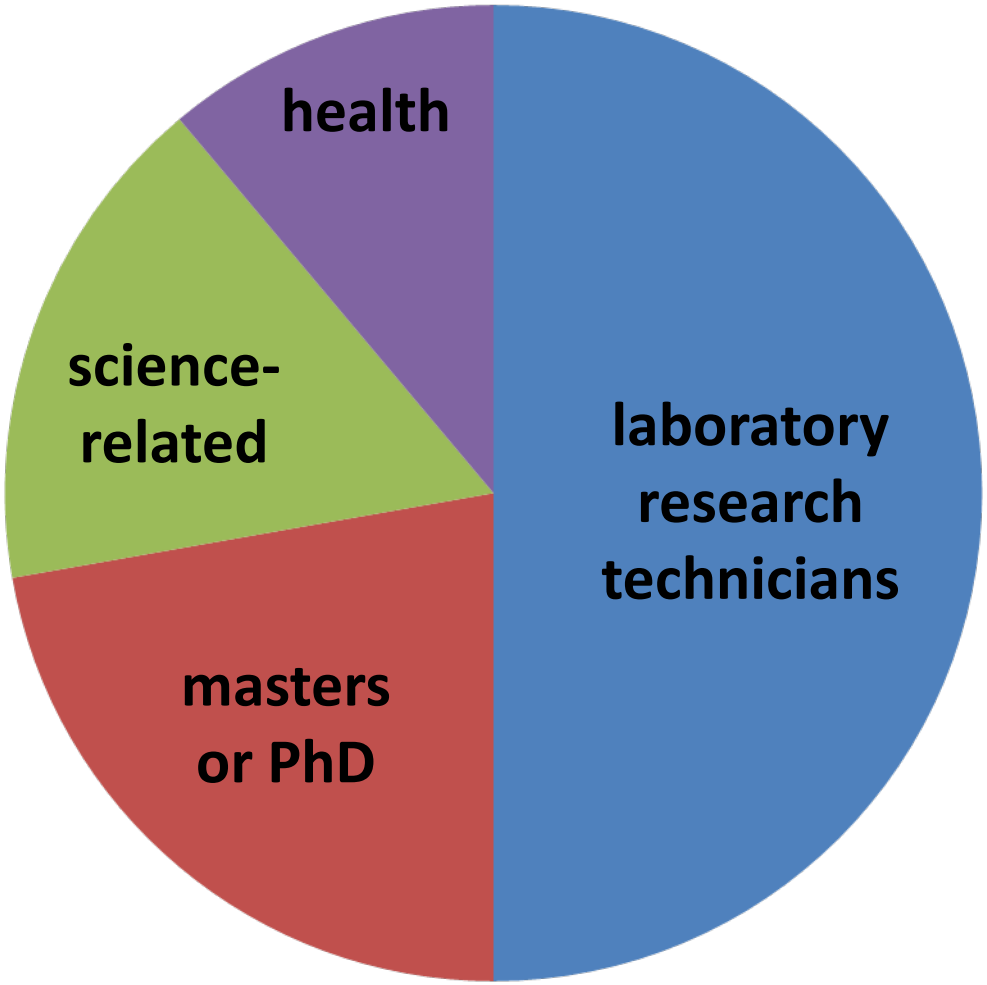
Underprepared

Diverse

“Grit”

Where do my students go after Suffolk?

What do I need to prepare them for?


health
science-related
laboratory research technicians
masters or PhD

Outline

- About Suffolk and our students
- **The prior biochemistry lab curriculum**
- Lab 1: Basic biochemical techniques (Skill-building)
- Lab 2: Advanced biochemistry research (Application)
- Advantages and disadvantages

Prior Biochemistry Lab Curriculum

Pipets

Purify lactate dehydrogenase

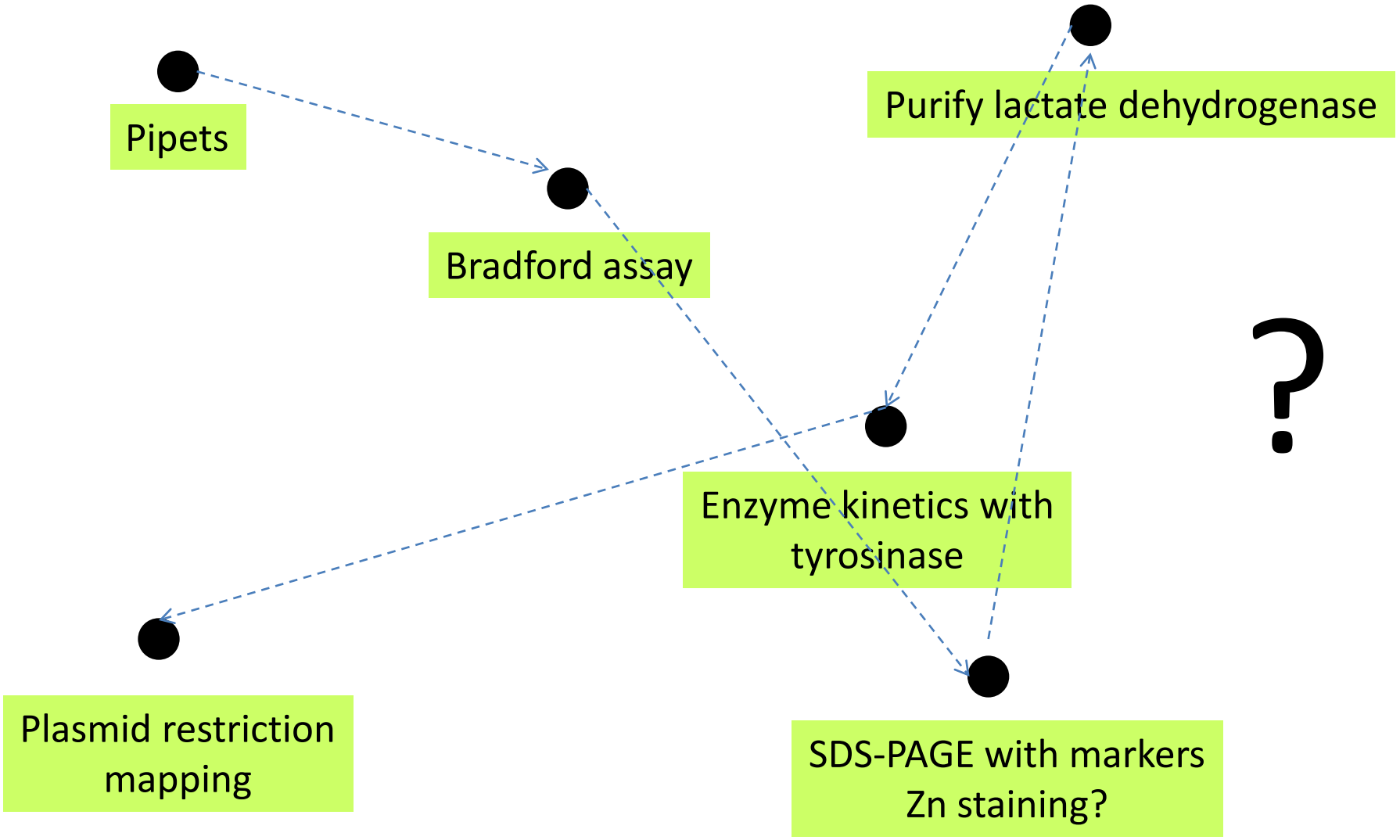
Bradford assay

Enzyme kinetics with tyrosinase

Plasmid restriction mapping

SDS-PAGE with markers

Dots do not connect



Skill-building

Basic Biochemical Techniques

Required lab for Biochemistry I

4 hours/week

~13 students per section
2 sections

Juniors

Required for biochem, chem, and biochem forensic science majors

Application

Advanced Biochem Research

Not associated with any course

4 hours/week

~5-13 students per section

Juniors

Required for biochem majors

Skill-building

Basic Biochemical Techniques

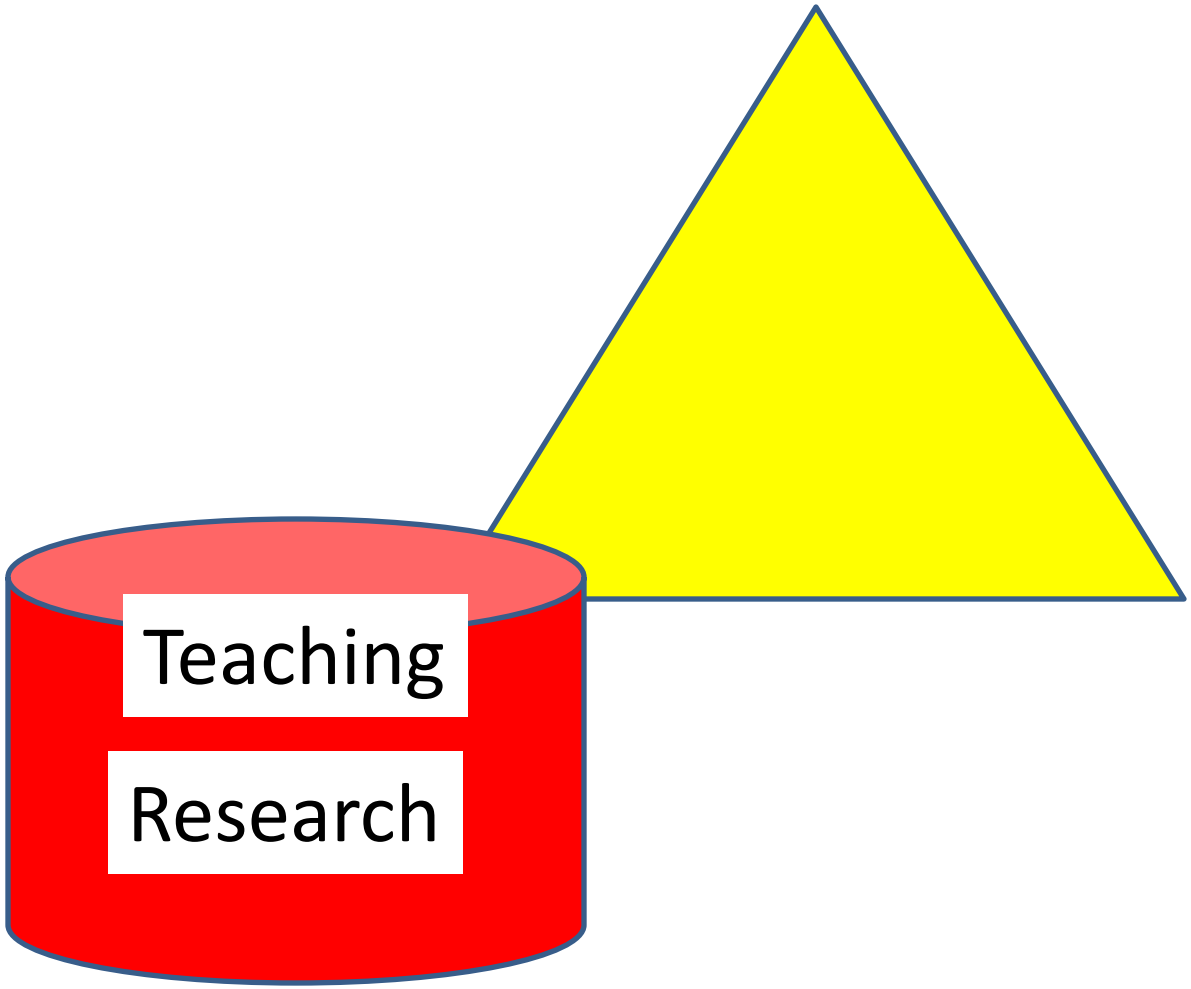
- Acquire basic lab skills
- Understand the basic *process of scientific discovery*
- Strengthen writing skills

Application

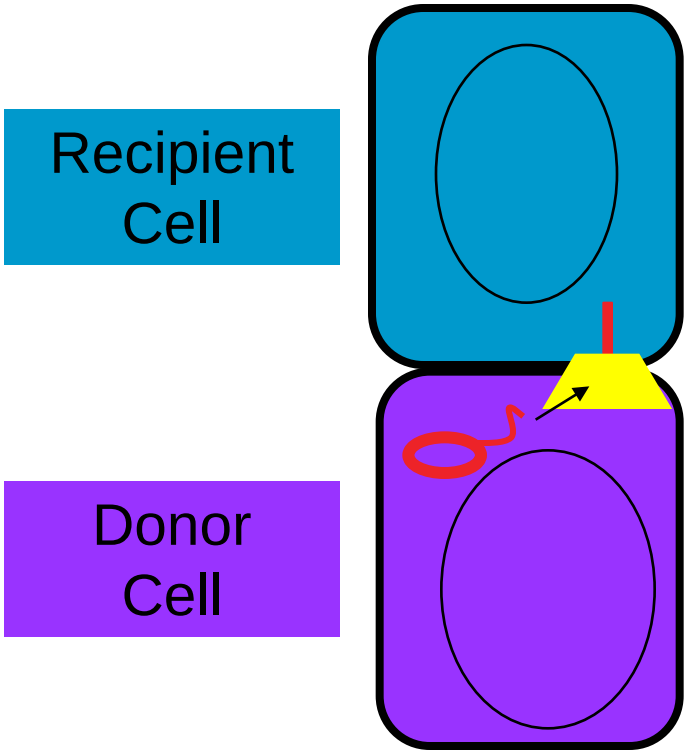
Advanced Biochem Research

- Apply the *process of scientific discovery* using good experimental design, controls, and trouble-shooting
- Develop the whole scientist
- Prepare students for thesis

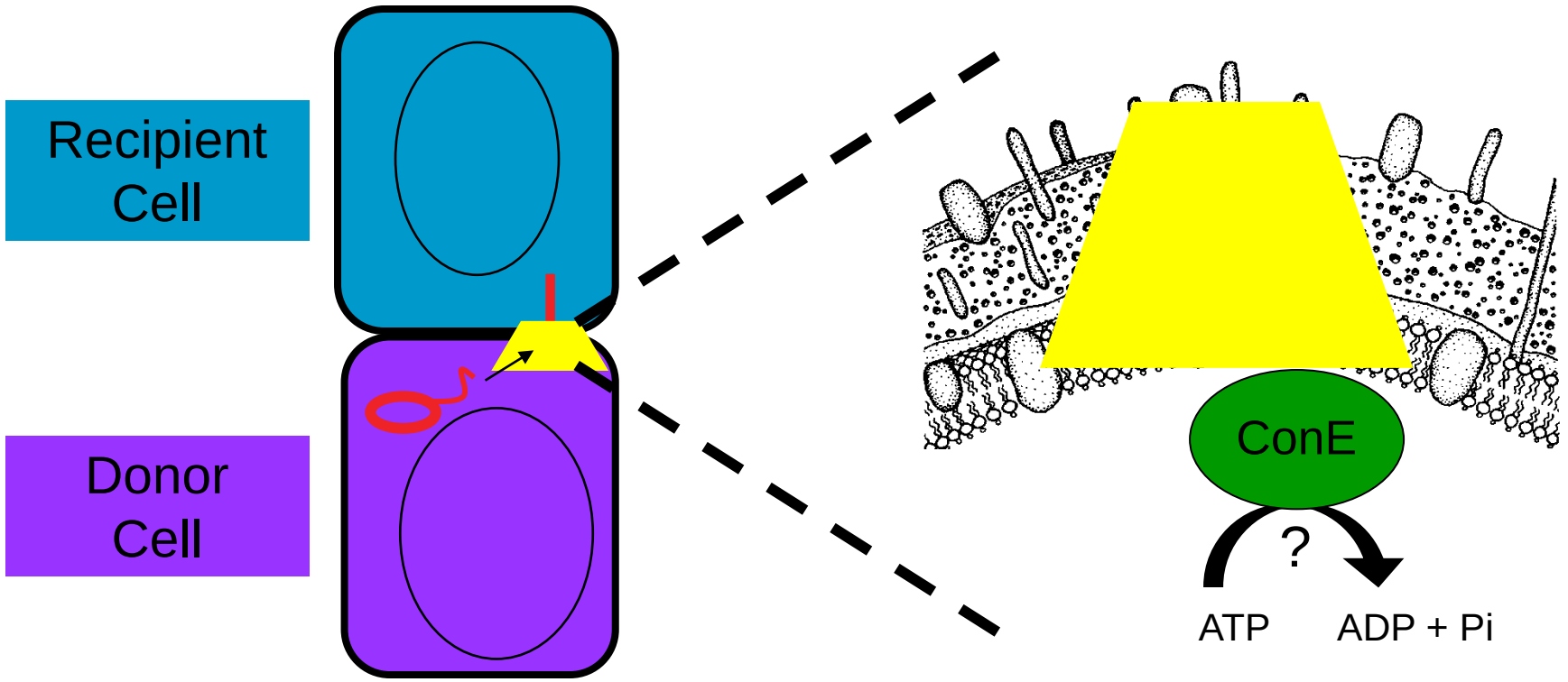
Double-dipping



Bacterial mating (conjugation)



ConE is a critical ATPase of the bacterial mating machinery



Advantages to me

- Easy (same literature and skill set)
- Cheap (same equipment)
- Quick (same reagents)
- Trained labor

- More results, faster: NSF-RUI

Skill-building

Application

Basic Biochemical Techniques

- Acquire basic lab skills
- Understand the basic *process of scientific discovery*
- Strengthen writing skills

Labs 1: Buffers, water, solutions, sterilization

Concentrations:

3 mM solutions

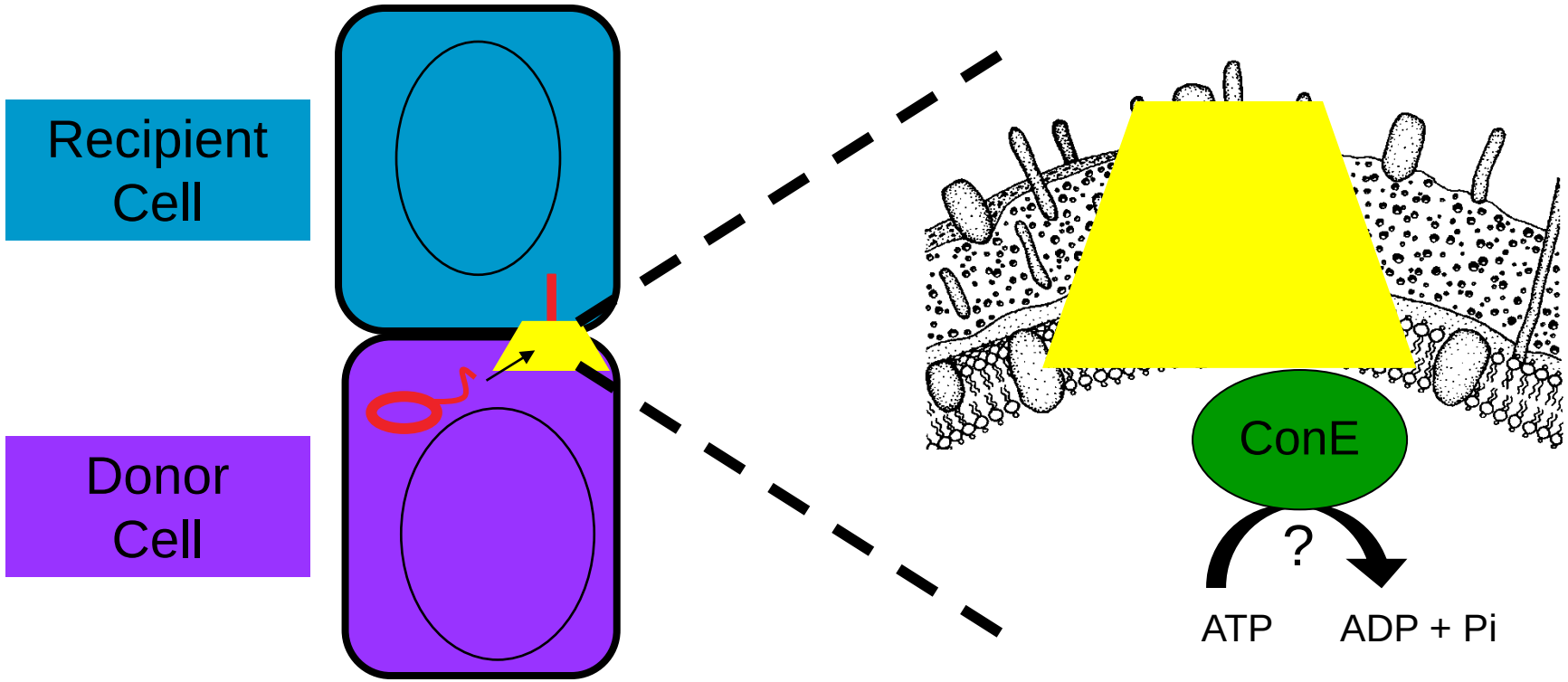
5% solutions

10x solutions

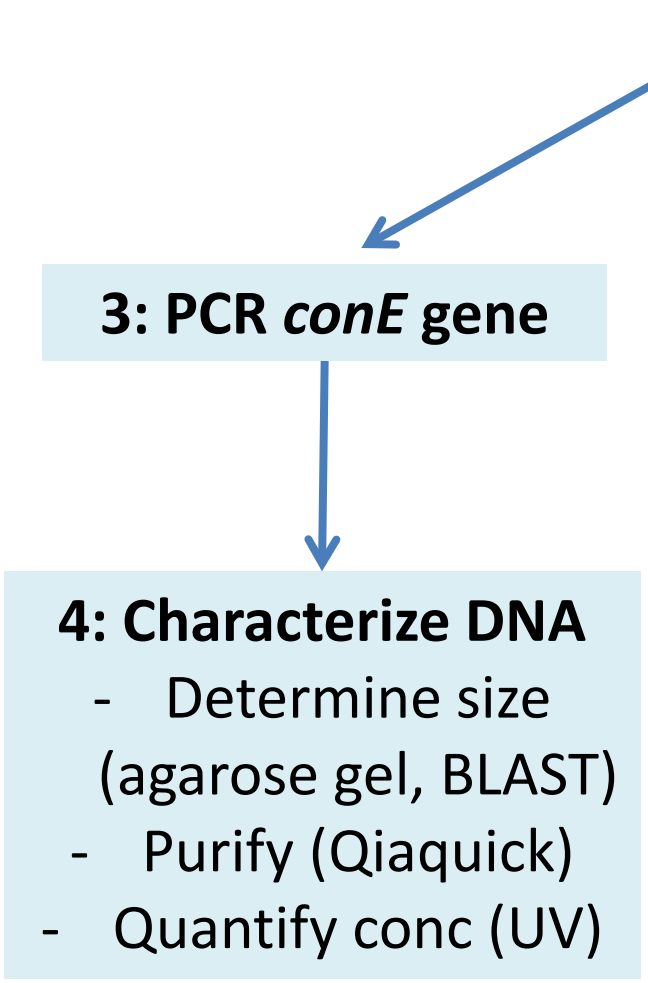
Lab 2: Pipets and statistics

(g) or (mg)	200 µL **P200**
Mass 1	
Mass 2	
Mass 3	
Mass 4	
Average ± SD	
Density at t°C, g/mL	
Volume ± SD	
%error	

Labs 3-10 are connected in terms of topic



Skills are learned through connected labs



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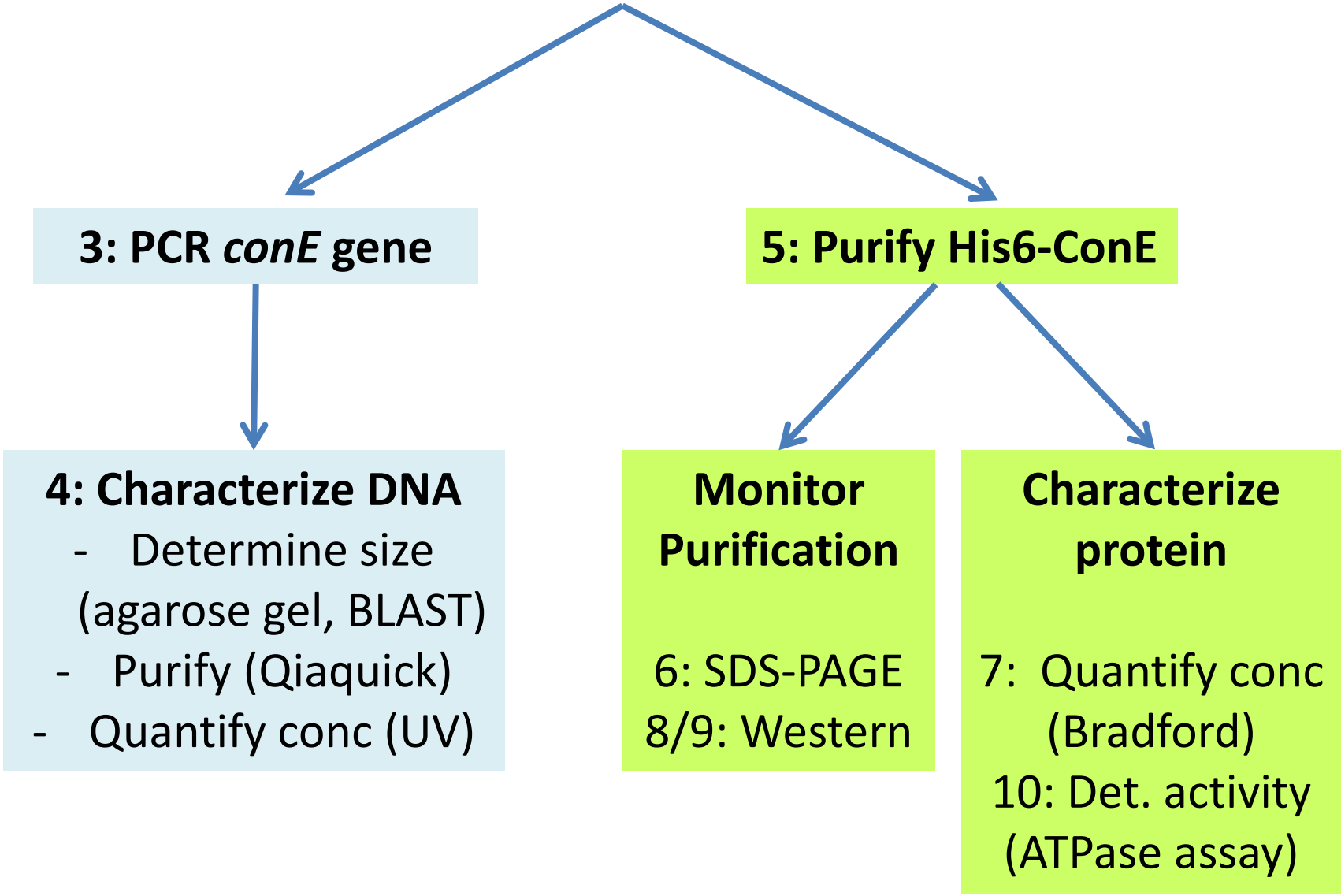
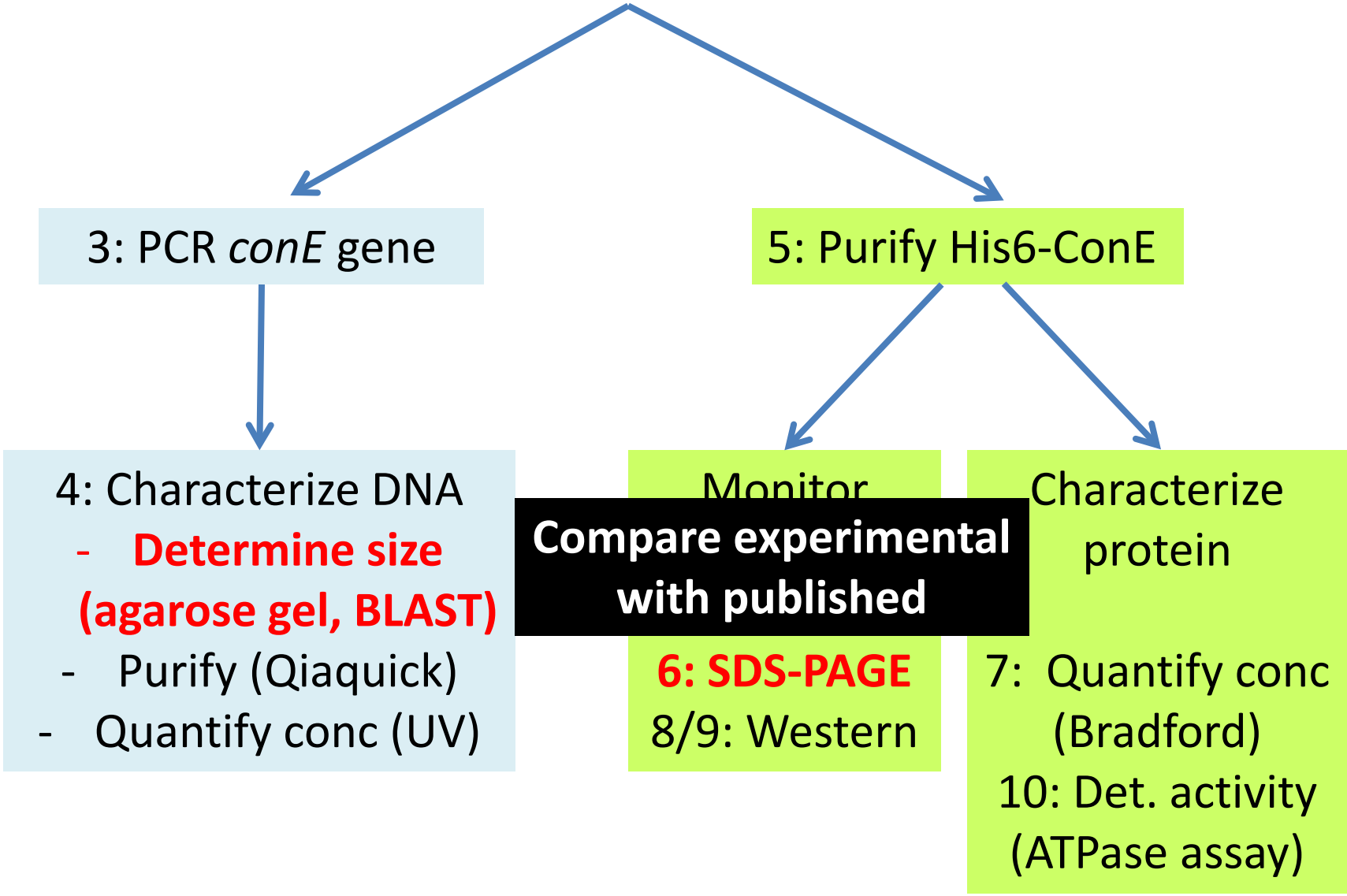
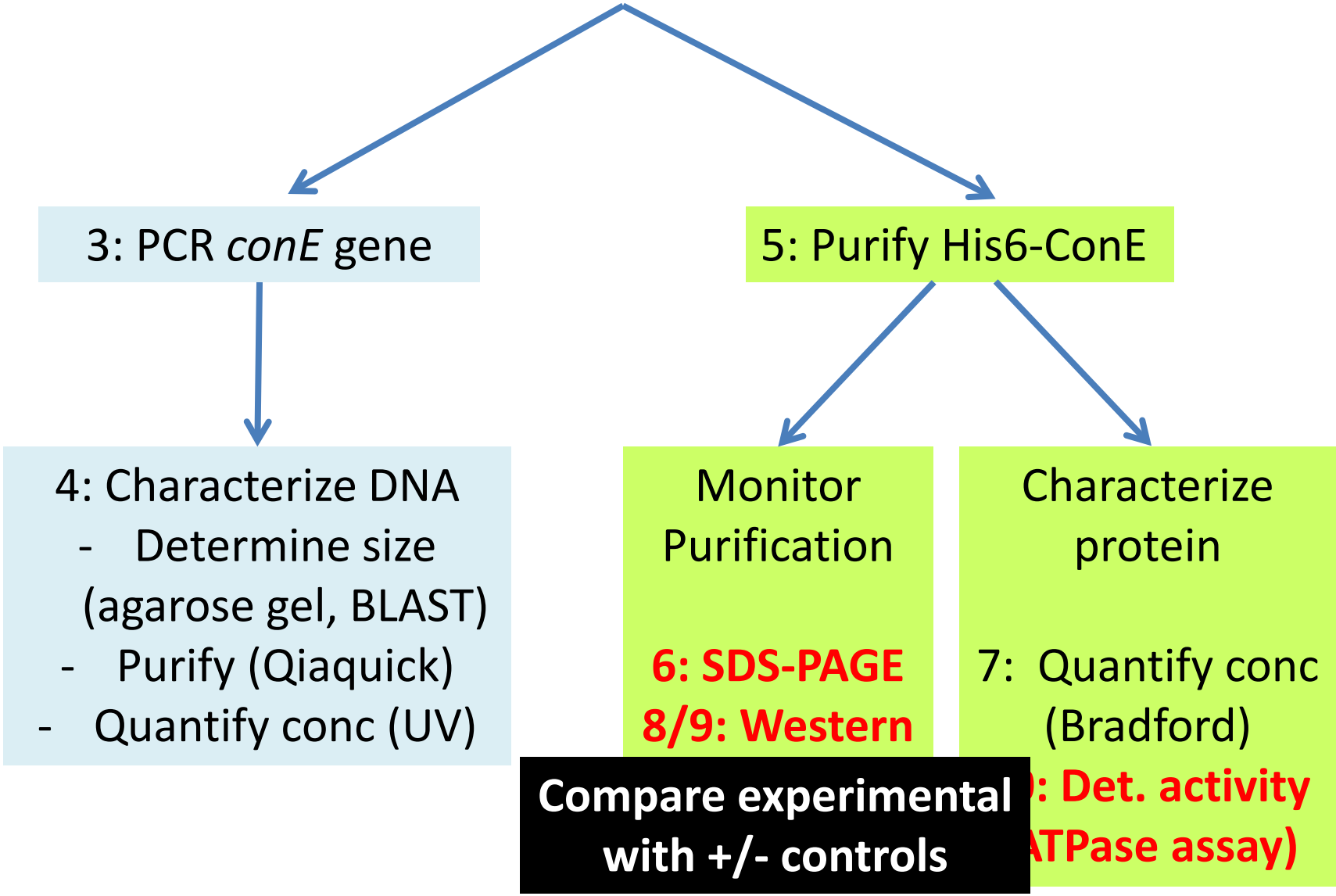


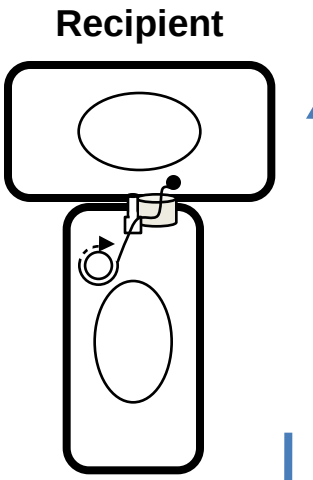
Basic experimental design learned

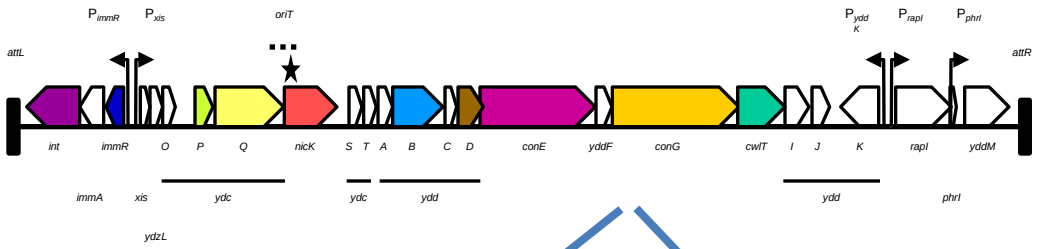


Basic experimental design learned

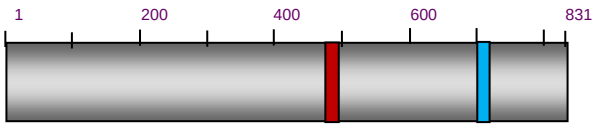


Depth of understanding





conE (wt)

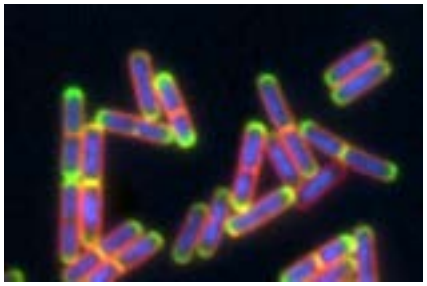


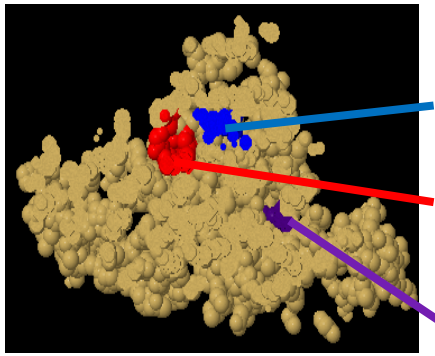
conE (Δ8-808)

Mating %

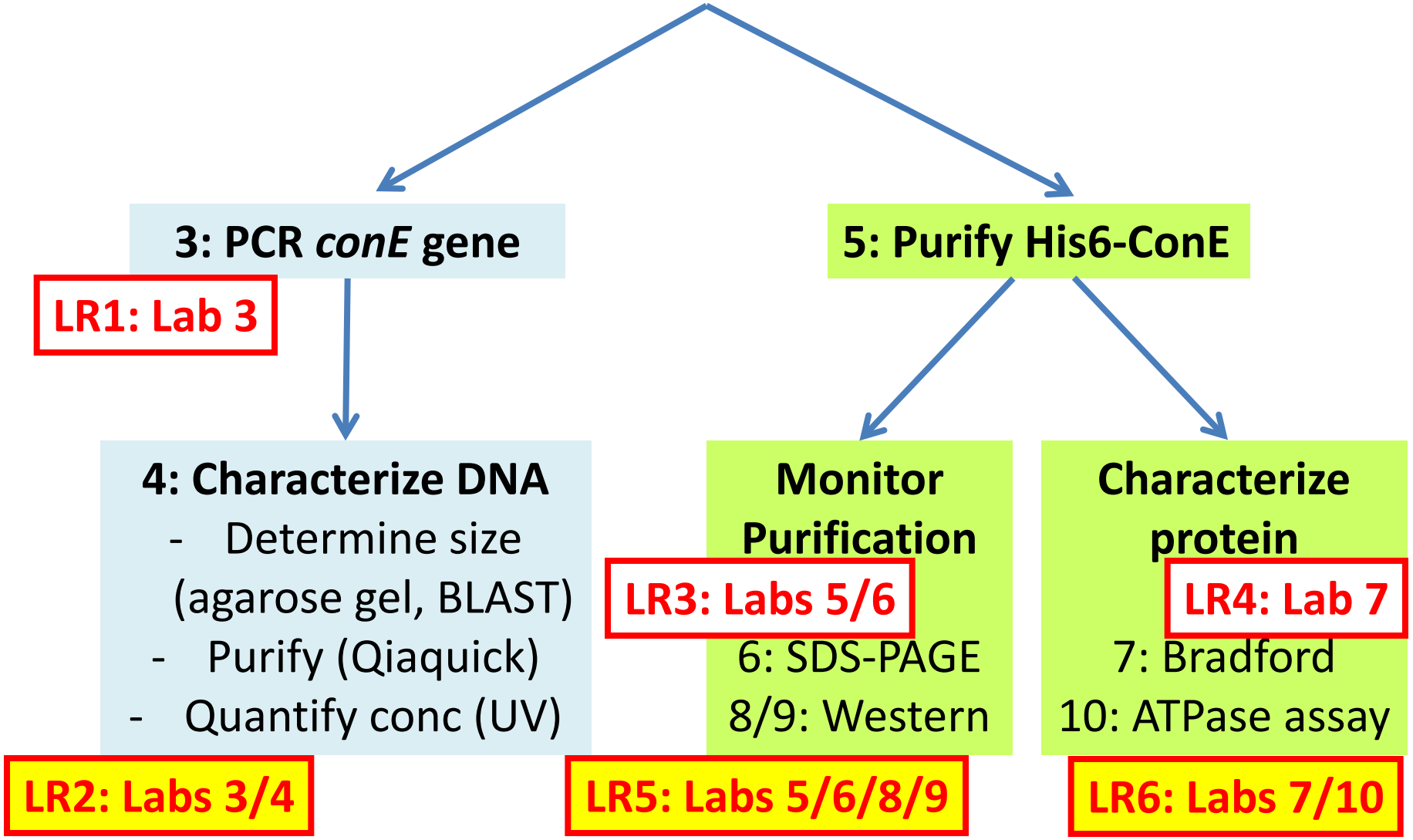
7

undetectable





Iterative drafts of lab reports = students learn to write + assessment



How to Improve Student Writing

Multiple drafts

Edit and comment reports

Staple new-to-old; deduct points

Space drafts appropriately

Hand out “cheat” sheet

and “universal lab report rubric” to students

Skill set	Expectations (for an A)
1. ABSTRACT (10 points)	Succinctly summarizes key aspects of the report: (a) brief background and significance, (b) purpose (c) brief experimental procedure, (d) most important results (e) main conclusions, 100-200 words
2. Introduction (20 points)	Describes the background necessary to understand the new results. Describes the DNA or protein you are making, purifying, or characterizing. Does not include irrelevant or protocol-like info. Briefly describes purpose of the experiment. First person, active voice, present/future tense.
3. Exper. Proc. (10 points)	Explains how experiment was done so another person (with similar skill set) can repeat it. Uses subheadings. Not a protocol. 3rd person, passive voice, past tense
4. Results & Discussion (30 points)	States what you did, (why you did it briefly), what you saw, and what you conclude. Pos/neg controls analyzed. Figures labeled and referred to. Correct sig figs. Analyzes results. Discusses inconsistencies. First person, active voice, past/present tense.
5. References (10 points)	<u>Excellent use of references (3+):</u> -all statements that are not common knowledge have citations -Relevant, formatted properly -Refers to papers read for class on subject, and not just lab manual and textbook
6.Organization And writing (20 points)	-Main points clearly articulated in topic sentences - Information is in proper sections of the paper <u>Excellent writing skills with great:</u> Grammar, clarity, conciseness Spelling, punctuation, transitions, Use of jargon Use of past/present/future, Use of active voice, Use of 1st and 3rd person

How to get students to connect the dots

- Iterative drafts
- Students “cite” their own prior lab report
- Temporally connect content in lecture and lab

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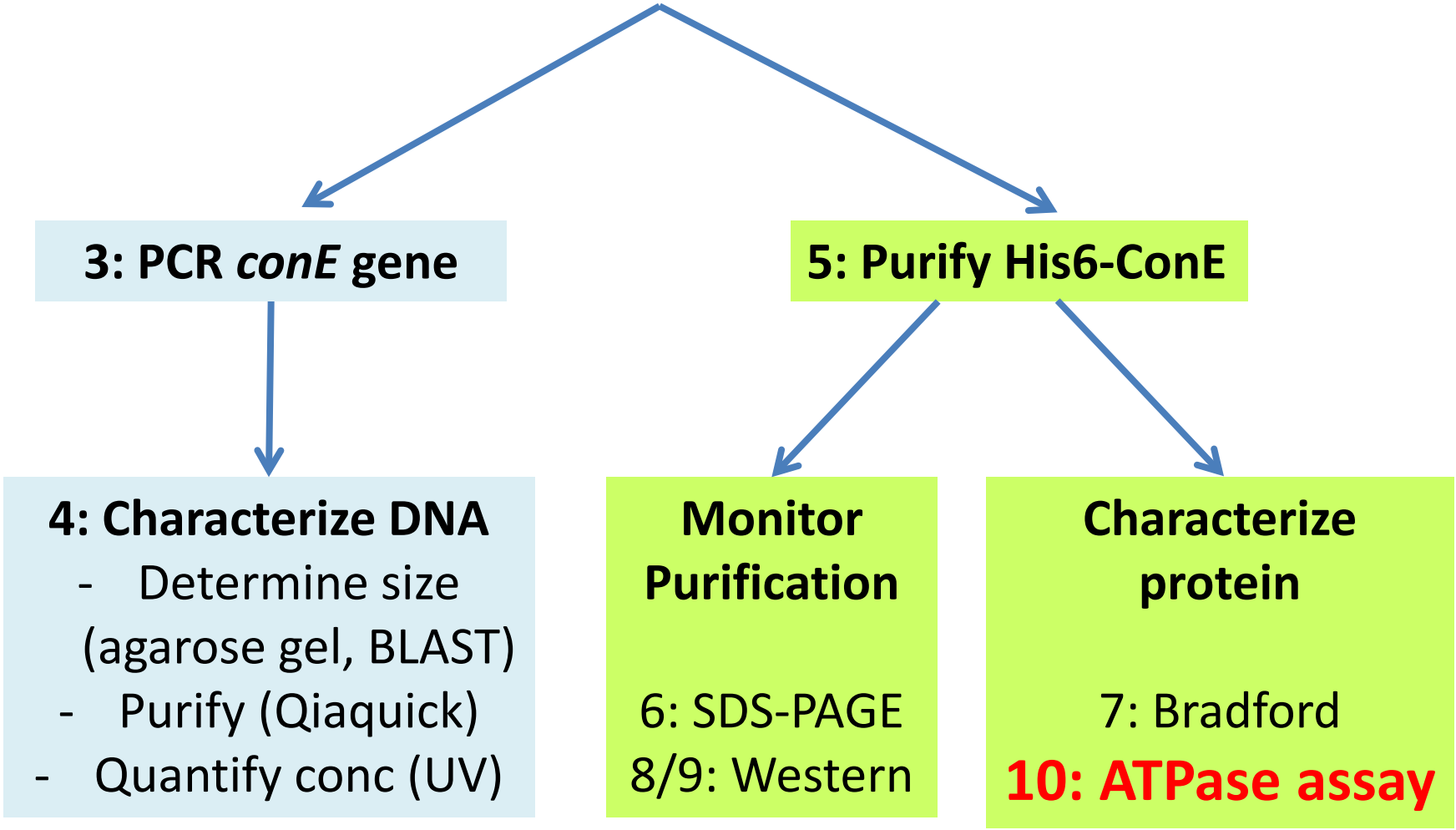
The Syllabus

Lab #	Reading*	Activities
Intro		Introduction Discuss group lab research projects
11	Arechaga et al, 2008	Choose group lab research projects and paper **Discuss/design ATPase experiments**
12		**Conduct ATPase experiments**
13	Iyer et al, 2004	**Quantitate & discuss ATPase results** **Work on group poster**
14	TBD	
15	Mondoux et al, 2011	
16	TBD	
17	TBD	**Field Trip to Biogen**
18	TBD	
19	TBD	
20	TBD	
21	TBD	
22	TBD	

Skills are learned through connected labs



Scaffold independence…

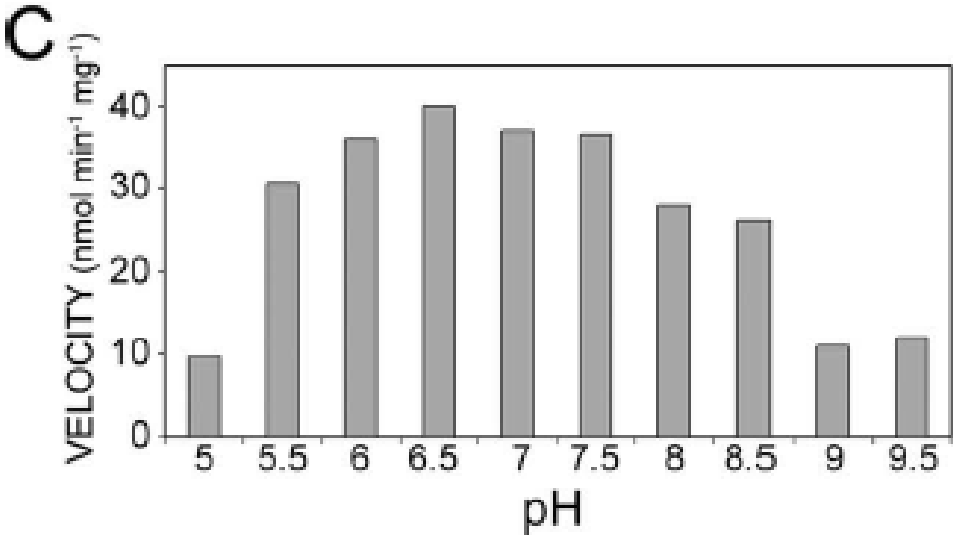


FIG. 2. TrwK ATP hydrolase activity. TrwK ATPase activity was monitored by the decrease of NADH absorbance at 340 nm (A) in the presence of 75 mM NaCl (trace b) or 75 mM KAc (trace c). The control is shown in trace a. The effects of salt concentrations (B) and pH (C) are represented.

Group
poster ???
#$%^&(!

The analysis of ATP hydrolysis from a conjugation protein in *Bacillus subtilis* in various environments

SUFFOLK UNIVERSITY

Department of Chemistry and Biochemistry, Suffolk University, Boston, MA 02114

CHEM L432

What about the next 8 labs?

1. BIOCHEM. Explore whether ConE can bind DNA using “gel-shifts.”

2. BIOCHEM. Characterize His6-ConE’s multimerization using BN-PAGE.

3. BIOCHEM. Test His6-ConE’s affinity for ATP using spectroscopy.

4. BIOCHEM. Try to purify ConE with a different tag or column.

5. BIOINFORMATICS.
   - Determine protein structures of ICE proteins using threading (Phyre2).
   - Search for ICE homologs.
   - Analyze/blast various ICE genes.

6. MICROBIOLOGY. Characterize change of variables on mating.

7. CELL BIOLOGY. Analyze ConE-GFP’s localization under some new condition using fluorescence microscopy.

Examples of past projects

2013 - Quikchange mutagenesis
- Purification of MBP-ConE

2012 - Quikchange mutagenesis
- Blue Native-PAGE of ConE

2011 - Bioinformatics
- Gel-shifts to explore DNA binding

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The hurdles

- Not normal (defies student expectations of the cookbook)
- Student boredom (not curing cancer)
- Endless grading of drafts
- There is no cookbook (requires continuous planning)
- How to deal with student absences

Dealing with risk

You must accept “failure” too.
Don’t re-do everything for them.

Dealing with risk

Do a variety of “sure” and “risky”

Do “sure” things first to build confidence

Warn students

Emphasize successes

Duplicates

The benefits to students

Student choice and novelty

- “allowing us to come up with our own experiments”
- “enjoy picking which designs/experiments to do”
- “being able to do actual research and choose what we learn”
- “loved that weren’t just ‘following protocols’, having the ability to try new things”

Depth and connections

- “I liked that we spent lots of time on only a few lab experiments. It made me really know what we were doing”

- “the experiments and how they all were built off of one another”

[I liked] “working in groups to come up with a procedure”

Start thesis & publish

- **Maria Levicheva** - B.S. Biochemistry, May 2009
- **Erin Cross** - B.S. Biochemistry, May 2009
- **Cori Leonetti** - B.S. Biochemistry, May 2010
- **Matt Hamada** - B.S. Biochemistry, December 2010
- **Ryan Hutchinson** – B.S. Biochemistry, May 2010
- **Georgeanna Morton** – B.S. Biochemistry May 2013

Berkmen MB, **Laurer SJ*, Giarusso BK*, Romero R***. (2011) The integrative and conjugative element ICE*Bs1* of *Bacillus subtilis*. In *Bacterial Integrative Mobile Genetic Elements*. (Roberts AP, Mullany P ed.). Landes Biosciences, Austin, TX.

Develop the whole scientist

Learn how scientists think, plan, conduct, analyze, write.

Learn how scientists **look** and **speak**.

Learn **where scientists work**.

Learn authentic process of science

- long-term
- *risky and exciting*
- “hard fun”

Thank you!

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