FRESHMAN RESEARCH IMMERSION PROGRAM

Walk in a freshman -
Walk out a researcher.

Making the most of course-based research experience

BINGHAMTON UNIVERSITY
STATE UNIVERSITY OF NEW YORK

CRE = Course-based Research Experience

- Engaging students in scientific practices
- Emphasizing collaboration
- Examining broadly relevant topics
- Exploring questions with unknown answers that expose students to real discovery
- Integrating iteration into course, thus how research builds on itself

From: Auchincloss et al (2014) Assessment of course-based undergraduate research experiences: a meeting report. CBE Life Sci Educ 13(1):29-40

Nationally students are becoming disengaged and leaving the sciences

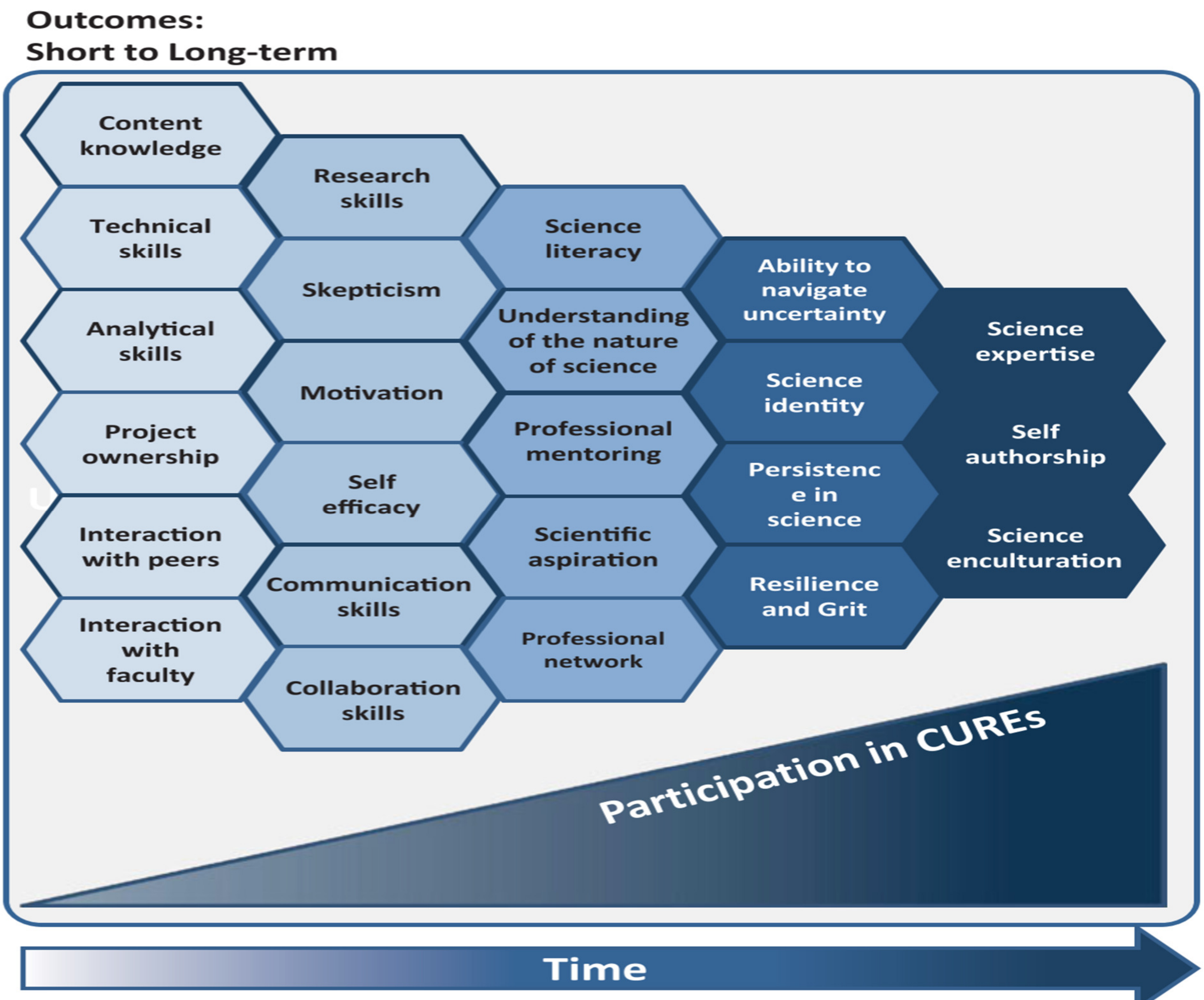
Fewer than 40% of students entering college with intention of majoring in STEM complete a STEM degree!

But why a three-course sequence of CREs?

Freshman fall
--
Research Methods Seminar

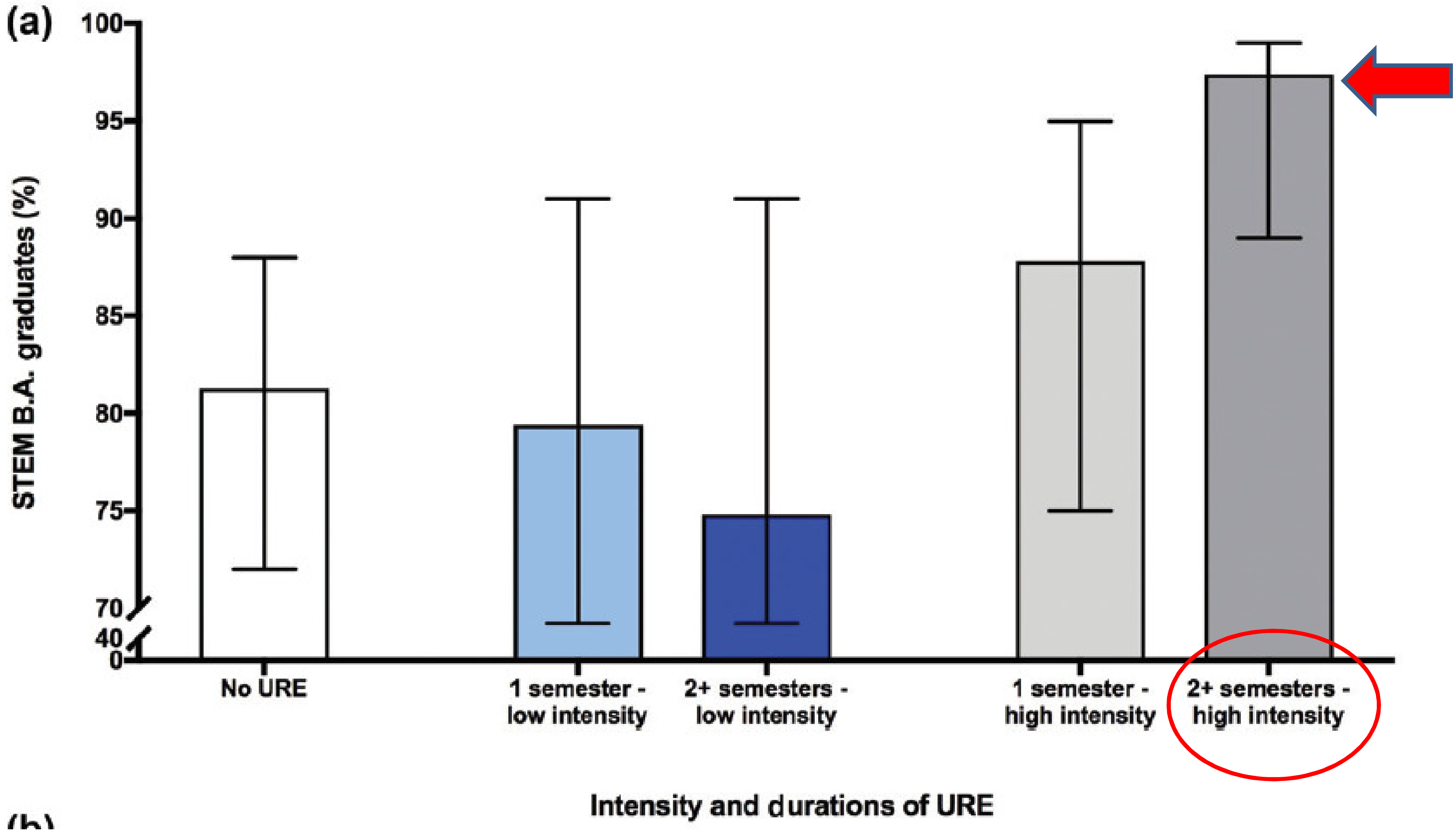
Freshman spring
--
Research Stream lab pt 1

Sophomore fall
--
Research Stream lab pt 2



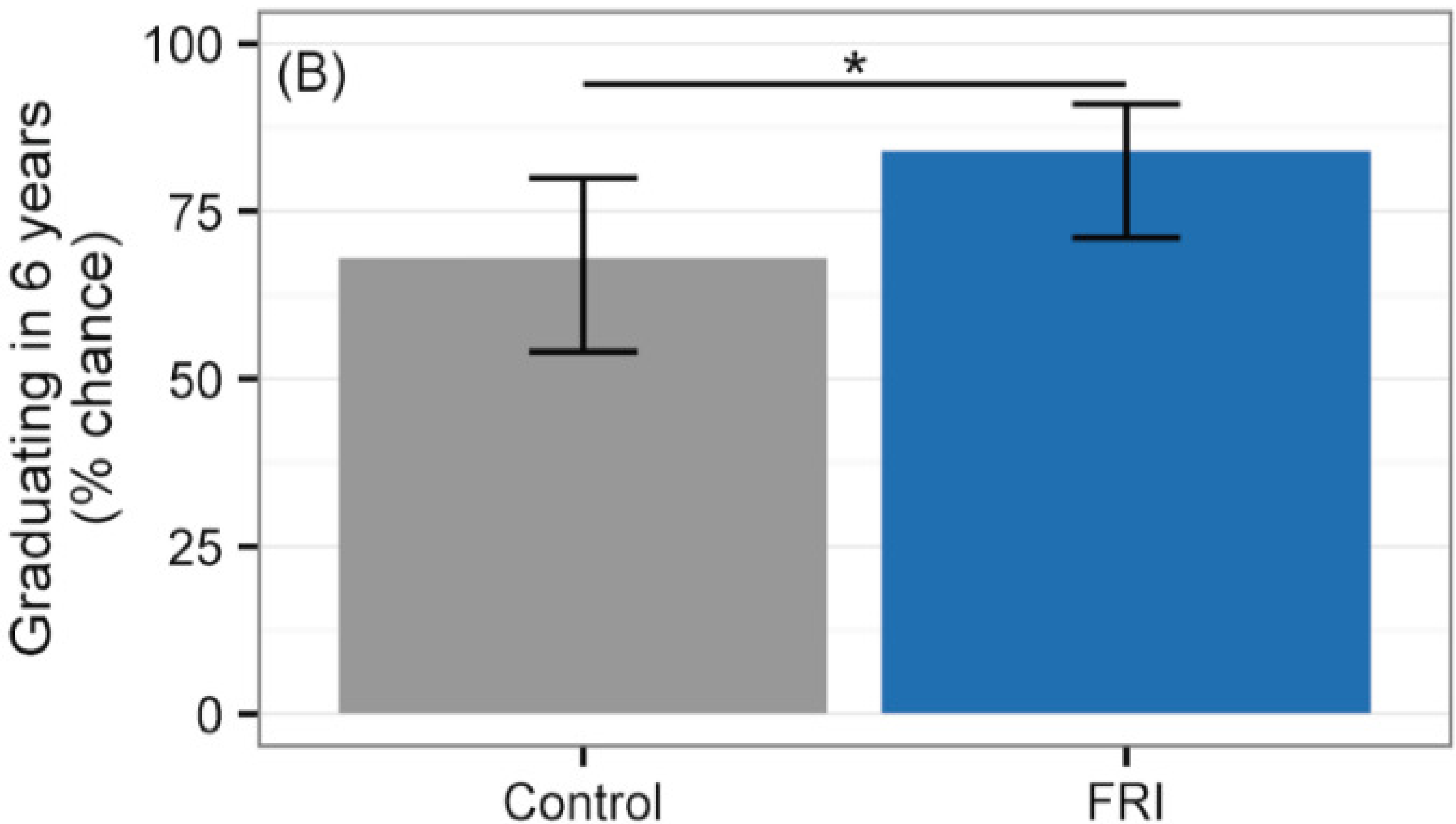
Auchincloss et al. (2014). Assessment of Course-Based Undergraduate Research Experiences. *CBE Life Sci Educ*, *13*(1), 29–40

UREs broaden diversity in science



Hernandez et al. 2018. BioScience 68(3): 204-211

UTA-FRI participation increased by 17% the graduation rate of STEM students



From Univ-Texas-Austin's FRI: Rodenbusch, Hernandez, Simmons, & Dolan, *CBE-Life Sciences Education*, June 2016

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FRESHMAN RESEARCH IMMERSION PROGRAM

Walk in a freshman -
Walk out a researcher.

- FRI began fall 2014
- Gradually added research streams
- University-wide STEM
- In AY2017-18, 9 research streams
- 270 freshmen per year
- ~80% continue as sophomores with third course

Research streams (= tracks)

- Biofilms (microbiology)
- Biogeochemistry (environmental science)
- Biomedical Anthropology (genetics, biochemistry)
- Biomedical Chemistry
- Community & Global Public Health (mining big data)
- Ecological Genetics
- Environmental Visualization/Geospatial Sensing
- Image & Acoustic Signals (computer science)
- Neuroscience
- Smart/Clean Energy (materials science & engineering)


First – Research Methods Seminar
(2 credits, "O" oral communication gen ed)
Second – Research Stream, pt 1
(4 credits, "L" laboratory science gen ed)
Third – Research Stream, pt 2
(4 credits, "C" composition gen ed)

Pre-proposal from Biomedical Chemistry

Fall freshmen – not in lab yet - students learn how to:

- Read journal articles
- Work in teams
- Select a topic for project
- State hypothesis
- Create schematic of system
- Create synthesis figure from articles that supports their hypothesis
- Make a conference poster
- Talk about their project to audience

Pre-proposal from Biomedical Chemistry

FRI public poster session in December

- Student teams present conference quality posters


First – Research Methods Seminar
(2 credits, "O" oral communication gen ed)
Second – Research Stream, pt 1
(4 credits, "L" laboratory science gen ed)
Third – Research Stream, pt 2
(4 credits, "C" composition gen ed)

Research poster from Neuroscience

In two subsequent semesters, students:

- Learn stream specific content
- Learn lab protocols
- Learn experimental design
- Write proposal for sophomore fall work
- Complete sophomore fall work
- Write report
- Create poster

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Examining Dopamine and Acetylcholine Induced Motor Deficits in a Parkinsonian Rat Model

Samantha Blum, Samuel Chen, Katherine Chemakin, Allison Halat, Maxwell Kesten, Kevin Langone, Jessica Obie, Alexander Vincent
Freshman Research Immersion, Binghamton University, Advisor: Dr. Corinne Kiessling

hhmi Howard Hughes Medical Institute

Abstract

Parkinson's disease is characterized by motor symptoms caused by striatal dopamine (DA) loss. Acetylcholine (Ach) neurons within the basal forebrain (BF) and pedunculopontine nucleus (PPN) also degenerate in PD. However, the traditional 6-hydroxydopamine (6-OHDA) rat model of PD does not display Ach deficits. Here, it was modified to examine whether central Ach loss affects motor performance. Sprague-Dawley rats received bilateral striatal 6-OHDA lesions to deplete DA, BF and PPN saporin lesions to deplete Ach, combined 6-OHDA + saporin lesions, or sham lesions. A battery of motor tests were performed and lesioned rats showed significant motor deficits while neurochemical assays to verify lesion are on-going.

Experimental Timeline

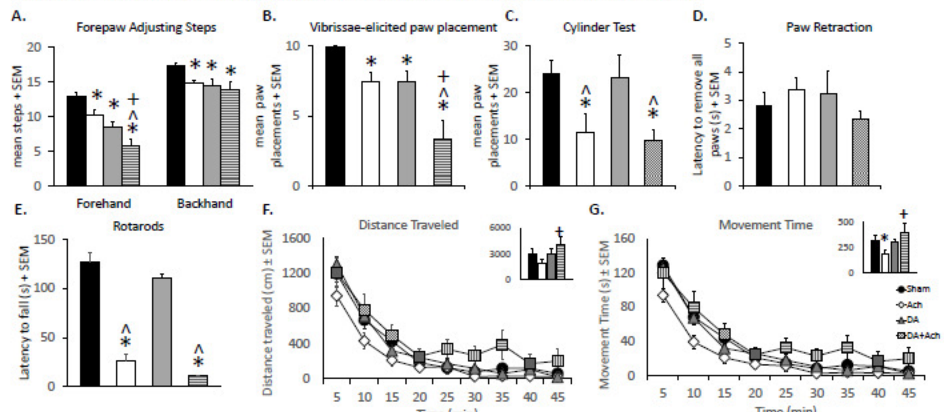
Surgery — Forepaw Adjusting Steps (A.) — Vibrissae-elicited paw placement (B.) — Cylinder Test (C.) — Locomotor activity chambers (F., G.) — Rotarods (E.) — Paw Retraction (D.)

Introduction

- Parkinson's disease (PD), a degenerative disorder of the central nervous system, presents with a variety of motor and cognitive symptoms.[1]
- Motor deficits in PD include tremor, rigidity, slowness of movement, and postural instability and are widely attributed to loss of dopamine (DA) neurons in the substantia nigra (SN).[2]
- However, some motor symptoms of PD do not respond to dopamine treatments and are thought to involve non-dopaminergic systems in the brain.[3]
- A growing body of evidence has implicated the Ach system originating in the pedunculopontine nucleus (PPN) in motor symptoms of PD.
  - The PPN innervates several nuclei within the basal ganglia known to control movement including the SN and subthalamic nucleus .[4,5]
  - Approximately 60% loss of basal forebrain and PPN Ach neurons has been shown in post-mortem PD brains.[5]
  - Stimulation of the PPN can improve Parkinsonian gait disturbances.[6]
- Most animal models of PD do not account for or display Ach loss. ***Therefore, the current work evaluated the role of DA and Ach in motor ability using a novel rodent model of Parkinson's disease with combined DA and Ach lesions.***

Results

Figure 1. The effects of individual or combined DA and Ach lesions on rat motor ability



■ Sham □ Ach ■ DA ▨ DA+Ach

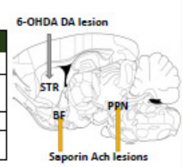
*p < 0.05 vs Sham; +p < 0.05 vs. Ach; ^p < 0.05 vs. DA

Methods

<u>Subjects</u>
Adult male Sprague-Dawley rats (N = 44)

<u>Lesion Surgery</u>
Rats received bilateral, multi-site lesions described below:

Lesion	n	Neurotoxin	Target
Sham	14	--	
Ach	10	192-IgG Saporin + anti-ChAT saporin	BF PPN
DA	14	6-OHDA	Striatum
DA+Ach	6	Saporin + 6-OHDA	BF, PPN Striatum



Behavioral testing for motor deficits commenced 3 weeks after surgery.

Key Findings

The current work compared the effects of DA and/or Ach lesions on several motor tasks.

We used a DA lesion known to produce moderate loss of function[7]; however, motor and sensory-motor ability were reduced in rats with bilateral DA lesions compared to shams on the forepaw adjusting steps (Fig 1A) and vibrissae-elicited paw placement tests (Fig 1B), but not in the cylinder test (Fig 1C) rotarods (Fig 1E), or locomotor chambers (Fig 1F, G).

Ach lesions globally reduced motor performance (Fig 1A, B, C, E, G) while combined DA+Ach lesions exacerbated motor disability (Fig 1A, B, C, E). Surprisingly, reduced movement was not found for dual lesioned rats in the locomotor chambers (Fig 1F, G).

While these results show that the DA and Ach systems are both important modulators of motor activity, a number of questions remain including: whether loss of Ach PPN neurons reduce DA treatment efficacy or whether Ach loss further worsens motor deficits in late-stage models of PD displaying severe DA loss.

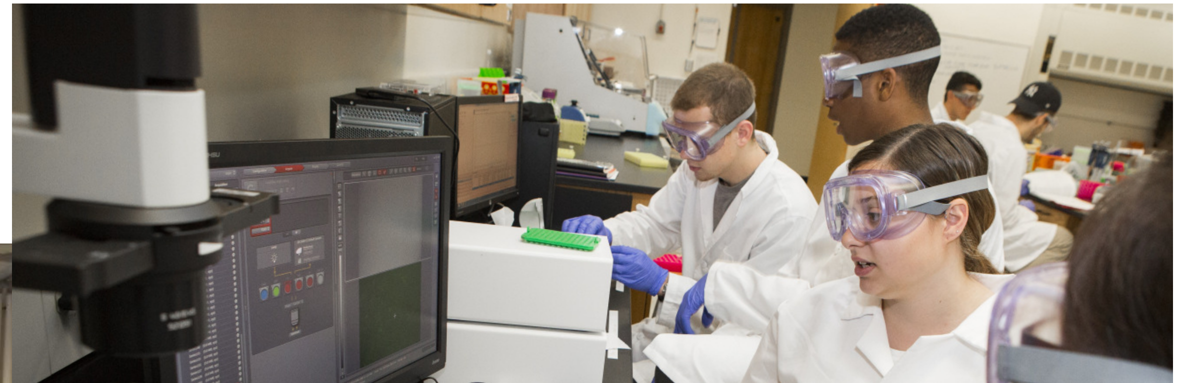
In conclusion, the dual DA +Ach model may be a valuable tool for future investigations of motor deficits in PD.

References

1. Parkinson's disease foundation website http://www.pdf.org/
2. Xia R & Mao ZH. 2012. Progression of motor symptoms in Parkinson's disease. Neurosci Bulletin 28(1):39-48.
3. Karachi C., et al., 2010. Cholinergic mesencephalic neurons are involved in gait and postural disorders in Parkinson disease. J Clinical Investigation 120, 2745-2754.
4. Martinez-Gonzalez C, Bolam JP, Mena-Segovia J. 2011. Topographical organization of the pedunculopontine nucleus. Frontiers in Neuroanatomy 5(22) 1:10.
5. Pahapill PA & Lozano AM. 2000. The pedunculopontine nucleus and Parkinson's disease. Brain 123, 1767-1783.
6. Park E, Song I, Jang DP, Kim IY 2014. The effect of low frequency stimulation of the pedunculopontine tegmental nucleus on basal ganglia in a rat model of Parkinson's disease. Neurosci Letters, 577:16-21.
7. Kirik D, Rosenblad C, Bjorkland A. 1998. Characterization of behavioral and neurodegenerative changes following partial lesions of the migrostriatal dopamine system induced by intrastriatal 6-Hydroxydopamine in the rat. Experimental Neurology 152, 259–277.

This program was supported in part by a grant to SUNY Binghamton from the Howard Hughes Medical Institute through the Precollege and Undergraduate Science Education Program and a pledge from Binghamton University.

To date……



- 25 student-team research posters at regional/national conferences
- 105 student co-authors

- Over 700 students involved in FRI
- > 50% continue as peer mentors for FRI
- > 45% enter faculty labs
- More obtaining summer internships

Assessment for BU-FRI

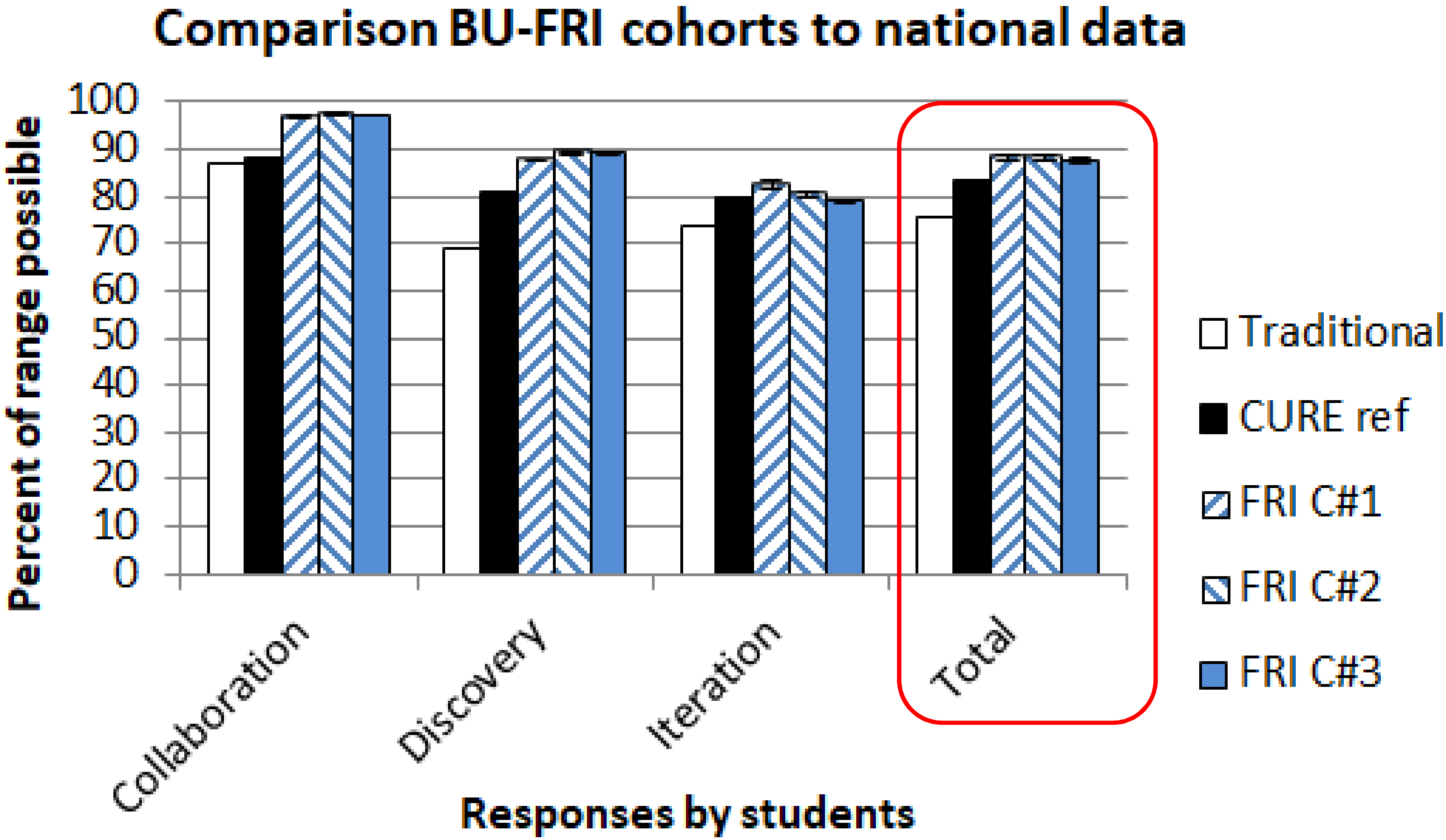
- Deliverables (using standardized rubrics)
  - Research proposal
  - Research report
  - Two research posters
  - Two "elevator talks"
- Reflection essay (on professional & personal growth after each FRI course)
- LCAS (Laboratory Course Assessment Survey)
- CURE (national online survey)

LCAS questions

	In this course, I was encouraged to …	
Collaboration	C1	discuss elements of my investigation with classmates or instructors.
	C2	reflect on what I was learning.
	C3	contribute my ideas and suggestions during class discussions.
	C4	help other students collect or analyze data.
	C5	provide constructive criticism to classmates and challenge each other's interpretations.
	C6	share the problems I encountered during my investigation and seek input on how to address them.
	In this course, I was expected to …	
Discovery	DR1	generate novel results that are unknown to the instructor and that could be of interest to the broader scientific community or others outside the class.
	DR2	conduct an investigation to find something previously unknown to myself, other students, and the instructor.
	DR3	formulate my own research question or hypothesis to guide an investigation.
	DR4	develop new arguments based on data.
	DR5	explain how my work has resulted in new scientific knowledge.
	In this course, I had time to …	
Iteration	I1	revise or repeat work to account for errors or fix problems.[b]
	I2	change the methods of the investigation if it was not unfolding as predicted.
	I3	share and compare data with other students.
	I4	collect and analyze additional data to address new questions or further test hypotheses that arose during the investigation.
	I5	revise or repeat analyses based on feedback.
	I6	revise drafts of papers or presentations about my investigation based on feedback.

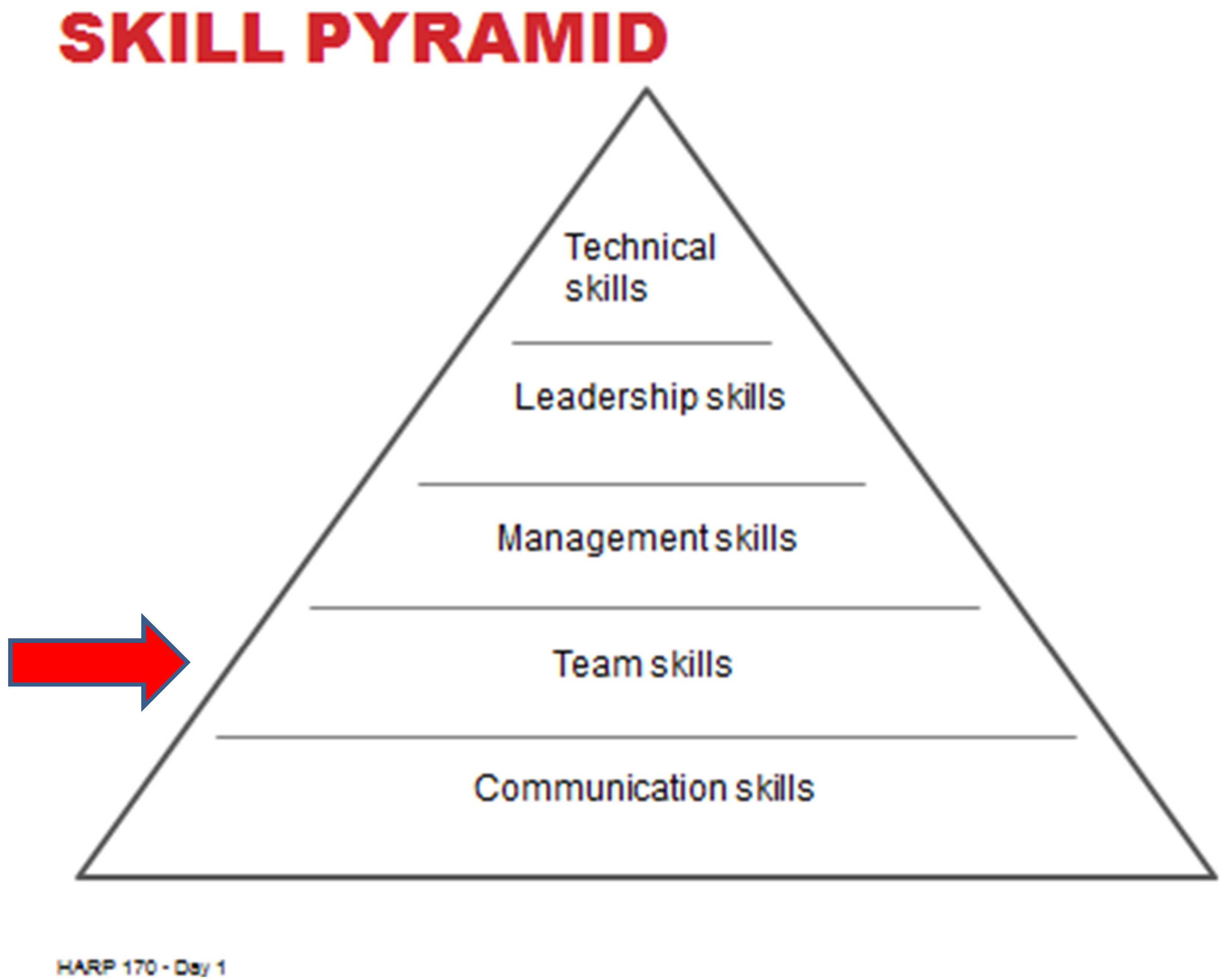
From: Corwin LA, Runyon C, Robinson A, Dolan EL (2015) The Laboratory Course Assessment Survey: A tool to measure three dimensions of research-course design. CBE Life Sci Educ 14:1-11

LCAS results for BU-FRI



National data from: Corwin et al. (2015) The Laboratory Course Assessment Survey. CBE Life Sci Educ 14:1-11

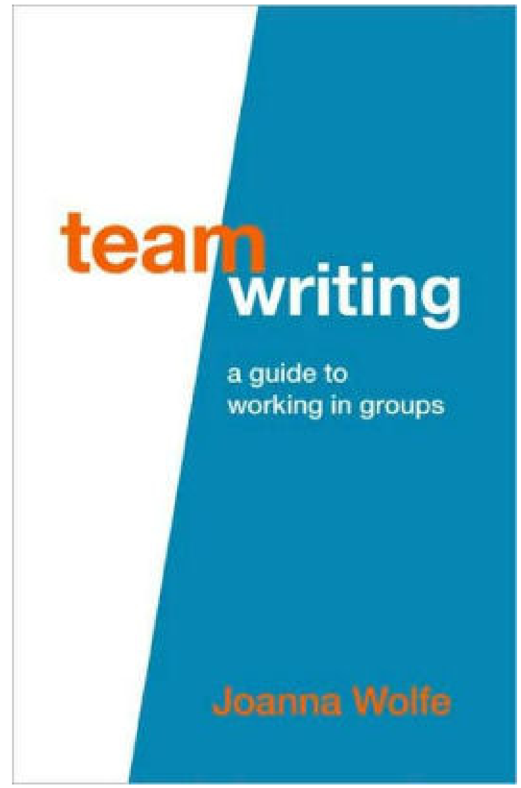
What employers and graduate schools want college graduate to have



Freshmen lack appropriate experience for kind of teamwork needed in lab or workplace

Joanna Wolfe's Team Writing

- Project management
- Team charter
- Task schedule
- Communication styles & diversity
- Trouble shooting team problems
- Exercises at end of chapters



CATME
SMARTER Teamwork

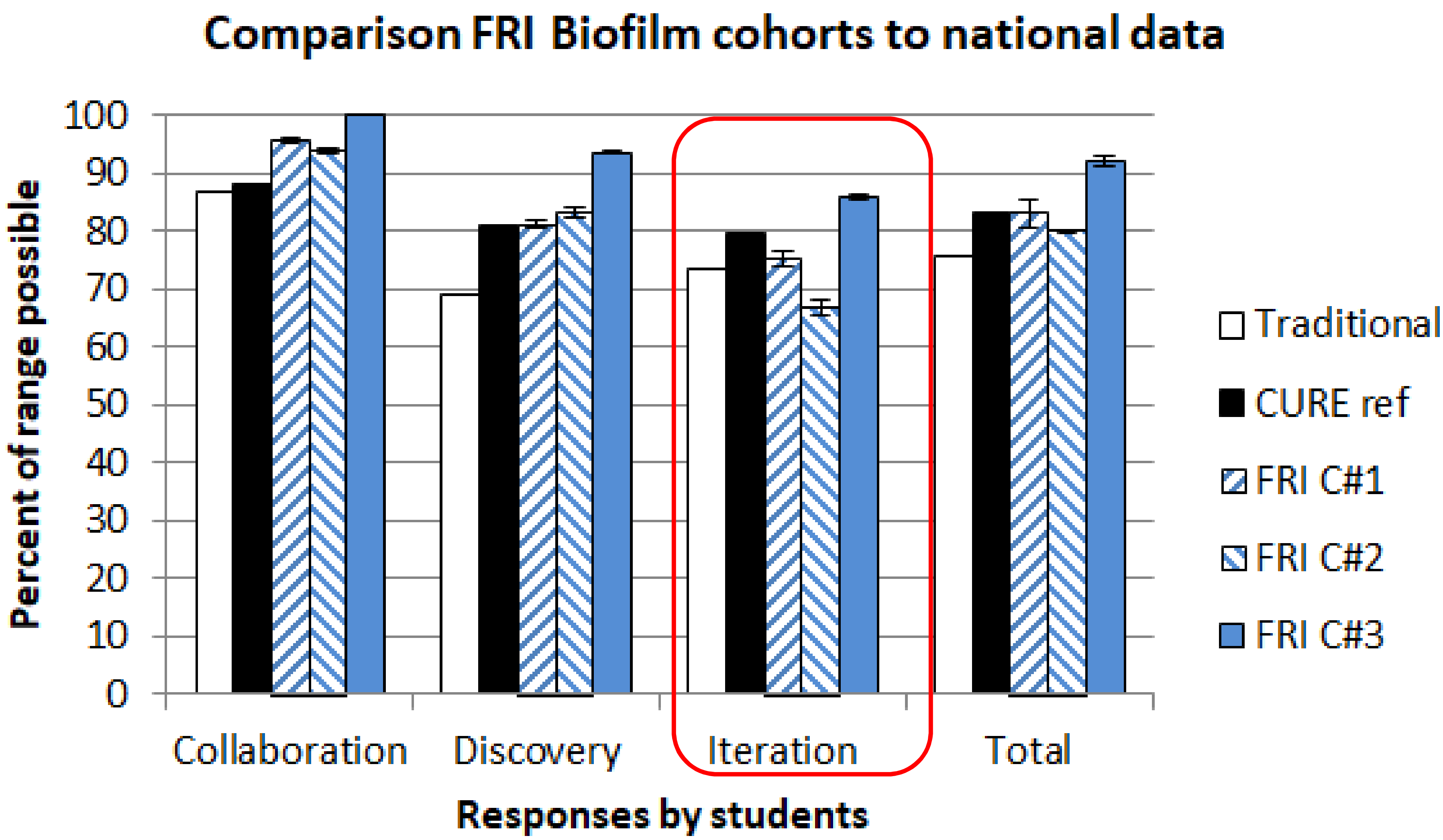
Contributing to the Team's Work

How You Rated Yourself	How Your Teammates Rated You	Average Rating for You and Your Team	Description of Rating
			• Does more or higher-quality work than expected. • Makes important contributions that improve the team's work. • Helps teammates who are having difficulty completing their work.
			Demonstrates behaviors described immediately above and below.
			• Completes a fair share of the team's work with acceptable quality. • Keeps commitments and completes assignments on time. • Helps teammates who are having difficulty when it is easy or important.
			Demonstrates behaviors described immediately above and below.
			• Does not do a fair share of the team's work. Delivers sloppy or incomplete work. • Misses deadlines. Is late, unprepared, or absent for team meetings. • Does not assist teammates. Quits if the work becomes difficult.

Research suggests the following behaviors will improve your ratings in this area:

- Do a fair share of the team's work.
- Fulfill your responsibilities to the team.
- Come to team meetings prepared.
- Complete your work in a timely manner.
- Do work that is complete and accurate.
- Make important contributions to the team's final product.
- Keep trying when faced with difficult situations.
- Offer to help teammates when it is appropriate.

http://info.catme.org/



Comparison FRI Biofilm cohorts to national data
Percent of range possible
100
90
80
70
60
50
40
30
20
10
0
Collaboration
Discovery
Iteration
Total
Responses by students
Traditional
CURE ref
FRI C#1
FRI C#2
FRI C#3

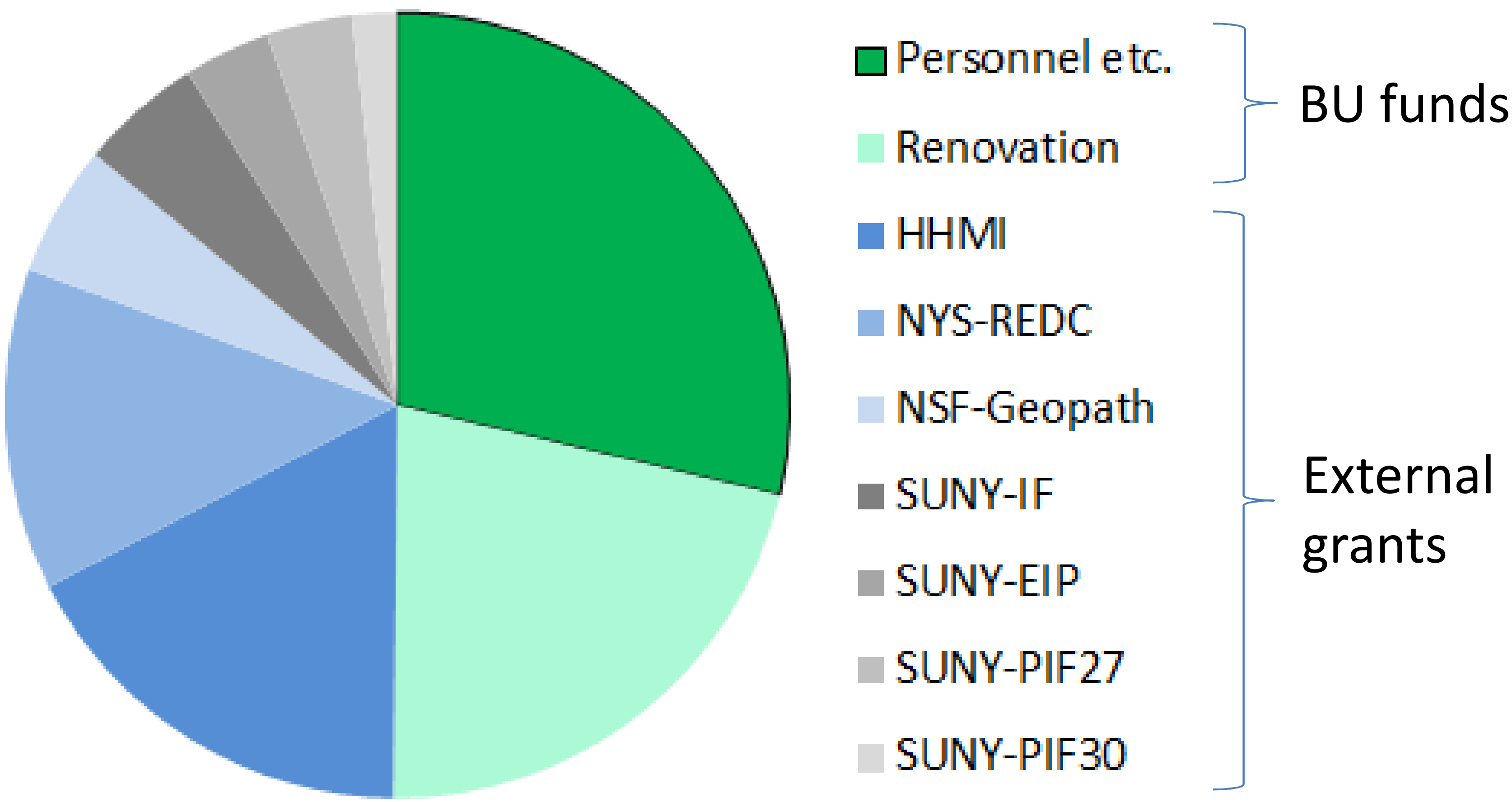
Key questions for startup

- Identify **institutional issues & priorities** to be leveraged for support for such a program
- Analyze **quantitatively** recruitment, persistence, matriculation, & graduation patterns
- Identify **subpopulations** for success & challenge
- Evaluate **existing courses** for potential as part of a research-course sequence
- Articulate **initial action items** relative to your institution

Strategy for FRI programs

- Development
  - Resources for startup
  - Faculty buy-in
- Implementation
- Sustainability

Percent of funds for establishment

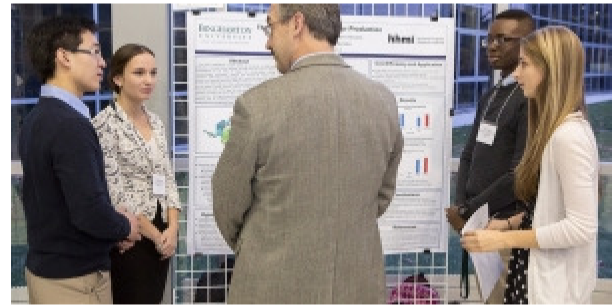


- Ramp-up over 5 year period
- Space renovation optional
- Plan for sustainability from outset

Faculty buy-in

- Emphasize benefits of FRI
  - FRI contributes real research outcomes for faculty research
  - Faculty have trained UGs longer in lab
  - UGs more mature professionally and technically skilled
  - Faculty participation for NSF Broader Impact statement
- Start with faculty with track record mentoring UG research
- Develop faculty <u>team</u> of sponsors / research stream
  - Spreads responsibility
  - More advocates for course approvals, etc.
  - Facilitates student placement after FRI
- Acquire some resources for support of FRI

Resources for FRI startup



- Analysis to justify implementation
- Administrative office(s) that are supportive of program
  - Seed money for establishing program (even if just by shifting administrative priorities)
  - Mechanism for FRI course credit applied to major
  - Lab space
  - Mechanism for “research educator” providing oversight & mentorship of research track
- External funding (grants, donors, corporate sponsors)

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http://www.binghamton.edu/freshman-research-immersion/