Undergraduate Research at Scale: Why, what, and how?
@curenet1 #CUREinstitutes #CUREnet2
Undergraduate research experiences

NSF, AAAS, NIH, HHMI Vision and Change (2011): Introduce research experiences as an integral component of biology education for all students...

AAC&U (2007): Undergraduate Research is one of 10 “high impact educational practices.”
This is not new...

(Kinkead, 2012)
How do students benefit from participating in research?
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Knowledge & Skills
Attitudes & Dispositions
Identity & Connections
Education & Career Pursuits

Caveats: Indirect measures, measures that lack validity evidence, self-selecting populations, lack of theoretical foundations (see Linn, Palmer, Baranger, Gerard, & Stone (2015) and Gentile et al., 2017)
Which students get access to research experiences?

Consider how faculty find undergraduate researchers
Theory: Bourdieu’s “Capital”

Human Capital
- “What you know”
  - coursework
  - grades
  - test scores
  - prior experience

Social Capital
- Connections
  - “Who you know”
    - special programs
    - major
    - agent
- Habitus
  - “How you know”
    - parents’ education
    - scientific identity

Cultural Capital

Access!!
Students who come to college primed for careers in science are most likely to persist and succeed.

Recapitulates the status quo: Not enough, not everyone

Reason 1: CUREs can broaden participation in research

Access based on capital → Research Experience → More capital
Course-based Undergraduate Research Experiences

When whole classes of students address a research question or problem that is of interest to the scientific community
What is a CURE? Lots of different names

• Course-based research experience (CRE)
• Authentic Laboratory Undergraduate Research Experience (ALURE)
• Discovery-based research in the curriculum
• Research courses
## CUREs versus Research Internships

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<th>CURE</th>
<th>Research internship</th>
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<tr>
<td><strong>Scale</strong></td>
<td>Many students</td>
<td>Few students</td>
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<tr>
<td><strong>Structure</strong></td>
<td>One to many</td>
<td>One to one</td>
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<td><strong>Enrollment</strong></td>
<td>Open to all students in a course</td>
<td>Open to a selected or self-selecting few</td>
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<td><strong>Timing</strong></td>
<td>Students invest time primarily in class</td>
<td>Students invest time primarily outside of class</td>
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<td><strong>Setting</strong></td>
<td>Teaching lab</td>
<td>Faculty research lab</td>
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<tr>
<td><strong>Mentoring</strong></td>
<td>Consistent / Structured</td>
<td>Varied</td>
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*But does it “work”?***

(Auchincloss et al., 2014)
Example CURE program: UT Austin’s *Freshman Research Initiative*
Freshman Research Initiative

Research Program:
• A faculty member’s body of work
• Interrelated, ongoing, usually with a common thread
• Sometime overlapping with other faculty collaborators
• Many different projects led by post-docs, grad students

Research Stream:
• Allows expansion of a subset of the research program by providing:
  • More minds and hands
  • Exploration of large variable space
  • Lower risk (a dissertation doesn’t have to result)
• Has its own potential to spawn other projects and research collaborations
Two-semester CURE courses: Research Streams
More than 6,000 students have participated in FRI, and more than 4,000 have had at least six years to graduate.

How does FRI affect students’ graduation rates and completion of a STEM major?

*How would you figure out the effect of FRI on students’ graduation rates and likelihood of completing STEM majors?*
FRI students more likely to graduate college and more likely to graduate with a STEM degree

Effect is the same for students from ALL backgrounds

Reason 2: Students benefit from CUREs

* Significant difference; error bars represent 98.75% confidence intervals

NOTE: 38.6% = National STEM 6-year graduation rate (Rodenbusch et al., 2016)
Reason 3: Faculty members benefit

Shortlidge et al (2016) Interview study (N=38):

• Connect teaching and research (76%)
• Enjoyment (74%)
• Promotion and tenure (74%)
• Publications (61%)
• Research productivity (61%)
• Personal satisfaction (47%)
Reason 4: Science and the scientific community benefits

Why Silver Nanoparticles Are Effective for Olefin/Paraffin Separations
Zachary D. Pozue, Kelly Tran, Anna Shi, Ryan H. Smith, and Graeme Henkelman

Discrimination of flavonoids and red wine varietals by arrays of differential peptidic sensors†
Alona P. Umana, Sarah E. LeBoeuf, Robert W. Newberry, Siwon K. Lee, Lee Tran, Whitney A. Rome, Tia Tian, David Timp, Jane Hong, Melissa Kwas, Hildegarde Heymann, and Eric V. Anslyn

Design, Synthesis, and Amplification of DNA Pools for In Vitro Selection
Bradley Hall, John M. Micheletti, Pooja Satya, Krystal Ogl, Jack Pollard, and Andrew D. Ellington†

Deletion of the eIFiso4G subunit of the Arabidopsis eIFiso4F translation initiation complex impairs health and viability
Andrew D. Lellis, M. Leah Allen, Alice W. Aertke, Jonathan K. Tran, David M. hills, Courtney R. Harbin, Christian Caldwell, Daniel R. Gallie, Karen S. Browning

Synthesis and Catalytic Evaluation of Dendrimer-Encapsulated Cu Nanoparticles
An Undergraduate Experiment Exploring Catalytic Nanomaterials

In Vitro Selection of RNA Aptamers to a Protein Target by Filter Immobilization
Bradley Hall, Seyed Arshad, Kyunghyun Seo, Catherine Bowman, Meredith Corley, Sulay D. Jnover, and Andrew D. Ellington†

Synthesis and Crystal Structure of a New Heterotrinuclear Schiff-Base Zn–Gd Complex
Andy Li, Xiaoping Yang, Julie M. Stanley, Richard A. Jones, Bradley J. Holliday

(Examples from UT Austin Freshman Research Initiative)
Database Entries or Community Reports

Examples from NRC Report (2016):
Integrating Discovery-based Research into the Undergraduate Curriculum
What makes FRI or other research experiences work?
In other words, what are the key features?

 Depends on what “working” means!
What happens during a research experience (FRI, CUREs, internships/UREs, etc.) that makes it effective for students?

What do you hypothesize are the key features?
Hypothesized Distinctive Features of CUREs

Internal Features

- Mentorship
- Collaboration
- Discovery & Relevance
- Cognitive & Emotional Ownership
- Iteration

(Auchincloss et al., 2014; Burgin et al., 2012, 2014; Corwin et al., 2015; Hanauer et al., 2012; Hanauer and Dolan, 2014)

Lisa Corwin, David Hanauer, Aspen Robinson, et al.
Cross-course comparison

- 800 students
- 23 different inquiry and CURE courses
- National sample of colleges and universities
- Surveyed about:
  - Course design features: discovery, iteration, collaboration
  - Proximal outcome: ownership
  - Distal outcome: intentions to pursue a science research related career (pre/post)
- Used structural equation modeling to determine...

(Corwin et al., 2018)
Do course features predict Δ career intentions?

(Corwin et al., 2018)
Are any observed relationships mediated by ownership?

(Corwin et al., 2018)
Course features have a **small but significant** effect on students’ career intentions.

Effects of course features on students’ intentions **fully mediated** by ownership.

**Iteration** (not discovery!) has the largest effect on ownership.

$R^2 = 0.11$

Numbers represent fully standardized path coefficients; all solid lines indicate statistically significant relationships.
Tip of the iceberg!

Cognitive Development
- Knowledge, skills, abilities
- Expertise development

Psychosocial Development
- Ownership
- Self-efficacy
- Sense of belonging
- Scientific identity

Affective Development
- Mindset
- Perseverance / Grit
- Values

Career Pursuits
- Interests
- Expectations
- Choice points
- Pathways in, out, through

And this is only from the student perspective!

Research perspective
Scientist/Educator perspective
Societal perspective
Which of the following scenarios would classify as a CURE?

**Scenario #1:** If the answer to the research question is unknown to the student, but the scientific community knows the answer

**Scenario #2:** If students use primary literature to come up with only “thought experiments” that are novel

**Scenario #3:** If students identify whether Maria or Kate has more bacteria on her shoes

**Scenario #4:** If students try to characterize a novel mutant version of a protein, but they get negative results

(Brownell, 2016)
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(Brownell, 2016)
Please introduce yourself and where you are from:

• What research area, topic, or focus are you thinking about for your CURE?

• What your goals are for the Institute?