The Genomics Education Partnership: A Path to Classroom Research Experiences In Person or at a Distance

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Genomics Education Partnership

Meet the Genomics Education Partnership

Our main goal is to increase accessibility to genomics and bioinformatics through the incorporation of Course-based Undergraduate Research Experiences (CUREs).

- Genomics Education Partnership (GEP) provides a web-based platform with:
  - Curated curriculum and training materials
  - A robust network of nationwide virtual TAs
  - Professional development before, during, and after curriculum implementation

- Through the GEP curriculum, students learn to annotate genes in eukaryotic genomes and become familiar with various bioinformatics tools.

- Students learn to leverage evidence from reference genomes, experimental data, gene prediction algorithms, evolutionary conservation, and molecular biology rules to create a defendable gene model.

- Implementation does not require external funds, expensive reagents, or equipment. Making the curriculum and the authentic research experience accessible for smaller institutions, newer faculty, and/or online students.

- GEP supports publication of gene models as microPublications, with students as lead authors.
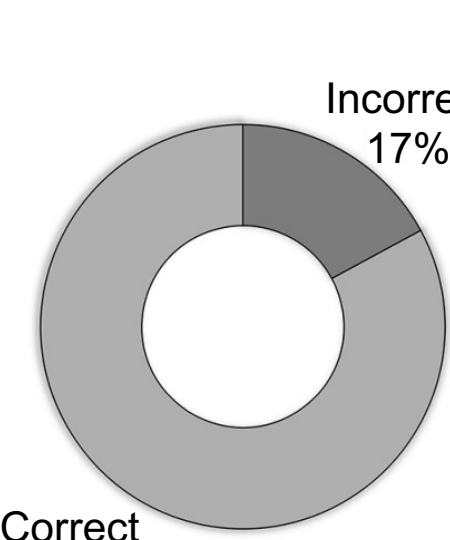
GEP Promotes Opportunities in Undergraduate Research

Enables undergraduates to participate in authentic genomics and bioinformatics research in a classroom setting
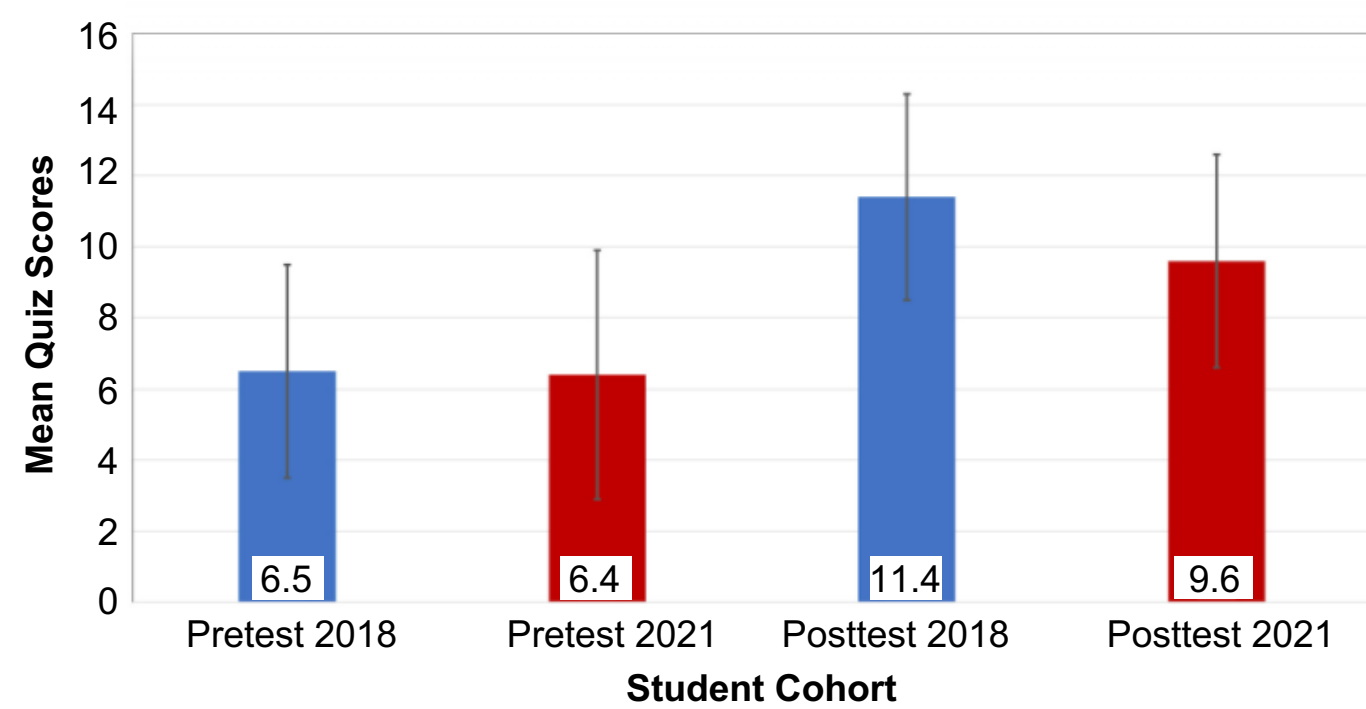

Mean scores for pretest and posttest annotation quizzes for a pre-pandemic, in-person instruction year (2017–2018, blue; N = 401) and a pandemic, remote learning year (2020–2021, red; N = 621). From Lopatto et al. (2023).

A. Error Rate — Correct 83%, Incorrect 17%

B. Error Type — Splice site boundaries 41%; Mislabeled / missing isoform 38%; Extra / missing exon(s) 19%; Not the orthologous model 2%

Error rate of student models that reach reconciliation (n=310). (A) The raw error rate of models, and the (B) breakdown of the error rates into the classes of errors. From Rele et al. (2023).
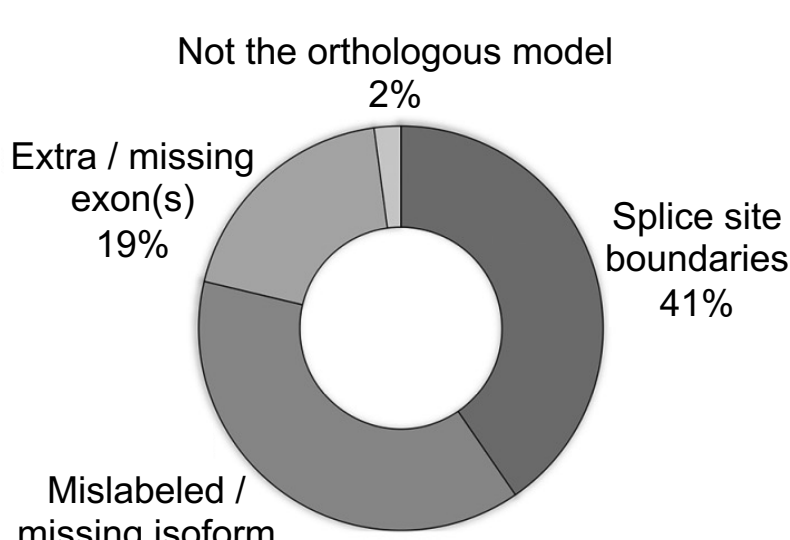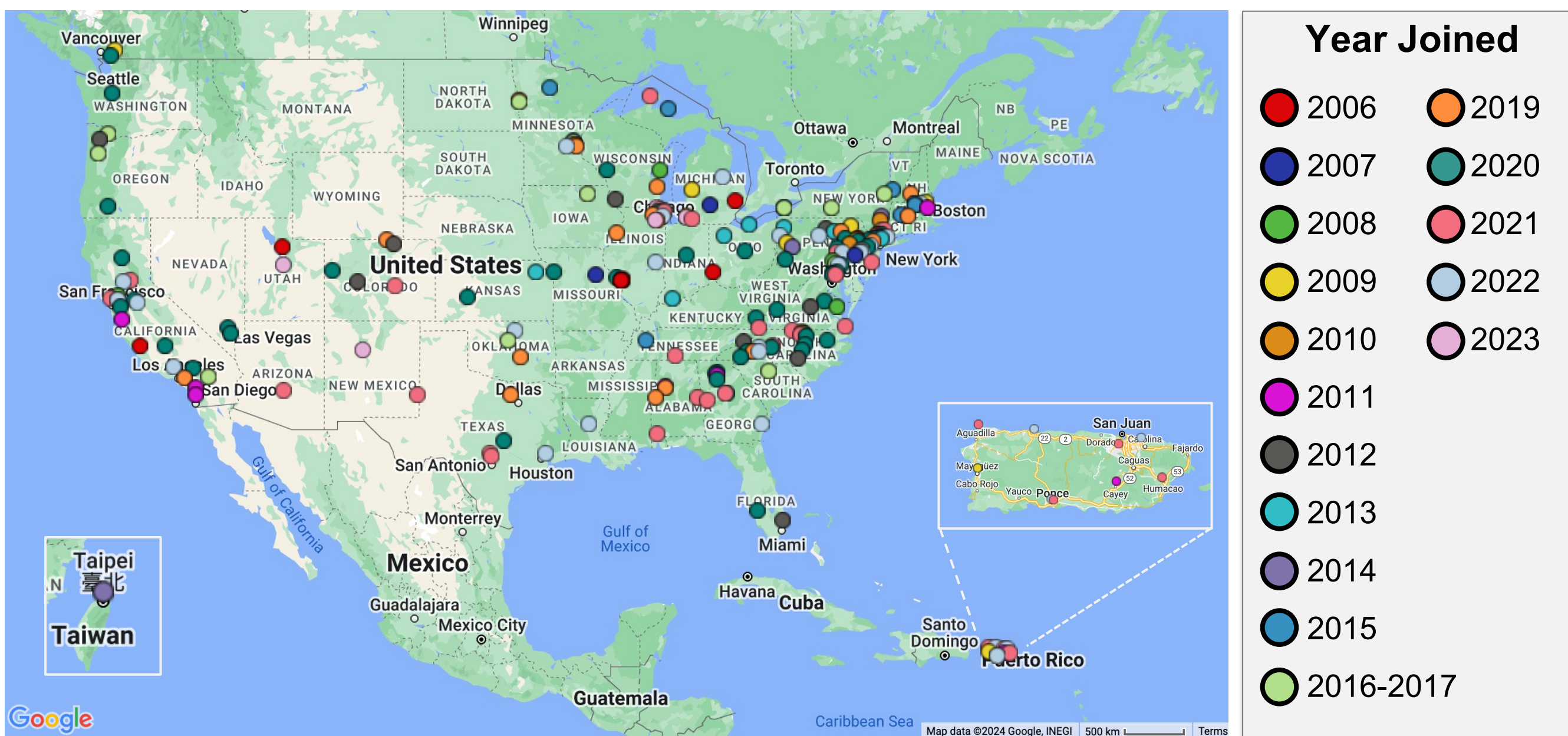
Approach is applicable and effective in person or online
- No significant differences in learning outcomes between online and in-person students

In most cases students found the correct gene model, generating publishable novel data
- The majority of student models received for the Pathways Project (n=310) agree with the final reconciled model.
- Most common errors were mislabeled or missing isoforms (38%) and incorrect splice sites (41%)

In 2022/2023 GEP Engaged >2,490 Students Nationwide

Year Joined: 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016-2017, 2019, 2020, 2021, 2022, 2023

265 active faculty members
213 active affiliated institutions
34 faculty and **42** undergraduate students represented GEP at conferences/workshops in 2023/2024

Benefits for Faculty and Students

Students generate novel data through the genomic annotation process

Curriculum for beginning students
Use the UCSC Genome Browser to teach eukaryotic gene structure and central dogma:
Laakso et al. (2017) *CourseSource*
Rele et al. (2023) *F1000Research*

Curriculum for advanced students
Hidden Markov Models
  Weisstein et al. (2016) *CourseSource*
Dynamic Programming
Genomic Neighborhood and Synteny

Use the Curriculum Search Tool
thegep.org/curriculum/

*Faculty are more likely to let their students risk failure in GEP research projects*
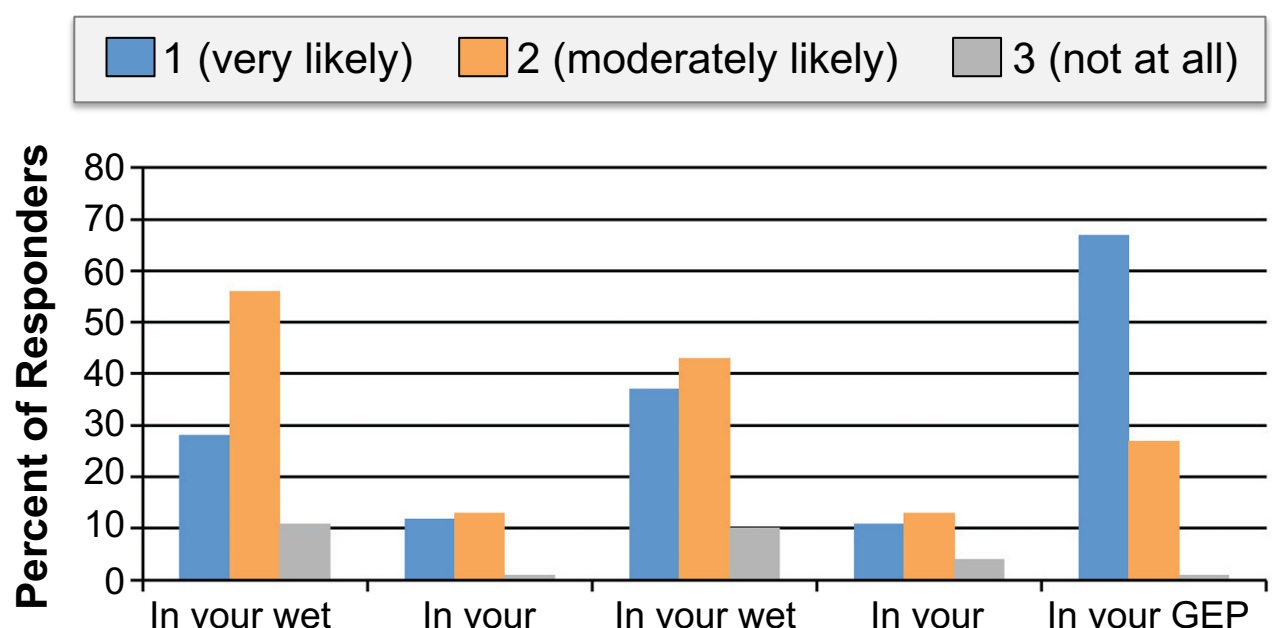
Faculty are more likely to let their students risk failure in GEP research projects than in wet bench or field work lab courses and research projects. Taken from Lopatto et al. (2020).

The GEP platform
1. Low cost, eliminates lab safety issues, 24/7 access, inexpensive mistakes.
2. Students that approach the CURE with positive attitudes are more likely to have learning gains.
3. Learning by doing and experiencing setbacks lead to higher student learning.
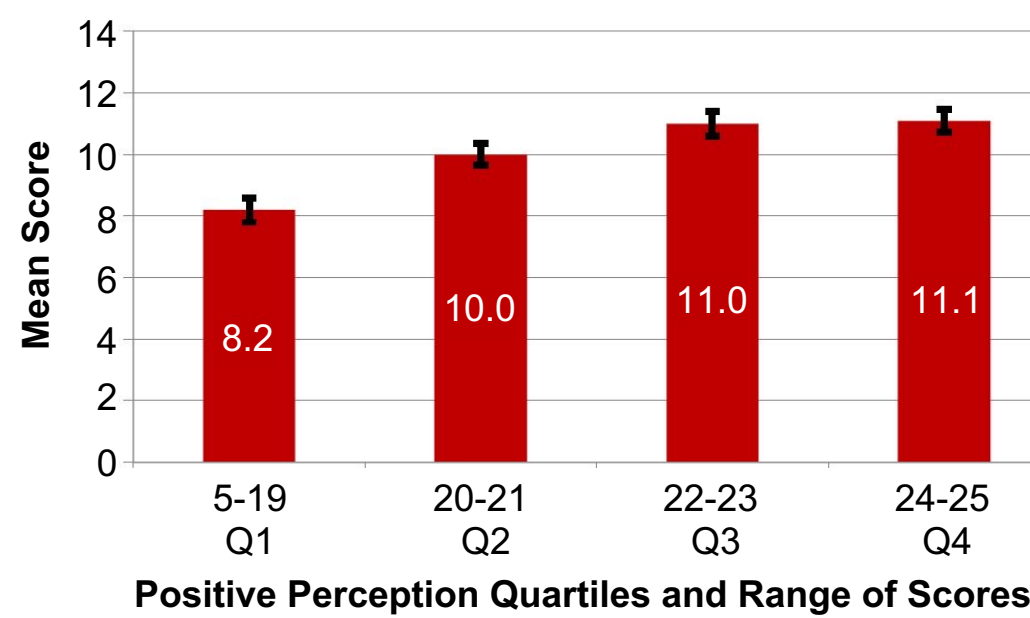
Students with positive perception of science score significantly higher and report having more benefits than students with more negative perceptions (p<0.05). Error bars represent 2 SEM. Taken from Lopatto et al. (2022).
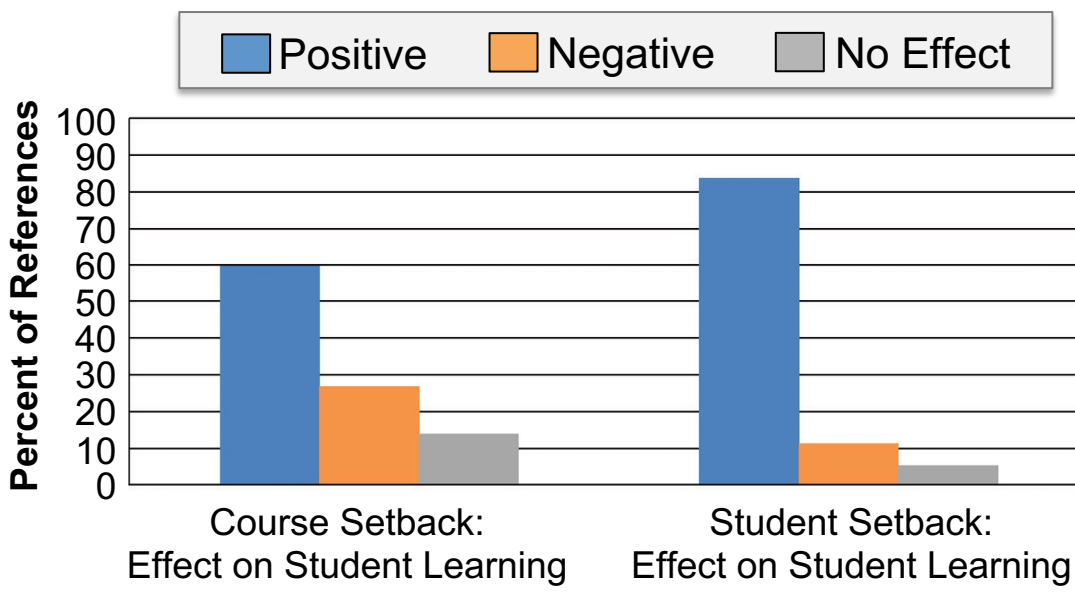
Faculty observe that setbacks in the research process promote student learning. Effects on student learning from course setbacks and student setbacks. The percent of faculty responses that were positive (blue), negative (orange), or neutral (no effect; grey) are shown. Taken from Lopatto et al. (2020).

Students as Co-authors in Publications and Lead Authors in microPublications
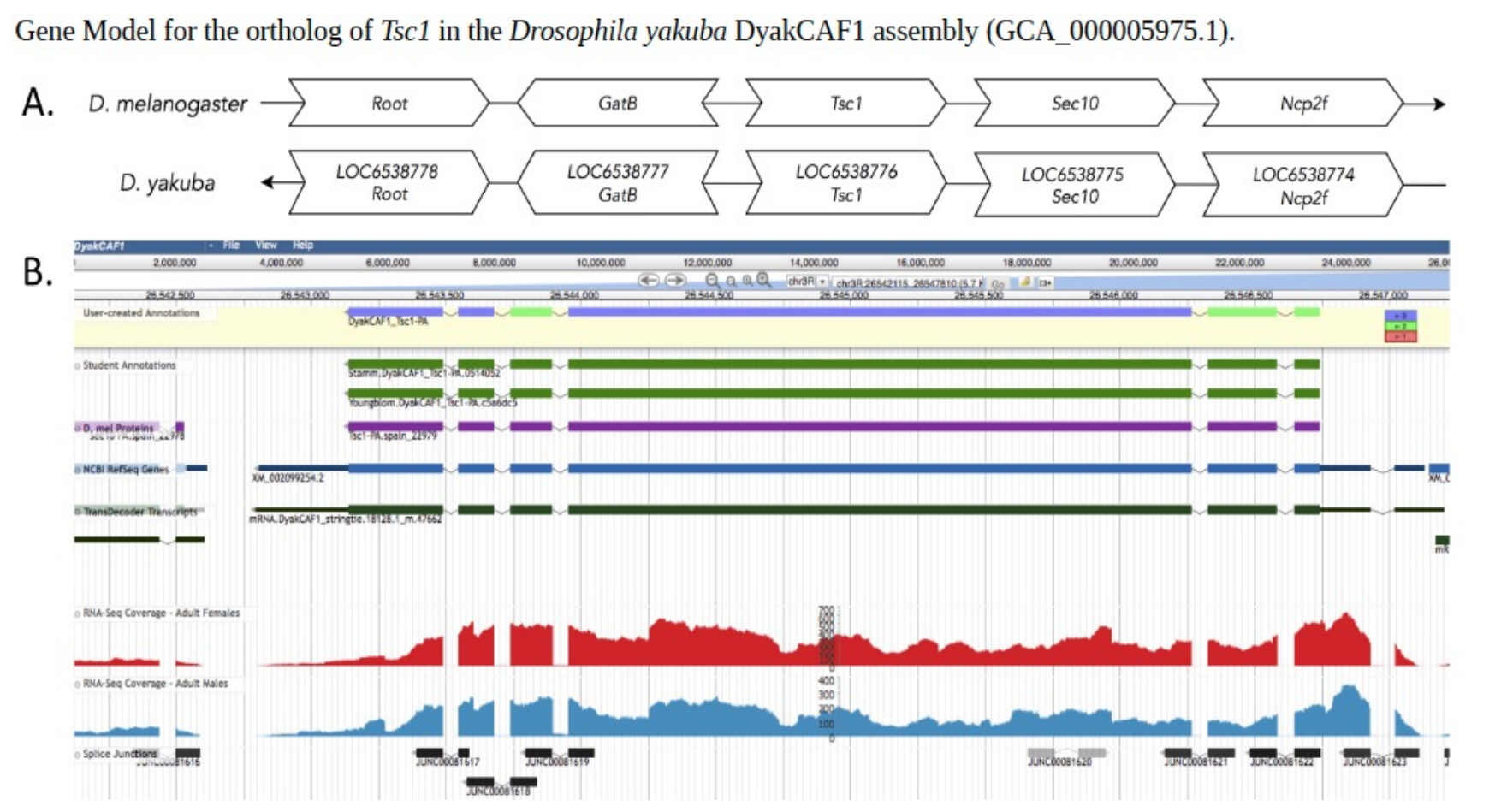
G3 Genes | Genomes | Genetics

Retrotransposons Are the Major Contributors to the Expansion of the *Drosophila ananassae* Muller F Element
Wilson Leung and Participating Students and Faculty of the Genomics Education Partnership[1]

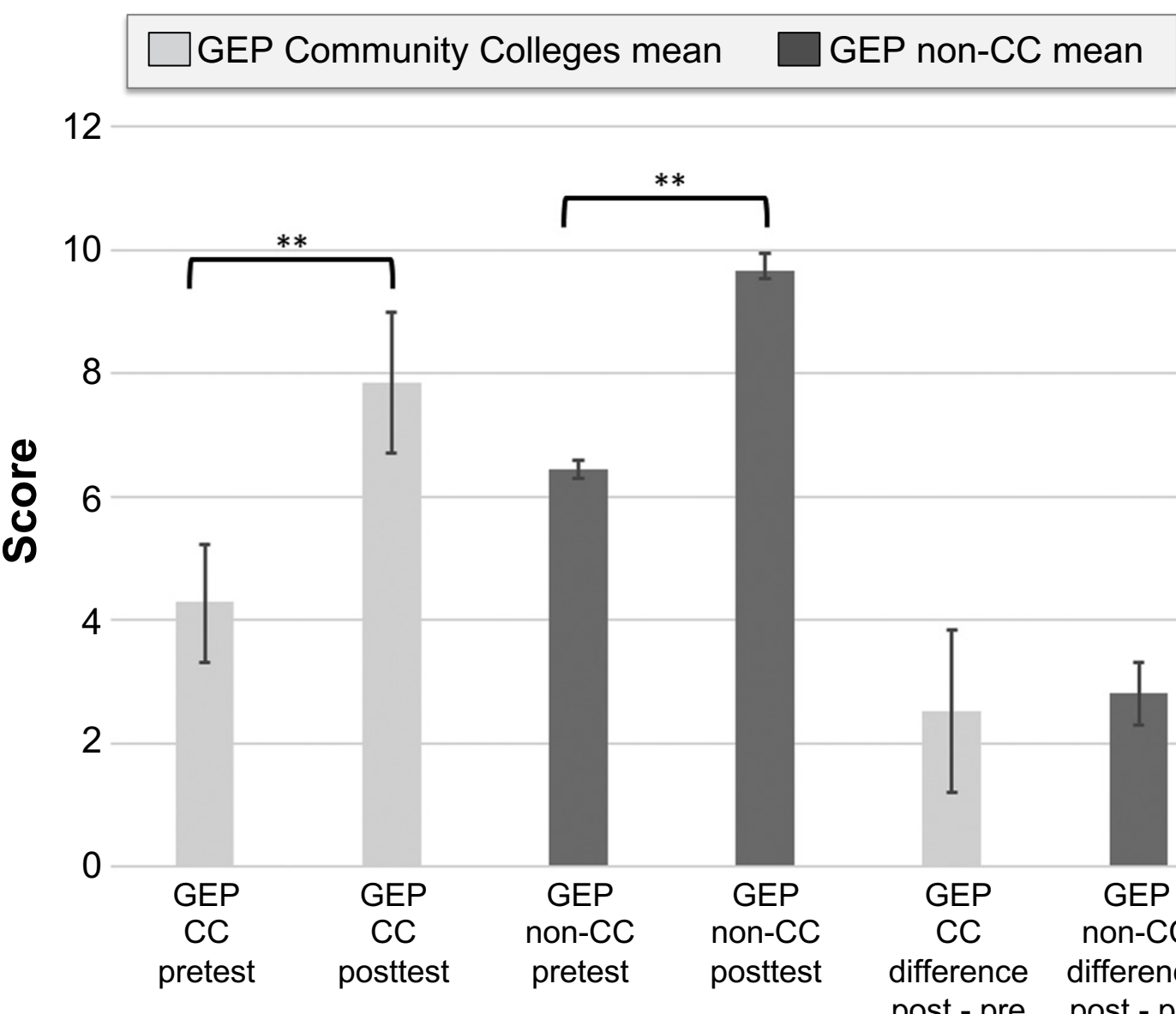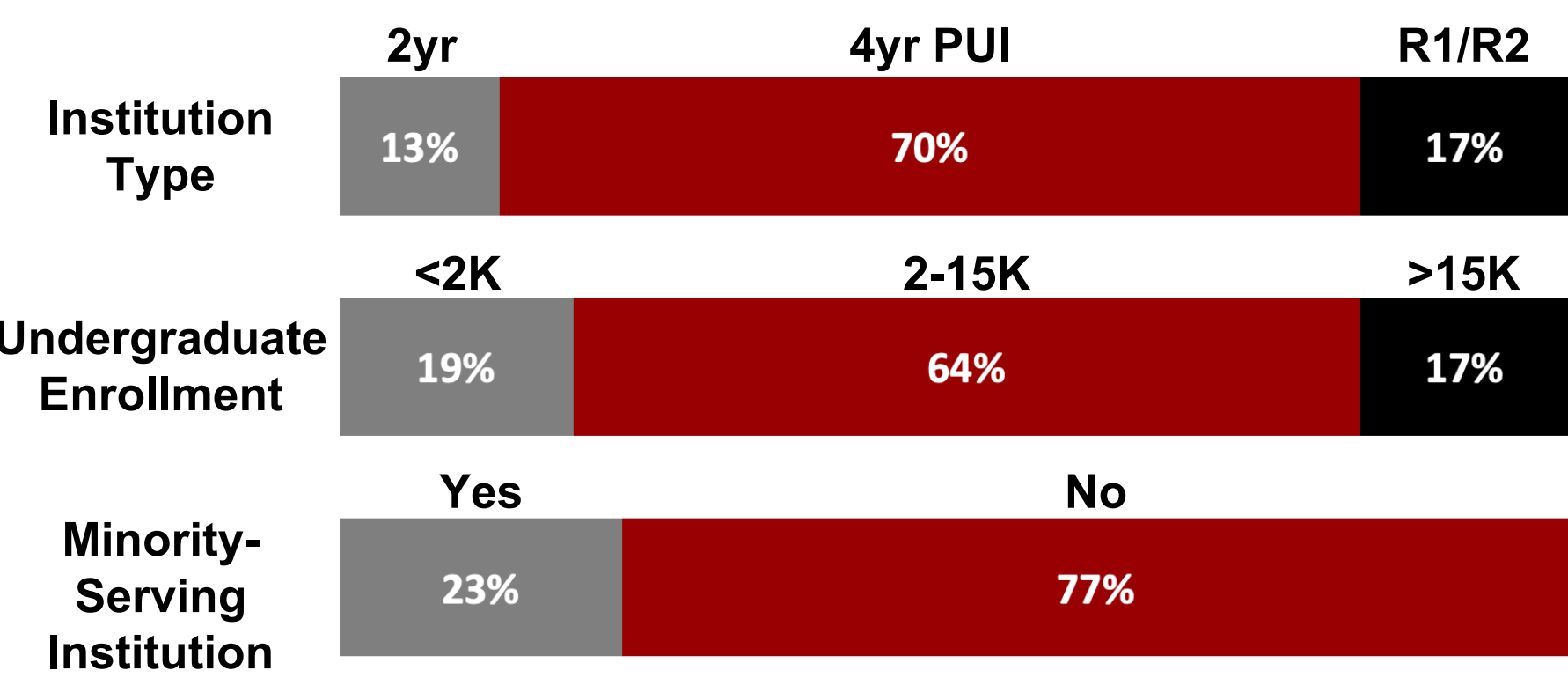G3 Genes | Genomes | Genetics, Volume 7, Issue 8

239 co-authors participated as students

Gene Model for the ortholog of *Tsc1* in the *Drosophila yakuba* DyakCAF1 assembly (GCA_000005975.1).

μP Lose, B; Myers, A; Fondse, S; Alberts, I; Stamm, J; Youngblom, JJ; Rele, CP; Reed, LK (2021). *Drosophila yakuba – Tsc1*. microPublication Biology. 10.17912/micropub.biology.000474.

Diversifying Opportunities in Bioinformatics

*The GEP curriculum promotes equity in undergraduate research opportunities to students at all sorts of institutions.*

Institution Type			
2yr	4yr PUI		R1/R2
13%	70%		17%

Undergraduate Enrollment			
<2K	2-15K		>15K
19%	64%		17%

Minority-Serving Institution		
Yes	No	
23%	77%	

GEP Institutional Characteristics as of February 29, 2024.

Community College (CC) students showed same gains as non-Community College (non-CC) students
- No significant differences in learning outcomes between CC and non-CC students

CC and non-CC students show comparable learning gains using the GEP curriculum to students at non-CC. Taken from Croonquist et al (2023).

Current Science Projects
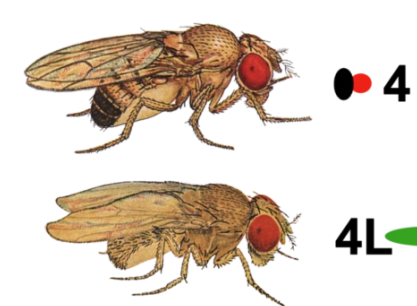
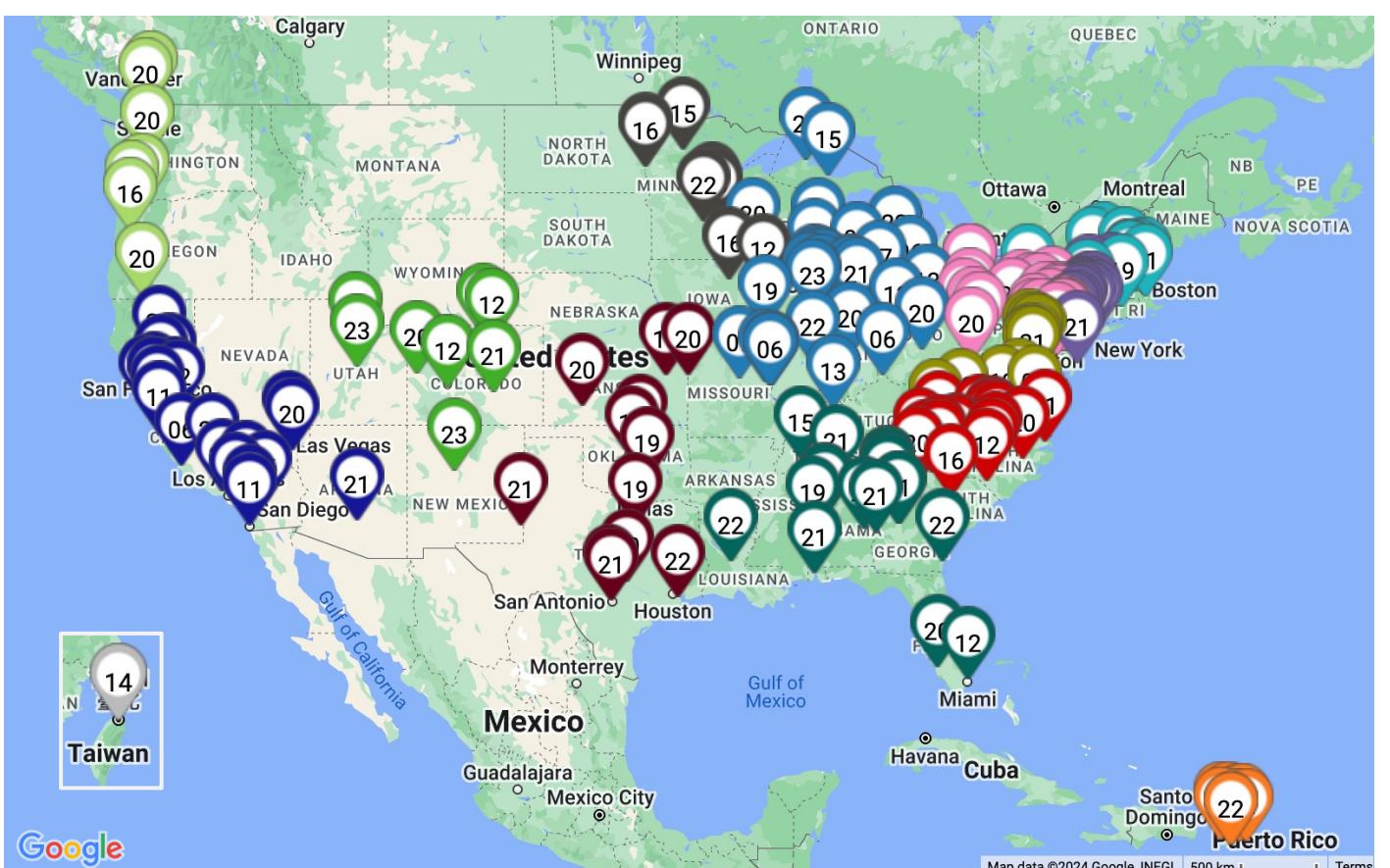**F Element Project**
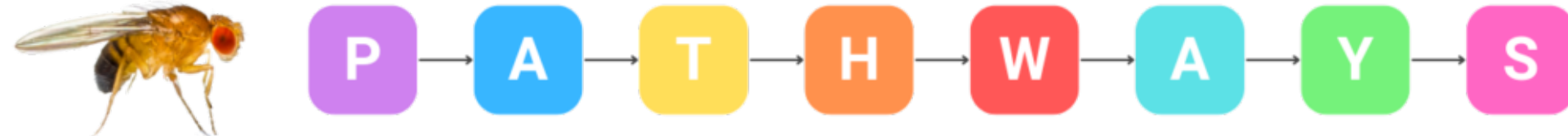
Parasitoid Wasps Project

Puerto Rican Parrot Project

GEP is a Supportive Community of Practice

14 Regional Nodes

GEP Virtual TAs experienced students support their peers during the semester

The number in each marker corresponds to the year when the member joined the GEP.

CalNeAr, Carolinas, D.C., Maryland, & Virginia, Midwest, Minnesota, Iowa, & Dakotas, New England, New York & New Jersey, Pennsylvania, Pacific Northwest, Puerto Rico / Caribbean, Rocky Mountain, Southeast, Taiwan, Texas & Oklahoma

GEP National Faculty Workshop held each summer to network and discuss on-going science, implementation, curriculum, assessment, and professional development, planning for the future.

Future Directions

- Increase the number and the diversity of undergraduate participants.
- Expand GEP faculty participation in leading research projects.
- Enhance contributions to the research community by student participation in microPublication process.

Acknowledgements

thegep.org