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#### LETTERS TO THE EDITOR

##### **Regression to the Mean in Pre–Post Testing: Using Simulations and Permutations to Develop Null Expectations**

*Robert E. Furrow*

##### **New Thermodynamics Boxes Simulation**

*Amy Styer Greene*

#### CURRENT INSIGHTS

##### **Learning in a Group, as a Group, and between Groups**

*Julia Svoboda Gouvea*

Learning in groups is now a common feature of most classrooms. This installment of *Current Insights* brings together three recent articles from outside life sciences education that expand our understanding of how students can learn together.

#### BOOK REVIEW

##### **Significant Enhancements in a New Edition Make a Cell Biology Text Well Worth Considering**

*David Burgess*

The thoroughly revised third edition of Pollard's *Cell Biology* is a vastly improved edition in terms of its readability for students and up-to-date information complemented by outstanding illustrations.

#### EVIDENCE-BASED TEACHING GUIDES

##### **Inclusive Teaching**

*Bryan Dewsbury and Cynthia J. Brame*

This essay introduces an evidence-based teaching guide presenting research and resources related to inclusive teaching, with a particular focus on differences in race, ethnicity, and gender. In addition to describing the guide, the essay identifies areas for further research.

#### MEETING REPORT

##### **Recommendations for Effective Integration of Ethics and Responsible Conduct of Research (E/RCR) Education into Course-Based Undergraduate Research Experiences: A Meeting Report**

*Laura A. Diaz-Martinez, Ginger R. Fisher, David Esparza, Jay M. Bhatt, Christina E. D'Arcy, Jennifer Apodaca, Sara Brownell, Lisa Corwin, William B. Davis, Kevin W. Floyd, Patrick J. Killion, Jaclyn Madden, Patricia Marsteller, Teresa Mayfield-Meyer, Kelly K. McDonald, Martina Rosenberg, Mark A. Yarborough, and Jeffrey T. Olimpo*

Course-based undergraduate research experiences, or CUREs, provide a valuable mechanism to engage emergent scholars in the rigorous process of scientific discovery, yet few efforts exist that address ethics and responsible conduct of research (E/RCR) education within such contexts. This report discusses theoretical and practical measures for addressing this concern.

## ESSAYS

### **A Framework to Guide Undergraduate Education in Interdisciplinary Science**

*Brie Tripp and Erin E. Shortlidge*

This essay provides an overview of the challenges and various definitions of interdisciplinary science. A framework is presented that practitioners can use in developing and assessing instruction that fosters students' ability to tap into the interdisciplinary nature of science.

### **Getting Messy with Authentic Data: Exploring the Potential of Using Data from Scientific Research to Support Student Data Literacy**

*Melissa K. Kjelvik and Elizabeth H. Schultheis*

This paper discusses why the strongest data literacy learning experiences may arise when students have the opportunity to work with data from scientific research. The overlap between quantitative reasoning, data science, and data literacy is explored, and learning opportunities in data literacy resulting from the use of authentic data in the classroom are highlighted.

## ARTICLES

### **Burnout and Mental Health Problems in Biomedical Doctoral Students**

*Gabriela A. Nagy, Caitlin M. Fang, Alexander J. Hish, Lisalynn Kelly, Christopher V. Nicchitta, Kafui Dzirasa, and M. Zachary Rosenthal*

High levels of burnout, depression, and anxiety were identified in a pilot study of biomedical doctoral students. Burnout was significantly associated with thoughts related to dropping out, subjective appraisal of employment opportunities, functional impairment due to a mental health problem, and having at least one current psychiatric disorder.

### **Exploring the Impact of Formal Internships on Biomedical Graduate and Postgraduate Careers: An Interview Study**

*Deepshikha Chatterjee, J. Kevin Ford, Julie Rojewski, and Stephanie W. Watts*

In this interview study, the efficacy of internships as career exploration tools and associated outcomes for graduate students and postdocs was investigated. It was found that internships were seen as effective career exploration and self-development vehicles that influenced participants' long-term career goals.

### **Volunteered or Voluntold? The Motivations and Perceived Outcomes of Graduate and Postdoctoral Mentors of Undergraduate Researchers**

*Lisa B. Limeri, Muhammad Zaka Asif, and Erin L. Dolan*

Graduate students and postdoctoral researchers (postgraduates) frequently mentor undergraduate researchers. Yet there has been only modest investigation of this relationship from the postgraduate perspective. This exploratory study characterizes postgraduate mentors' motivations and perceived outcomes and proposes a model of mentoring motivation.

### **Problem Solving in Genetics: Content Hints Can Help**

*Jennifer S. Avena and Jennifer K. Knight*

Student problem solving in several genetics content areas was explored, and it was found that, overall, students who did not initially understand a concept were assisted by receiving a single content hint. However, some students answered problems incorrectly even after receiving a hint; the specific content errors these students made are described.

### **Big Data to the Bench: Transcriptome Analysis for Undergraduates**

*Carl Procko, Steven Morrison, Courtney Dunar, Sara Mills, Brianna Maldonado, Carlee Cockrum, Nathan Emmanuel Peters, Shao-shan Carol Huang, and Joanne Chory*

A CURE combining RNA-sequencing analysis with student-driven, wet-lab experiments is described. The course promotes exploration of the links between gene expression and phenotype using examples that are clear and tractable and develops quantitative and computational skills to prepare students for the "big data era" of modern biology.

### **One-Year Research Experience for Associate's Degree Students Impacts Graduation, STEM Retention, and Transfer Patterns**

*Ron Nerio, Althea Webber, Effie MacLachlan, David Lopatto, and Avrom J. Caplan*

Quantitative and qualitative assessment of a 1-year faculty-mentored undergraduate research experience for associate's degree students demonstrates significant impact on graduation, STEM retention, and transfer patterns to research-intensive 4-year schools. Student participants report an increased sense of belonging in college.

### **Peer Teaching Increases Knowledge and Changes Perceptions about Genetically Modified Crops in Non-Science Major Undergraduates**

*Hanya E. Chrispeels, Jordan M. Chapman, Carole L. Gibson, and Gloria K. Muday*

The impact of cross-age peer teaching on non-science major undergraduates' opinions, perceptions, and knowledge of genetically modified (GM) crops was examined. After teaching high school students about plant breeding and genetic engineering, more undergraduates had favorable opinions and perceptions about the use of GM crops.

### **Characterizing Students' Ideas about the Effects of a Mutation in a Noncoding Region of DNA**

*Scott A. Sieke, Betsy B. McIntosh, Matthew M. Steele, and Jennifer K. Knight*

Student answers to a question on the effects of a mutation in a noncoding region of DNA reveal many incorrect ideas initially, but show improvement following a targeted instructional activity. The question, computer-scoring model, and activity can be used by instructors to better understand and characterize student ideas on this topic.

### **Participation in Voluntary Re-quizzing Is Predictive of Increased Performance on Cumulative Assessments in Introductory Biology**

*Elise M. Walck-Shannon, Michael J. Cahill, Mark A. McDaniel, and Regina F. Frey*

We examined student use of online, ungraded practice quizzes that are reopened near exam time after a first graded attempt. It was found that, when controlling for performance in a previous STEM course and incoming biology knowledge, re-quizzing predicts better performance on two cumulative exams in introductory biology, a course posttest, and final exam.

### **Retention following Two-Stage Collaborative Exams Depends on Timing and Student Performance**

*James E. Cooke, Laura Weir, and Bridgette Clarkston*

Using open-ended questions, a model that controls for the test effect, and isomorphic posttest questions, this study assessed whether collaborative exams improve retention of course content at 9 and 23 days and whether content retention differed for low-, mid-, or high-performing students.

### **Applying Graph Theory to Examine the Dynamics of Student Discussions in Small-Group Learning**

*Albert Chai, Joshua P. Le, Andrew S. Lee, and Stanley M. Lo*

Group work in STEM courses is an effective means of improving student outcomes. The substance and dynamics of group discussions have largely been examined using qualitative methods. A quantitative methodology that uses graph theory to map the progression of talk-turns of discussions within a group is presented here.

### **Opportunities for Self-Evaluation Increase Student Calibration in an Introductory Biology Course**

*Jennifer L. Osterhage, Ellen L. Usher, Trisha A. Douin, and William M. Bailey*

Students overestimate their performance on introductory biology exams early in the semester, but the accuracy of most students' exam predictions improves over time. Instructional strategies can increase students' metacognitive awareness and improve performance on the first exam.

### **Knowledge of Learning Makes a Difference: A Comparison of Metacognition in Introductory and Senior-Level Biology Students**

*Julie Dangremond Stanton, Kathryn Morris Dye, and Me'Shae Johnson*

This study examined introductory and senior-level biology students' use of the metacognitive skill of evaluation to gain insights on how metacognition develops in undergraduates. Senior students use their knowledge of learning to make evaluations, while introductory students consider other factors, such as whether their strategies align with exams.

### **Student Anxiety and Perception of Difficulty Impact Performance and Persistence in Introductory Biology Courses**

*Benjamin J. England, Jennifer R. Brigati, Elisabeth E. Schussler, and Miranda M. Chen*

The effects of different types of student anxieties (general, test, social, and communication) and perception of difficulty on student performance (grades) and persistence (intention to remain in the major), as evaluated using regression models, are reported. Student demographic effects on these variables are also presented.

### **Student Learning Dispositions: Multidimensional Profiles Highlight Important Differences among Undergraduate STEM Honors Thesis Writers**

*Jason E. Dowd, Robert J. Thompson, Jr., Leslie Schiff, Kelaine Haas, Christine Hohmann, Chris Roy, Warren Meck, John Bruno, and Julie A. Reynolds*

Personal dimensions of students can change in response to teaching. Here, the combined contributions of personal dimensions to learning in disciplinary writing are considered. On average, it was found that some dimensions change across a capstone writing course, and there was considerable variability at the level of individual students. This variability is explored in this work.

### **Navigating Social Relationships with Mentors and Peers: Comfort and Belonging among Men and Women in STEM Summer Research Programs**

*Heather A. Daniels, Sara E. Grineski, Timothy W. Collins, and Angela H. Frederick*

Little is known about how women and men students establish social relationships with STEM research mentors and peers. In interviews, men's greater comfort with social relationships reflected their affinity with the masculine-dominated culture of STEM. For women, cultivating safe spaces mitigated some of the repelling effects of their STEM research experiences.

### **Supports: A Key Factor in Faculty Implementation of Evidence-Based Teaching**

*Meghan E. Bathgate, Oriana R. Aragón, Andrew J. Cavanagh, Jennifer Frederick, and Mark J. Graham*

This study examines 584 STEM faculty members' motivations (e.g., value, self-efficacy) and experience with their institutional teaching environments (supports, barriers) as predictors of their reported use of evidence-based teaching (EBT). The number of faculty-perceived supports was by far most associated with their use of EBT.

### **A Multi-Institutional Analysis of Instructional Beliefs and Practices in Gateway Courses to the Sciences**

*Joseph J. Ferrare*

This paper reports findings from a study of instructional practices in 71 introductory STEM courses across six institutions of higher education. Data collection included more than 140 hours of classroom observations and in-depth interviews with the instructors of record concerning their beliefs about teaching and learning in STEM.

#### *On the Cover*

This image captures Purkinje cells (red), one of the main types of nerve cell found in the brain. These cells have elaborate branching structures called dendrites that receive signals from other nerve cells. Originally shown at the "Life: Magnified" Washington Dulles International Airport Exhibit. Image credit: Yinghua Ma and Timothy Vartanian, Cornell University, Ithaca, NY.