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Three aspects of the interactions of physics and biology are covered as seen from the viewpoint of four members of the Division of Undergraduate Education of the National Science Foundation.

From the National Science Foundation

On the Edge of Mathematics and Biology Integration: Improving Quantitative Skills in Undergraduate Biology Education
Jason Feser, Helen Vasaly, and Jose Herrera 124–128

The feature describes two major efforts to integrate mathematics and biology. A call is made to biologists to consider the need to address biology undergraduate education changes and to use the resources described.

From the National Research Council

Biology Education Research: Lessons and Future Directions
Susan R. Singer, Natalie R. Nielsen, and Heidi A. Schweingruber 129–132

This feature draws on a 2012 National Research Council report to highlight some of the insights that discipline-based education research in general—and biology education research in particular—have provided into the challenges of undergraduate science education. It identifies strategies for overcoming those challenges and future directions for biology education research.

WWW. Life Sciences Education

Physics and Biology Collaborate to Color the World
Dennis W. C. Liu 133–138

To understand how life works, it is essential to understand physics and chemistry. Physics informs and enlightens biology in myriad dimensions, yet many biology courses proceed with little or no consideration of physical properties or principles. The intersection between physics and biology is explored in this review of online media.

Perspectives on Interdisciplinary Science Education

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Perspectives on Interdisciplinary Science Education

Interdisciplinarity: The Right People, a Supportive Place, and a Program Emerges
David G. L. Van Wylen, Beth R. J. Abdella, Shelly D. Dickinson, Jason J. Engbrecht, and Rebecca Vandiver 140–143

This paper describes the St. Olaf College experience moving to a more interdisciplinary approach to student learning. The authors place this within the context of the three “P”s of higher education—*people, place,* and *program*. The key for transformation resided in focusing on the people and the place. In so doing, an interdisciplinary program emerged.

Perspectives on Interdisciplinary Science Education

Preparing High School Students for the Interdisciplinary Nature of Modern Biology
Barbara Nagle 144–147

Preparing students for the interdisciplinary nature of modern biology will require changes in curriculum, instruction, assessments, and teacher professional development in order to support teaching for conceptual understanding and for making cross-disciplinary connections.

Perspectives on Interdisciplinary Science Education

A Problem with STEM

Michael Marder 148–150

Everyone loves STEM, the acronym for science, technology, engineering, and mathematics, that sits in every call to improve U.S. competitiveness. But hidden within “science” are many different ways of thinking and acting, and unless we protect them separately, the whole scientific enterprise may be at risk.

Book Review

Genesis of *What Is Life?: A Paradigm Shift in Genetics History*

John R. Jungck 151–152

Erwin Schrödinger’s 1944 book *What Is Life?* has often been cited as a driving force in figuring out the structure of DNA and cracking the genetic code. Schrödinger’s book drew upon a paper by Nikolai Timofeëff-Ressovsky, Karl Zimmer, and Max Delbrück—the “Three-Man Paper.” *Creating a Physical Biology* argues why and how this paper produced a paradigm shift in biology.

ESSAYS

How Can We Improve Problem Solving in Undergraduate Biology? Applying Lessons from 30 Years of Physics Education Research

A.-M. Hoskinson, M. D. Caballero, and J. K. Knight 153–161

How can physics inform biology in problem-solving? The authors discuss how research-supported approaches developed by physics education researchers can be adopted by biologists to enhance student problem-solving skills.

Competency-Based Reforms of the Undergraduate Biology Curriculum: Integrating the Physical and Biological Sciences

Katerina V. Thompson, Jean Chmielewski, Michael S. Gaines, Christine A. Hrycyna, and William R. LaCourse 162–169

In response to the Association of American Medical Colleges–Howard Hughes Medical Institute report *Scientific Foundations for Future Physicians*, a collaborative effort by four institutions has produced an introductory physics for life sciences course that stresses competency building and helps students apply strategies from the physical sciences to solve authentic biological problems.

Biology and Physics Competencies for Pre-Health and Other Life Sciences Students

Robert C. Hilborn and Michael J. Friedlander 170–174

We describe how the competencies articulated in the *Scientific Foundations for Future Physicians* report influenced the structure of the revised MCAT.

Learning Each Other’s Ropes: Negotiating Interdisciplinary Authenticity

Edward F. Redish and Todd J. Cooke 175–186

This essay considers a multiyear conversation between a physicist interested in adapting a physics course for biologists and a biologist interested in including more physics in a biology course. Examples are given, along with insights developed about the different approaches biologists and physicists tend to take toward the same phenomena.

ARTICLES

A Framework for Analyzing Interdisciplinary Tasks: Implications for Student Learning and Curricular Design

Julia Svoboda Gouvea, Vashiti Sawtelle, Benjamin D. Geller, and Chandra Turpen 187–205

The authors present a framework, developed in an introductory physics for life sciences majors course, for analyzing interdisciplinary tasks. This framework will be useful for both curriculum designers and education researchers seeking to understand how integrated science curricula can be designed to support interdisciplinary learning objectives.

Toward University Modeling Instruction—Biology: Adapting Curricular Frameworks from Physics to Biology	
Seth Manthey and Eric Brewe	206–214
The curricular framework and pedagogical approach of University Modeling Instruction—Biology, adapted from University Modeling Instruction—Physics, is described and presented.	
Advantages and Challenges of Using Physics Curricula as a Model for Reforming an Undergraduate Biology Course	
D. A. Donovan, L. J. Atkins, I. Y. Salter, D. J. Gallagher, R. F. Kratz, J. V. Rousseau, and G. D. Nelson	215–229
This paper describes the collaborative development process and necessary modifications required to apply a physics pedagogical model in a life sciences context. It shows that modifications of the physics curriculum to address the biological framework promote strong gains in student understanding of these topics, as evidenced by analysis of student work.	
From $F = ma$ to Flying Squirrels: Curricular Change in an Introductory Physics Course	
Brian O’Shea, Laura Terry, and Walter Benenson	230–238
We present outcomes from the implementation of a “Physics of the life sciences” curriculum in an introductory physics sequence whose audience is mainly life science majors. Students experienced high conceptual learning gains, an increased interest in physics, and a high ability to relate physics to their interests and majors.	
Using Assessments to Investigate and Compare the Nature of Learning in Undergraduate Science Courses	
Jennifer Momsen, Erika Offerdahl, Mila Kryjevskaja, Lisa Montplaisir, Elizabeth Anderson, and Nate Grosz	239–249
Characterizing and comparing cognitive skills assessed by introductory biology and physics indicate that (a) both course sequences assess primarily lower-order cognitive skills, (b) the distribution of items across cognitive skill levels differs significantly, and (c) there is no strong relationship between student performance and cognitive skill level.	
Developing and Assessing Curriculum on the Physics of Medical Instruments	
Warren Christensen, James K. Johnson, Grace R. Van Ness, Elliot Mylott, Justin C. Dunlap, Elizabeth A. Anderson, and Ralf Widenhorn	250–261
Undergraduate educational settings struggle to provide biologically or medically relevant situations and problems that simultaneously improve students’ understanding of physics. Exercises developed in an elective physics course for life sciences or pre-health majors at Portland State University are aimed at teaching fundamental physics concepts within the context of biomedical devices.	
Using a Physics Experiment in a Lecture Setting to Engage Biology Students with the Concepts of Poiseuille’s Law	
Jennifer L. Breckler, Tina Christensen, and Wendy Sun	262–273
A physics experiment on Poiseuille’s law was performed as a demonstration in a physiology course. Students who viewed the demonstration reacted positively and increased their test performance, although the control group eventually “caught up,” despite not having seen the demonstration. Students with lower math skills who viewed the demonstration benefited slightly more than did those with higher math skills.	
Context Dependence of Students’ Views about the Role of Equations in Understanding Biology	
Jessica Watkins and Andrew Elby	274–286
The authors show how students’ views about what counts as learning in biology can be context-dependent. They examine an interview in which a student expressed two different views about the use of equations in biology. The results highlight how a given student can have diverse ways of thinking about the value of bringing physics and math into biology.	

The Effects of the SUN Project on Teacher Knowledge and Self-Efficacy Regarding Biological Energy Transfer Are Significant and Long-Lasting: Results of a Randomized Controlled Trial
 Ann Finney Batiza, Mary Gruhl, Bo Zhang, Tom Harrington, Marisa Roberts, Donna LaFlamme, Mary Anne Haasch, Jonathan Knopp, Gina Vogt, David Goodsell, Eric Hagedorn, David Marcey, Mark Hoelzer, and Dave Nelson 287–305

The Students Understanding eNergy (SUN) Project reports significant long-term effects on biology teacher knowledge and self-efficacy regarding biological energy transfer. Teachers use a hydrogen fuel cell and manipulatives to develop a model of energy transfer based on electrons moving in thermodynamically spontaneous reactions.

The Trouble with Chemical Energy: Why Understanding Bond Energies Requires an Interdisciplinary Systems Approach
 Melanie M. Cooper and Michael W. Klymkowsky 306–312

Helping students understand “chemical energy” is notoriously difficult. Change will require an interdisciplinary approach to curriculum reform, building on the National Research Council Framework for K–12 Science Education and learning progressions designed to help students move from the macroscopic- to molecular-level understanding of energy.

CORRECTIONS

Assessment of Learning Gains Associated with Independent Exam Analysis in Introductory Biology
 Adrienne E. Williams, Nancy M. Aguilar-Roca, Michelle Tsai, Matthew Wong, Marin Moravec Beaupré, and Diane K. O’Dowd 313

Recent Research in Science Teaching and Learning
 Deborah Allen 314

On the Cover

These elegant constructs were first known to mathematics and then to engineers as structures that are physically strong with minimal mass. As mentioned in the feature on page 133, only later were these shapes found in biology, the products of evolutionary tinkering iteratively optimizing structure and function. The “saddle” shape on the left is the form of the familiar potato chip, but mathematicians know it as a hyperbolic paraboloid. Jewelers and builders use it to fashion strong, light structures that distribute loads evenly. In biology the mantis shrimp incorporates this saddle structure into the joint of its raptorial limb, which is capable of producing shell crushing force and traveling through water so fast that a trail of evaporative bubbles and light flashes can be detected by high-speed video. The middle and right images form the softer side of biology; these “gyroid” structures decorate the colorful wings of butterflies, bouncing light to produce brilliant colors not based on pigment, but on reflection and refraction of light by the physical shape of the gyroid. Before being found on the wings of butterflies, gyroids were fabricated as a by-product of NASA research into “minimal surfaces.” (image credit: left, courtesy of mathforum.org; middle and right courtesy of Adam G. Weyhaupt)