

## CATHERINE HIRSHFELD CROUCH, PH.D.

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### PRESENT POSITION

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Professor of Physics (since 2017) and Chair (since 2021), Swarthmore College (at Swarthmore since 2003)

### EDUCATION

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Postdoctoral Fellow in Applied Physics and Physics Education with Eric Mazur, Harvard University, 1996–2003.

Ph.D. in Physics with Robert M. Westervelt, Harvard University, September 1996.

B.A. in Physics *summa cum laude* with Highest Honors, Williams College, 1990.

### AWARDS AND GRANT FUNDING

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Co-PI on NSF IUSE grant, “Investigating how life science students develop lasting skill in making connections between physics and biology” (DUE-2142074), \$300k, 2022-25, with PI Benjamin Geller (Swarthmore Physics).

Elected a Fellow of the American Physical Society, through the Topical Group in Physics Education Research, October 2021: “For leadership in physics education research focused on promoting thoughtful use of interactive engagement for all students, and for making physics relevant to life science majors, as well as for supporting others through archiving of key resources, mentoring, and commitment to equity and inclusion in STEM.”

PI on NSF IUSE grant “Do Connections Persist? A Pilot Study Investigating the Lasting Impact of a Physics Course Designed to Facilitate Connections With Biology” (DUE-1710875), \$220k, August 2017- August 2021, with co-PIs Benjamin Geller (Swarthmore Physics) and Sara Hiebert Burch (Swarthmore Biology).

Co-PI on NSF IUSE grant “Collaborative Research: Community Sourcing of Introductory Physics for the Life Sciences” (DUE-1624017), PI Robert Hilborn (American Association of Physics Teachers); \$58k to Swarthmore (2016-2019), funding summer salary for CHC and Ben Geller for disseminating curricular resources.

Co-PI on NSF TUES grant “Creating a Common Thermodynamics,” DUE-1122941, PI Edward F. Redish (University of Maryland); \$20k to Swarthmore (2011-2014), funding release time for curriculum development.

National Science Foundation Research Opportunity Award to join the laboratory of Prof. Tobias Baumgart, University of Pennsylvania as part of 2010-11 sabbatical.

Co-PI on NSF award “Conference on Scientific Foundations of Future Physicians: How do physics departments respond?” DUE-0965156, PI Mark Reeves, funded October 2009 conference held at George Washington University.

### ACTIVE and RECENT RESEARCH INTERESTS

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Outcomes (immediate and long-term) of introductory physics for life science students (current)

Cell membrane biophysics and the role of proteins in cell membrane curvature generation (through 2017)

### RECENT CURRICULUM AND TEXTBOOK DEVELOPMENT PROJECTS

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*Introductory Physics for the Life Sciences (Swarthmore College Physics 3L- 4L)*. Courses developed and taught with HHMI support (Physics 4L first offered Spring 2008; Physics 3L first offered Fall 2015.) Complete description at [materials.physics.swarthmore.edu/IPLS](http://materials.physics.swarthmore.edu/IPLS).

*Living Physics Portal*. Multi-institution NSF-funded project (Swarthmore DUE-1624017, 2016-2020) led by Robert Hilborn (American Association of Physics Teachers) to disseminate curricular materials for reformed introductory physics for life science courses. The site is maintained and I am still contributing, although the grant has ended.

Contributing author for *University Physics for the Life Sciences* (Pearson Education/Addison-Wesley), with lead authors Randall Knight, Brian Jones, and Stuart Field, published 2020.

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#### NOTEWORTHY SWARTHMORE COLLEGE LEADERSHIP AND INTERDISCIPLINARY ACTIVITIES

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Cofounder (with Liz Vallen and Kathy Siwicki, 2016-17) and Chair of NSE Inclusive Excellence Faculty Working Group, May 2017–July 2021. Established science division-wide programs to promote effective teaching, mentoring, and support for all students, including training of peer helpers for introductory courses.

Curriculum development, teaching, and mentoring for Swarthmore Summer Scholars Program, 2016 and 2017.

Designed assessment of Swarthmore Summer Scholars Program and led assessment team 2015-2018, with support from Institutional Research.

Faculty chaperone for Dec 2016 – Jan 2017 Israel-Palestine study trip through Peace & Conflict Studies 053 (led by Sa'ed Atshan).

Participated in 2016-17 Faculty Pedagogy Seminar at Swarthmore, in which twelve Swarthmore faculty from departments around the College discussed pedagogy on a monthly basis (led by faculty from English and Biology).

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#### NOTEWORTHY SERVICE TO PHYSICS AND PHYSICS EDUCATION COMMUNITY

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Co-Chair, APS Committee on Education, 2022. Includes serving as Chair of APS Task Force on Teaching Evaluation.

Steering Committee, APS/AAPT Department Chairs' Conference, 2022, and session organizer, 2023.

Panelist and reviewer for National Academy of Sciences [Decadal Study of the Physics of Life](#) (published 2022).

Chair line, APS Forum on Education (elected Fall 2018 for 2019-22); member, APS Committee on Education (ex officio as Forum on Education leader, 2020-22). Previously served on meeting program committee (2015) and Excellence in Education Award selection committee (2010-11).

Member-at-Large, APS Topical Group on Physics Education Research Executive Committee, 2016-2018.

American Physical Society Outstanding Referee 2016 (reflects cumulative service).

Co-organizer of NSF-Funded conferences on introductory physics for life sciences, April 2014 (NSF DUE 1322895, \$97,513, PI R. Hilborn, co-PIs: J. Burciaga, D. Meredith, M. Reeves, and P. Soto.) and October 2009 (DUE-0965156, \$31,465, PI M. Reeves, co-PIs C. Crouch, S. Amador Kane, and T. McKay). With co-organizers of 2014 meeting, prepared a conference report for APS and AAPT with recommendations for national reforms of this course. With co-organizers of 2009 meeting, wrote APS News Back Page (editorial) summarizing directions for reform.

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#### PEER-REVIEWED PUBLICATIONS SINCE 2003: PHYSICS EDUCATION (\*Swarthmore undergraduate)

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[1] Catherine H. Crouch and Benjamin D. Geller, "[Introductory Physics for Life Sciences: Preparing and Engaging Students through Authentic Interdisciplinary Connections](#)," Ch. 20 in *The International Handbook of Physics Education Research: Learning Physics*, eds. M. F. Tasar and P. R. L. Heron, AIP Publishing (2023).

[2] Benjamin D. Geller, Jack Rubien, \* Sara M. Hiebert, and Catherine H. Crouch, "The impact of introductory physics for life sciences in a senior biology capstone course," [Phys. Rev. Phys. Educ. Res.](#) **18**, 010120 (2022).

- [3] Benjamin D. Geller, Maya Tipton,\* Brandon Daniel-Morales,\* Nikhil Tignor,\* Calvin White,\* and Catherine H. Crouch, “The role of introductory physics for life sciences in supporting students to use models flexibly,” [Phys. Rev. Phys. Educ. Res. 18, 010131 \(2022\)](#).
- [4] Catherine H. Crouch and John W. Hirshfeld, Jr, “Teaching the electrical origins of the electrocardiogram: An introductory physics laboratory for life science students,” [American Journal of Physics 88, 526 \(2020\)](#).
- [5] Catherine H. Crouch, Panchompoo Wisittanawat,\* Ming Cai, and K. Ann Renninger, “Supporting life science students’ interest in physics by embedding physics in life science contexts: An exploratory study,” [Phys. Rev. Phys. Educ. Res. 14, 010111 \(2018\)](#).
- [6] Benjamin Geller, Chandra Turpen, and Catherine H. Crouch, “Sources of student engagement in introductory physics for life sciences,” [Phys. Rev. Phys. Educ. Res. 14, 010118 \(2018\)](#).
- [7] Catherine H. Crouch and Kenneth Heller, “Introductory Physics in Biological Context: An Approach to Improve Introductory Physics for Life Science Students,” [American Journal of Physics 82, 378 \(2014\)](#).
- [8] E. F. Redish, C. Bauer, K. L. Carleton, T. J. Cooke, M. Cooper, C. H. Crouch, B. W. Dreyfus, B. Geller, J. Giannini, J. Svoboda Gouvea, M. W. Klymkowsky, W. Losert, K. Moore, J. Presson, V. Sawtelle, C. Turpen, and K. Thompson, “NEXUS/Physics: An interdisciplinary repurposing of physics for biologists,” [American Journal of Physics 82, 368 \(2014\)](#).
- [9] Catherine H. Crouch, Panchompoo Wisittanawat,\* and K. Ann Renninger, “[Initial Interest, Goals, and Changes in CLASS Scores in Introductory Physics for Life Sciences](#),” in *Proceedings of the 2013 Physics Education Research Conference*, Paula Engelhardt, editor (American Association of Physics Teachers, 2013).
- [10] Catherine H. Crouch and Kenneth Heller, “Teaching physics to life science students: examining the role of biological context,” in *Proceedings of the 2011 Physics Education Research Conference*, Sanjay Rebello, editor (American Association of Physics Teachers, 2011).
- [11] Catherine H. Crouch, Jessica Watkins, Adam P. Fagen, and Eric Mazur, “Peer Instruction: Engaging students one-on-one, all at once,” in *Research-Based Reforms in University Physics*, Edward F. Redish, editor (American Association of Physics Teachers, 2007, online at <http://www.compadre.org/PER/items/detail.cfm?ID=4990>).
- [12] Mercedes Lorenzo, Catherine H. Crouch, and Eric Mazur, “Reducing the gender gap in the physics classroom,” *American Journal of Physics* 74, 118 (2006).
- [13] Catherine H. Crouch, Adam P. Fagen, J. Paul Callan, and Eric Mazur, “Classroom demonstrations: learning tools or entertainment?” *American Journal of Physics* 72, 835 (2004).
- [14] K. Kelvin Cheng, BethAnn Thacker, Richard L. Cardenas, and Catherine H. Crouch, “Using an online homework system enhances students’ learning of physics concepts in an introductory physics course,” *American Journal of Physics* 72, 1447 (2004).

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PEER-REVIEWED PUBLICATIONS SINCE 2003: EXPERIMENTAL (\*Swarthmore undergraduate)

- [1] Catherine H. Crouch, Margaret H. Bost,\* Tae H. Kim,\* Bryan M. Green,\* D. Stuart Arbuckle, Carl H. Grossman, and Kathleen P. Howard, “Optimization of Detergent-Mediated Reconstitution of an Integral Membrane Protein,” [Membranes 8\(4\), 103 \(2018\)](#).
- [2] Siying Wang, Claudia Querner, Tali Dadosh, Catherine H. Crouch, Dmitry Novikov, and Marija Drndic, “Collective fluorescence enhancement in nanoparticle clusters,” [Nature Communications 2, 364 \(2011\)](#).
- [3] Catherine H. Crouch, Orion Sauter\*, Xiaohua Wu, Robert Purcell\*, Claudia Querner, Marija Drndic, and Matthew Pelton, “Facts and artifacts in the blinking statistics of semiconductor nanocrystals,” [Nano Letters 10, 1692 \(2010\)](#).
- [4] Catherine H. Crouch, Robert Mohr\*, Thomas Emmons\*, Siying Wang, and Marija Drndic, “Excitation energy dependence of fluorescence intermittency in CdSe/ZnS core-shell nanocrystals,” [J. Phys. Chem. C 113, 12059 \(2009\)](#).

- [5] Siying Wang, Claudia Querner, Michael D. Fischbein, Lauren Willis, Dmitry Novikov, Catherine H. Crouch and Marija Drndic, “Blinking statistics correlated with nanoparticle number,” *Nano Letters* **8**, 4020 (2008).
- [6] Mengyan Shen, James E. Carey, Catherine H. Crouch, Maria Kandyla, Howard A. Stone, and Eric Mazur, “High-density regular arrays of nanometer-scale rods formed on silicon surfaces via femtosecond laser irradiation in water,” *Nano Letters* **8**, 2087 (2008).
- [7] Siying Wang, Claudia Querner, Thomas Emmons\*, Marija Drndic, and Catherine H. Crouch, “Fluorescence blinking statistics from CdSe core and core-shell nanorods,” *Journal of Physical Chemistry B* **110**, 23221 (2006).
- [8] James E. Carey, Catherine H. Crouch, Mengyan Shen, and Eric Mazur, “Visible and near-infrared responsivity of femtosecond laser-structured photodiodes,” *Optics Letters* **30** (14), 1773 (2005).
- [9] C. H. Crouch, J. E. Carey, M. Y. Shen, E. Mazur, and F. Y. Génin, “Infrared absorption by sulfur-doped silicon formed by femtosecond laser irradiation,” *Applied Physics A* **79**, 1635 (2004).
- [10] C. H. Crouch, J. E. Carey, J. M. Warrender, M. J. Aziz, and E. Mazur, “Comparison of structure and properties of femtosecond and nanosecond laser-structured silicon,” *Applied Physics Letters* **84**, 1850 (2004).
- [11] M. Y. Shen, C. H. Crouch, J. E. Carey, and E. Mazur, “Femtosecond laser-induced formation of submicrometer spikes on silicon in water,” *Applied Physics Letters* **85**, 5694 (2004).
- [12] M. Y. Shen, C. H. Crouch, J. E. Carey, R. Younkin, M. Sheehy, C. M. Friend, and E. Mazur, “Formation of ordered silicon microspikes by femtosecond laser irradiation through a mask,” *Appl. Phys. Lett.* **82**, 1715 (2003).

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#### INVITED PRESENTATIONS SINCE 2003: PHYSICS EDUCATION

- [1] With co-presenter Benjamin Geller, “Does it stick? A longitudinal study of introductory physics for life sciences at a small college,” plenary talk at the [2024 Physics Education Research Conference](#), Boston, MA, July 2024.
- [2] “Developing physical modeling skills in introductory physics for life sciences,” AAPT Summer Meeting, July 2024.
- [3-8] “Supporting interdisciplinary, enduring learning: Strategy and results from introductory physics for the life sciences,” Amherst College (April 2023), Harvard University Learning Incubator talk series (March 2023), UMass STEM Education seminar (May 2021); George Washington University Walker Lecture, Oct 2020; NSF-funded high school teacher development workshop, July 2020; Widener University, March 2020.
- [9] Invited panelist for National Academy of Sciences decadal study of biological physics, April 2020.
- [10] Catherine H. Crouch, “Balancing Methods and Content: Good for Everyone and Good for Inclusion,” American Association of Physics Teachers (AAPT) Summer Meeting 2019, Provo, UT.
- [11-13] “Does it stick? Assessing the long-term impact of IPLS” (with co-authors Benjamin Geller, Chandra Turpen, Jonathan Solomon, and Nathaniel Peters), discipline-based education research (DBER) colloquia at Cornell, May 2019, and Harvard, March 2019; and AAPT Winter Meeting, January 2019.
- [14] “Supporting interdisciplinary learning: Experiences and results from teaching physics to life science students,” Discipline-Based Science Education and Research Center colloquium, University of Pittsburgh, April 2019.
- [15, 16] “Living Physics Portal: Community and Resources for Physics for Life Sciences,” AAPT Summer Meeting, July 2018 and American Physical Society (APS) March Meeting, March 2019.
- [17] Benjamin Geller, Chandra Turpen, Nathaniel Peters, Jonathan Solomon, and Catherine H. Crouch, “Do connections persist? Assessing the longitudinal impact of IPLS,” AAPT Summer Meeting 2018, Washington DC.
- [18-29] “Teaching Introductory Physics in Biological Context,” UCLA Biology Department, Feb. 2015; Harvard University, Derek Bok Center for Teaching and Learning, November 2014; Seattle Physics Education Research Seminar Series, October 2014; plenary speaker for June 2014 Gordon Research Conference in Physics and Education; Yale Center for Scientific Teaching, May 2014; University of North Carolina-Chapel Hill, April 2014; APS April Meeting, April 2014; AAPT National Meeting, July 2013; Univ. of Pittsburgh, Feb. 2013; Univ. of Maryland-Baltimore County, May 2011; AAPT/APS New Faculty Reunion Workshop, Oct. 2012.

- [30] “Science Teaching for the New Millenium,” science pedagogy seminar, Williams College, November 2013.
- [31] “Reforming the Introductory Physics Course for Life Science Students,” workshop offered at the AAPT Summer Meeting, July 2012, organized by Dawn Meredith.
- [32] “Biomedical-Inspired Laboratories for Introductory Physics,” workshop offered at AAPT Summer Meeting, with organizer Mark Reeves and co-presenter Suzanne Amador Kane, Portland, OR, July 2010.
- [33] “Teaching Underrepresented Groups with Peer Instruction,” American Association of Physics Teachers Summer Meeting, Portland, OR, July 2010.
- [34] “Gender and student achievement with Peer Instruction,” 2008 Physics Education Research Conference, Edmonton, Alberta, Canada, July 2008. Also served as organizer for one of six invited sessions.
- [35-37] “Reducing the gender gap in introductory physics,” Physics Education Research Group seminar, Rutgers University, October 2007; University of Maryland, September 2007; University of Colorado, March 2007.
- [38] “Promise and pitfalls of reformed instruction for female students,” workshop at Physics Teacher Education Coalition 2007 conference, Boulder, CO, March 2007.
- [39, 40] “Classroom demonstrations: Learning Tools or Entertainment?” 19<sup>th</sup> Biennial Conference on Chemical Education, August 2006; APS April Meeting, Philadelphia, PA, April 2003.

#### INVITED PRESENTATIONS SINCE 2003: EXPERIMENTAL

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- [1] “Making Model Cell Membranes to Study How Proteins Reshape Cells,” Swarthmore College Physics Colloquium, April 2016.
- [2] “Studying Virus Budding with Physics,” Williams College Physics Colloquium, November 2013.
- [3] “Membrane-Protein Binding: Basic Physics and Two (Fairly) New Experimental Techniques,” Swarthmore College Physics Colloquium, February 2012.
- [4] Catherine H. Crouch, Orion Sauter\*, Xiaohua Wu, Robert Purcell\*, Claudia Querner, Marija Drndic, and Matthew Pelton, “Facts and artifacts in the blinking statistics of CdSe nanoparticles,” DOE Triennial Review, Argonne National Laboratory, May 2010.
- [5] “Dynamics on the Nanoscale: Light Emission from Single Semiconductor Nanorods,” Swarthmore College Physics Colloquium, February 2008.
- [6] “Fluorescence blinking statistics from CdSe core and core-shell nanorods,” Workshop on Fluorescence Intermittency in Molecules, Quantum Dots, and Quantum Wires, Notre Dame University, April 2007.
- [7 - 12] “Intermittent fluorescence from semiconductor nanorods,” Argonne National Laboratory Nanomaterials seminar, June 2007; Laboratory for Surface Modification Seminar, Rutgers University, October 2007; Materials Science Graduate Student Seminar, Princeton University, December 2006; Physics colloquia, Wheaton College, October 2007; Amherst College, November 2006; and St. Joseph’s University, November 2006.
- [13] “Light emission from single quantum rods: Research as education and vocation,” keynote address at Erickson Undergraduate Research Conference, Seattle Pacific University, May 2006.
- [14] “Black silicon: changing structure and properties with light,” Physics Colloquium, Haverford, March 2004.

#### SWARTHMORE UNDERGRADUATES INVOLVED IN RESEARCH

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Nathan Landy '06	summer 2004, summer 2005, fall 2005
Tara Finley Bartiromo '06	summer 2005
Thomas Emmons '08	summer 2006, summer 2007, fall 2007
Benjamin Blonder '08 and Benjamin Plotkin-Swing '09	summer 2007 (with Carl Grossman)
Corey White '11	research assistant spring 2007, summer 2007
Robert Mohr '09 (Honors)	spring 2007, summer 2008, honors research fall 2008

Margaret Cosgriff '09 summer 2008 (with Carl Grossman)  
 Orion Sauter '11 summers 2008 (with Carl Grossman) and 2009, academic year 2008-09 and 09-10  
 Robert Purcell '11 summer 2009  
 Sandra Liss '11 research assistant (analyzing physics education data) fall 2010, spring 2011  
 Ayman Abunimer '12 and Tiffany Lee '12 summer 2011, TL also fall 2011 (with Tobias Baumgart, UPenn)  
 Panchompoo Wisittanawat '13 (Honors) academic year 2012-13 (with Ann Renninger)  
 Tae Kim '14 (Honors) June 2012 – May 2014 (with Kathleen Howard and Carl Grossman)  
 Mariel Freyre '15 September 2014 – May 2015 (with Kathleen Howard and Carl Grossman)  
 Margaret Bost '17 summer 2015 (with Kathleen Howard and Carl Grossman)  
 Tessa Williams '17 summer 2015 (with Benjamin Geller)  
 Bryan Green '16 September 2015 – May 2016 (with Kathleen Howard)  
 Haley Gerardi '17 summers 2016, 2019 (with Benjamin Geller)  
 Tyler Alexander '17 fall 2016 (with Kathleen Howard)  
 Max Franklin '19 summers 2016 and 2017 (with Benjamin Geller)  
 Jess Li '19 summer 2017 (with Benjamin Geller)  
 Jonathan Solomon '20 and Katherine Lima '20 summer 2018 (with Benjamin Geller)  
 Nathaniel Peters '18 summers 2018, 2019 (with Benjamin Geller)  
 Tarzan Aqil MacMood '20 summers 2019 and 2020 (with Benjamin Geller)  
 Jack Rubien '20, Gwendolyn Rak '22, and Maya Tipton '23 summer 2020 (with Benjamin Geller)  
 Brandon Daniel-Morales '24, Nikhil Tignor '24, and Rain White '24 summer 2021 (with Benjamin Geller)  
 Drake Roth '25 and Angelina Tjia '26 summer 2023 (with Benjamin Geller)  
 Lundy Zheng '26 and Nikhil Tignor '24 spring semester and summer 2024 (with Benjamin Geller)