Sandra **Laursen**
Anne-Barrie **Hunter**
Elaine **Seymour**
Heather **Thiry**
Ginger **Melton**

Undergraduate Research in the Sciences

Engaging Students in Real Science

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Foreword by
Jim Swartz, Jim Gentile,
Mary Allen, Sheldon Wettack

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The Authors

ETHNOGRAPHY & EVALUATION RESEARCH (E&ER) is an independent research and evaluation unit at the University of Colorado at Boulder. Our interdisciplinary team specializes in qualitative studies of education, career paths, and diversity in science, technology, engineering, and mathematics, most often at the undergraduate, graduate, and professional levels. Founded by Elaine Seymour and Nancy Hewitt, the group is currently led by Anne-Barrie Hunter and Sandra Laursen. At the university, E&ER has been affiliated with the Center to Advance Research and Teaching in the Social Sciences.

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Anne-Barrie Hunter, codirector and senior professional researcher with E&ER, served as lead researcher and analyst of this eight-year study to establish and explore the benefits and costs of undergraduate research (UR). Since 1991, she has collaborated with group members to conduct qualitative research and evaluations on science, technology, engineering, and mathematics (STEM) initiatives to improve college science education, including the research study that produced *Talking About Leaving: Why Undergraduates Leave the Sciences* (Seymour & Hewitt, 1997). She has played a major role in evaluations for ChemConnections, the College Board, Project Kaleidoscope, and the Los Alamos National Laboratory internship program. More recently, she has collaborated on evaluations of several UR programs: Louisiana State University's LA-STEM Scholars program, Carleton College's off-campus Marine Biology Seminar, the University of Colorado's Biological Sciences Initiative, the Significant Opportunities in Atmospheric Research and Science program (SOARS)

sponsored by the University Corporation for Atmospheric Research, and the Society of Physics Students internship program. She is also coauthor (with Seymour) of *Talking About Disability: The Education and Work Experiences of Graduates and Undergraduates with Disabilities in Science, Mathematics and Engineering* (1998), the first study of STEM students with disabilities. Current research interests include issues for women and underrepresented groups in STEM education and career pathways, faculty professional development, and organizational change and development in higher education.

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Sandra Laursen works in both research and practice in science education. As codirector and research associate with E&ER, her research interests include underrepresentation of women and minorities in the sciences, professional socialization and career development of scientists, teacher professional development, and science education reform. In addition to UR, her recent publications have addressed scientists' participation in education and outreach, STEM graduate education, and gender issues in academe. In her work as curriculum developer and outreach scientist with the Cooperative Institute for Research in Environmental Sciences, she has developed inquiry-based teaching materials and led professional development for educators and scientists on a wide range of topics in earth and physical science and inquiry-based teaching and learning. As an undergraduate at Grinnell College, her summer research efforts yielded brown gunk of high molecular weight, leading her to abandon synthetic inorganic chemistry and pursue instead a Ph.D. in physical chemistry from the University of California at Berkeley. She later taught and conducted chemistry research with undergraduates at Kalamazoo College. She has published chemistry curriculum modules and journal articles in chemistry, education, gender studies, and the *Journal of Irreproducible Results*; codirected a documentary film on scientific inquiry; and recorded a CD with Resonance Women's Chorus.

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Ginger Melton was a research associate with E&ER for several years. She worked for fourteen years as an electrical engineer before obtaining her Ph.D. in sociology from the University of Colorado at Boulder. Her area of special interest is the experiences of racial minorities and women in the

sciences, mathematics, and engineering. As a researcher with E&ER, she was the lead interviewer and analyst for the evaluation of SOARS and studied the professional development of teaching assistants and of scientists involved in science education. She is currently working as a project manager for implementations of geographic information system software.

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Elaine Seymour was cofounder and, for seventeen years, director of E&ER. Her best-known work, coauthored with Nancy M. Hewitt, is *Talking About Leaving: Why Undergraduates Leave the Sciences* (1997). In 2005 she and E&ER members published *Partners in Innovation: Teaching Assistants in College Science Courses*, a work drawing on several of the group's science education studies. She has been an evaluator for many initiatives focused on improving quality and access to science education and careers. In response to the learning assessment needs of classroom innovators, she designed two online resources for undergraduate faculty: the Field-Tested Learning Assessment Guide and the widely used online instrument, the Student Assessment of their Learning Gains. In 2002, in recognition of her work on women in science, she was awarded the Betty Vetter Award for Research. In retirement, she is helping to organize a national endeavor, Mobilizing STEM Education for a Sustainable Future. She is a sociologist and a British American whose education and career have been conducted on both sides of the Atlantic.

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Heather Thiry is a research associate with E&ER. She has a Ph.D. in education and a background in women's studies. She has worked with E&ER since 2003 on research and evaluation studies on undergraduate research, STEM education reform and assessment, professional development, teacher education, career pathways in the sciences, and graduate education. She specializes in qualitative research and analysis, and her current research interests include gender and science and the professional socialization of doctoral students in the sciences. Her recent publications examine the needs and motivations of scientists involved with educational outreach and nontraditional career paths of doctoral students in the life sciences.

Foreword

ALL FOUR OF us had experiences as undergraduates that substantively involved us in scientific research. Those experiences made significant differences in our professional lives. We all have spent our careers at institutions that have strong traditions of undergraduate research (UR) in the sciences and believe that such experiences have positive educational value. Reviews of the literature, however, yielded scant scholarly work about what kinds of learning occur in undergraduate research. The literature revealed studies correlating undergraduate research with pursuing graduate study or careers in science and plenty of anecdotal testimonials, but it was essentially devoid of studies of learning. Based on our experiences as students, faculty members, and administrators, we believed that undergraduate research results in high-quality student learning, but we did not know that with confidence since no careful assessment had been done.

Grinnell College decided to look at this issue using funding from its National Science Foundation (NSF) Award for Integration of Research and Education (AIRE). At an AIRE project directors meeting, Jim Swartz, professor of chemistry, vice president for academic affairs, and dean of the college, and David Lopatto, professor of psychology, discussed this project and invited others to participate. Mary Allen, professor of biological sciences at Wellesley College, Jim Gentile, professor of biology and dean of the natural sciences at Hope College, and Sheldon Wettack, professor of chemistry and vice president and dean of the faculty at Harvey Mudd College, all expressed enthusiasm, and their institutions agreed to engage in a pilot project in the summer of 1999. Elaine Seymour, a sociologist from the University of Colorado at Boulder, attended that project meeting, expressed a real interest, and joined in the pilot project. Elaine and her research group, Ethnography & Evaluation Research (E&ER), had

done seminal work in science education using ethnographic techniques to shed light on the issue of why excellent students leave the study of science and had helped to assess a major pedagogical development project in which one of us (J.S.) was a principal. Thus we were thrilled to partner with a group with experience and credentials to help in the assessment of student learning and whose members could offer a complement to the quantitative research that David Lopatto was starting.

That first summer, our AIRE funds were used to pay for surveys and interviews with participants in summer research projects on our campuses. During the time when we were working on the pilot project, David and Elaine submitted a proposal to the NSF in the first round of funding of the Research on Learning and Education program. The focus of the project was to address the question of what learning gains are achieved by students who engage in undergraduate research. Specifically, the grant proposal requested support to:

- Clarify the nature of authentic undergraduate research experiences—and their variations—in a sample of science disciplines from the viewpoints of participating and nonparticipating undergraduates (both as seniors and one year from graduation), faculty, and their institutions
- Identify and categorize the essential elements of good UR experiences, the learning gains (cognitive, behavioral, affective, social, and professional) that they produce over time, the conditions and processes by which these occur, and their relative significance in the achievement of outcomes that students and faculty value.

Ultimately a grant was awarded, and the project took off. Since this was a research project, we decided to start with a relatively homogeneous set of subjects—like chemists trying to use the purest reagents to study a chemical reaction. The study would examine students at liberal arts colleges who were engaged in full-time, ten-week summer research projects supervised by the faculty members at those same colleges. Our colleges were certainly not the only sites where these questions could be explored, but we knew there was much to learn on our campuses that would be of interest to us and to others—and importantly, we and our colleagues were willing to host the study. Furthermore, we were interested in the possibility that the results would help our institutions seek support from foundations and individuals to expand and enhance our UR programs. The colleges also brought the study some diversity: Wellesley is an eastern women's college; Harvey Mudd in the West focuses on science, engineering, and mathematics; and Grinnell and Hope are midwestern colleges, with Grinnell having a more national and Hope a more regional student body.

David and Elaine regularly gathered the four of us to talk about their findings, coordinate surveys and interviews, and suggest directions and questions for the project. Three of the four of us have changed jobs since this project started, but we remained committed to the project. The work described here and in Lopatto's forthcoming book, *Science in Solution*, gives the findings of this important project. The E&ER team and David Lopatto accomplished much more than we had imagined in those first informal conversations.

The results mirror much of what we, as practitioners, intuitively thought were the benefits of UR. There are, however, some surprising findings, in particular about the impact on student career choices and faculty concerns about the costs and benefits of UR. We not only learned about what students learned but also about faculty views of their work with students. Although the work started with summer research in science, engineering, and mathematics at liberal arts colleges, we believe that much of what was learned can be extrapolated to other institutional types and disciplines. There is much to learn from it about how to create fertile environments for both students and faculty members to engage in what George Kuh calls a "high-impact" educational practice. We are very happy to see this product of the work.

Jim Swartz, Grinnell College, Grinnell, Iowa
Jim Gentile, Research Corporation for the Advancement of Science, Tucson, Arizona (formerly at Hope College)
Mary Allen, Wellesley College, Wellesley, Massachusetts
Sheldon Wettack, Hope College, Holland, Michigan (formerly at Harvey Mudd College)
March 2009

Preface

EACH YEAR IN the summer and during academic terms, thousands of undergraduate science, mathematics, and engineering students participate in research in U.S. university, college, and government laboratories. Some students attend organized programs that involve them with a cohort of peers and a planned curriculum of academic, career, and social activities to support the research experience; others simply join a laboratory group at the invitation of an individual faculty member. Millions of public and private dollars are spent to provide these opportunities. Faculty and institutional leaders affirm undergraduate research as a powerful form of experiential education, and departments track the entrance of their research students into graduate programs. Many scientists recall their own undergraduate research project as a formative experience that launched them on a path to a scientific career.

Undergraduate research (UR) experiences in the sciences are thus a common practice in U.S. higher education, and their benefits to students are nearly a matter of faith. Yet until quite recently, little evidence from educational research underlay this belief. In this book, we report on evidence gathered from a decade of research on the nature and outcomes of UR as practiced in the sciences—using the latter term broadly to include the natural sciences but also mathematics, engineering, computer science, and psychology, all represented in our research. Our findings identify the benefits to students in the short and longer terms and address the extent to which these benefits are uniquely derived from research experiences. We also describe the practices of research advisors who supervise students' work and guide their development, and the inherent tensions that frame that work as faculty balance their own scholarly goals with students' educational needs. Together with recent work

from other scholars and evaluators who have examined undergraduate research as an educational and scholarly practice, our studies yield a body of evidence that elucidates and supports many practitioners' long-held beliefs, challenges others, and provides a research basis to ground the development of future innovations.

While current interest in inquiry-based science education has led to broadened use of the term *undergraduate research* to include research-like activities and projects included in formal course work, this book focuses on the traditional and most intensive model of undergraduate research, where students are immersed in a multiweek, open-ended scientific project, often part of a larger, scientist-led research effort. Summer is the time when this intensive immersion is most readily, though not exclusively, accomplished. One crucial component is the relationship of the novice researcher as apprentice to an experienced scientist. As the novice learns the intellectual craft and social practice of science by doing it, she is guided by advice, help, and moral support from a more experienced colleague. Also crucial is the authentic nature of the scientific problem under study, which motivates and gives intellectual significance to the investigation, but also offers a limitless supply of teachable moments that research advisors exploit for their deep educational value. As we shall argue, the participation of a faculty research advisor as both a scholar and a teacher is a key aspect that distinguishes this apprentice model of undergraduate research from course-based forms of inquiry.

This book is aimed at all those who are interested in undergraduate research in the sciences:

- STEM faculty and other scientists, engineers, and mathematicians who work with student researchers, are considering it, or seek similar outcomes from their classroom work
- Faculty in other fields where UR is less common but who seek to understand the fundamental nature of UR so that they can adapt it to the forms of scholarly and creative work practiced in their own disciplines
- Academic administrators interested in the value added by UR to their institution's programs, the costs incurred, and the choices to be made about whether, and in what form, UR can be supported and sustained
- Program developers and facilitators who coordinate UR efforts on campuses or run UR programs for universities and laboratories
- Policymakers and program officers whose organizations promote and support UR or are interested in the broad educational and workforce issues that UR is thought to address

- Researchers and evaluators who seek to improve science education through studying or evaluating UR program outcomes or by collaborating with UR practitioners.

We have sought to elucidate the outcomes and processes of undergraduate research as practiced by science students and faculty. Most of our data come from two studies, each of which examines UR in a best-case scenario of a particular type. The four-college study examines apprentice-model UR as practiced at four liberal arts colleges with long experience of UR. The Significant Opportunities in Atmospheric Research and Science program, known as SOARS, serves as an exemplar of structured UR programs designed to recruit, retain, and support students from groups underrepresented in the science, technology, engineering, and mathematics (STEM) fields. These sites are not unique in providing the student benefits and elucidating the practices of research advisors that we document here, but as excellent examples of both faculty-led and structured UR programs, each offered an opportunity to study a well-defined and relatively homogeneous phenomenon. This research thus addresses the question, "What outcomes are possible from well-designed and well-implemented apprentice-model UR experiences, and by what means do these arise?" This is distinct from the separate, and also important, question of what outcomes actually result from the broader set of practices encompassed by all the forms of UR that have arisen in diverse institutions and settings. Given the lack of research on UR in nonscience disciplines and on all the varieties of UR and similar experiences available to students, the latter question cannot be generally answered at this time.

Chapter One establishes our definition of undergraduate research and its crucial components of authenticity and apprenticeship. It traces the history of UR in the United States and its apparent, though ill-documented, growth in recent decades. The national context for the interest in UR now is described, and the design of our research studies is outlined to illuminate the source and nature of the evidence offered throughout the book.

Chapter Two summarizes the literature that provides evidence about the outcomes of undergraduate research, in both faculty-led research efforts and structured programs, particularly those targeted to students from groups underrepresented in the STEM fields. Relatively few well-designed research and evaluation studies have been published, and most of these have appeared within the past few years. To date, the outcomes of these studies align well with each other and with our own findings.

Chapter Three describes the benefits to students of conducting research as undergraduates, based on the evidence from interviews with

UR students, alumni, and research advisors in our four-college study. These benefits are grouped into six main categories and identified in reports from students, alumni, and advisors.

Chapter Four addresses whether these benefits of UR can also be gained from other sources, including courses, based on data from interviews with a group of comparison students who did not undertake summer UR. Because these students participated in a variety of other educational experiences, we can discern alternative sources of the same benefits gained by the UR students and discuss the efficacy of these alternative sources, relative to UR, in providing the benefits.

Chapter Five discusses the longer-term outcomes of UR that are seen in longitudinal data from both UR and comparison students when interviewed as alumni, two to three years after they finished college. These outcomes emphasize the influences of UR on early career paths for alumni, and they reveal gains that were enhanced with the perspective of time as students recognized additional gains and came to value others more fully.

Chapter Six examines the use of UR in programs seeking to recruit and retain students from groups that are underrepresented in STEM fields. Because certain benefits of UR directly address the challenges minority students face, UR is often a centerpiece of such programs. Through a case study of one such program, we examine critical elements and how they build on, amplify, and augment general features of undergraduate research to address minority students' needs.

Chapter Seven discusses how UR advisors work with students, based primarily on data from interviews with faculty who were active or former UR advisors, and with program administrators. Advisors clearly identify aspects of their UR work as teaching, while also emphasizing the importance of working on unsolved problems of genuine interest in their field. Their use of authentic projects and methods with students gives rise to several distinct pedagogical strategies that are individually adjusted to foster individual students' development. This chapter emphasizes the strategies that advisors use in their everyday work with research students.

Chapter Eight examines research advisors' mentoring and career advising work. By the use of distinctive markers, they monitor and assess students' progress toward their learning objectives for students. These more global functions of advisors arise from their close daily work and observation of their research students but extend beyond it.

Chapter Nine discusses the costs and benefits to UR advisors of conducting UR as part of their faculty work. It explores what motivates

and sustains faculty's UR work, what they need to sustain it, how they balance the costs and benefits of undertaking UR, and how these shape individual decisions to participate. Central to this discussion is the dual role of UR as an educational experience for students and a scholarly activity for faculty. Faculty report benefits that are largely intrinsic, but their costs are more concrete. Some difficulties are inherent in conducting research with short-term, novice assistants, while other strains arise from unresolved considerations of the place of UR in the institutional mission.

Chapter Ten summarizes key findings and makes arguments about the implications of these findings for faculty, campus leaders, funders, and researchers, including those working in diverse institutional settings. Some emergent issues and issues for future study are also highlighted.

In order to keep the main narrative readable and engaging for those who do not have prior experience with social science research methods, we have documented in a set of appendixes the methodological details for the four-college study that provides the bulk of the evidence discussed. Appendix A describes the interview samples in detail, providing breakouts by discipline, gender, and other key variables. Appendix B elaborates on the methods of the study. Appendix C summarizes the interview protocols. Appendix D provides a detailed table that includes the frequency counts for each student benefits category for all five main interview groups. These counts underlie the discussion of quantitative evidence in the student-focused chapters.

This book is not a how-to manual for those starting new UR programs or labs. For such resources, we recommend that readers consult the extensive publication list of the Council on Undergraduate Research. This research aims instead to identify the good outcomes of UR for students, elucidate how and why these outcomes arise, and clarify what factors support or constrain UR. It can thus work in tandem with the wisdom of experienced UR practitioners to guide program designers and faculty in identifying trade-offs and making choices among approaches or in creating new types of programs that aim to secure similar benefits for students. Which strategies best protect the fundamental importance of authenticity in achieving the benefits of UR for students? What methods might begin to foster the same benefits in younger students or in more constrained circumstances? How should institutions recognize and reward UR as part of faculty work? Our research does not answer these questions, but it does provide a platform of evidence on which possible answers can be devised and tried by individual advisors, programs, and institutions.

If our findings come as no surprise to readers who are personally familiar with undergraduate research as students or advisors, then that is validation that we have gotten something right. The details of how research advisors work—and, to a lesser extent, how students respond—will necessarily vary from place to place. But we are persuaded that many of the UR outcomes and processes documented here can be achieved in other institutions and through other models of UR when those settings adhere to fundamental principles that are apparent in the accounts of research advisors and research students that we share in this book.

Acknowledgments

WE HAVE MANY people to thank for their many contributions to this book. We are especially grateful to the faculty and students who shared their experiences and ideas at the four colleges that hosted this study and to the faculty, staff, and leaders who made arrangements and facilitated our work. We have valued the insights and assistance of our collaborators at these colleges: Jim Swartz and David Lopatto at Grinnell College, Jim Gentile at Hope College, Sheldon Wettack at Harvey Mudd College, and Mary Allen and Adele Wolfson at Wellesley College. From the Significant Opportunities in Atmospheric Research and Science (SOARS) program, we thank the protégés, mentors, and other study participants for their welcome and for their candid observations. Thomas Windham and Rajul Pandya were gracious, astute, and interested supporters of our SOARS work. We also thank Tom and Raj for their input into Chapter Six. We award a special gold star to Joanne Stewart for her rapid reading, critical commentary, and long-time encouragement to "get it out." S.L. thanks her former research students for their good work, scientific insights, and companionship: Luke, Stew, Jamie, Becky, Hannah, John, Mike, Jenny-Meade, Craig, James, Alice, Kwasi, and Heather.

A variety of funding agencies provided essential support for our work across its life span of nearly a decade. Initiated under a National Science Foundation (NSF) award to Grinnell College for Integration of Research and Education, the four-college study was supported by the NSF's Research on Learning and Education program under grant 0087611 and by a grant from the Howard Hughes Medical Institute. Additional data analysis and dissemination were made possible by a grant from the Spencer Foundation. The SOARS evaluation study was supported by the NSF's Division of Atmospheric Sciences, Geoscience Directorate, under grant

0401704, and by the University Corporation for Atmospheric Research. Funds for the preparation of this book were contributed by the Alfred P. Sloan Foundation, the Noyce Foundation, and Research Corporation for Science Advancement, with additional assistance from the National Science Foundation under grant 0548488, jointly supported by the Division of Chemistry, the Division of Undergraduate Education, the Biological Sciences Directorate, and the Office of Multidisciplinary Affairs.

The late John J. Coppers, Elaine's long-time partner, was a great cheerleader for our work: he stood ready to brag about E&ER's accomplishments to anyone who would listen. John was not an academic but had the knack of getting to central issues quickly. When he attended one of our early brown bag sessions on this work, he listened carefully to everything we had to say and then asked, "Why would these good people put themselves through that every summer?" We have been trying to answer his question ever since. John was particularly supportive of the UR book project during a period when funding was elusive. After several setbacks, he encouraged Elaine to persist until she put together the collaborative sponsorship that made it possible to write this book. John was often right about things that matter. We miss him.

This book truly represents a group effort. From conceiving the project and writing proposals (and still more proposals), to conducting the many interviews, transcribing them, coding, parenting, and analyzing them, every author has taken responsibility for particular tasks and done a lot of heavy lifting. At various stages, each has provided significant professional contributions in carrying out this research. A qualitative study as large as this indeed depended on a team effort. Close collaboration and cooperation throughout was essential. We thank others in our group whose efforts also helped this research: Tracee DeAntoni, Catherine Riegle-Crumb, Kris De Welde, Rebecca Crane, Liane Pedersen-Gallegos, Richard Donohue, Becky Gallegos, and our many student transcribers. Susan Lynds was our punctilious and speedy technical editor and spreadsheet wrangler; her expertise and calm were invaluable. Special thanks go to Sandra Laursen, who took charge, organized our unwieldy group, put us on a schedule, coordinated this volume, and ultimately sewed our individual ragged bits and pieces together into (we hope) a strong, coherent whole. The collegiality and friendship experienced throughout this project are in themselves immeasurable rewards. To Elaine Seymour, our fearless, indefatigable leader, we offer our deep gratitude and best wishes for her retirement.

Undergraduate Research in the Sciences

Chapter 1

What Is Undergraduate Research, and Why Does It Matter?

CONDUCTING RESEARCH IS an important culminating experience in the education of many undergraduate science students in the United States. This book describes the outcomes of undergraduate research (UR) experiences, the processes by which these outcomes are achieved, and the meaning of these outcomes for both students and the mentors who work with them on scientific research projects, based on our findings from a multiyear study of undergraduate research and its role in science education. An overarching theme in these findings is the notion of "real science," which recurs throughout the comments of undergraduate research students and their advisors. Their work together on scientific research projects provides the experiences and observations that form the backbone of this book. The importance of "real science" for students' educational and professional growth is evident in their own words:

> *It's kind of scary, especially at the beginning. I was like, "How can someone like me be doing this?" [But now] I'm coming up with valuable information and it's great. I mean, actually producing data and actually doing it, I felt like a scientist. But you really feel more like a scientist when you have something good! (female UR student, biology)*

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> *Once your superiors—whom you admire and look up to as scientists—start asking your opinion on a scientific matter. . . . Personally, it made me feel like I was actually a real physicist. (male UR alumnus, physics)*

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Presenting at a conference made me feel like I was a part of the scientific community. . . . I have been able to talk about my work and feel like an equal [with my advisor], and do it with other people [at my school]—but being able to do that with a total stranger was a really, really neat experience. It gave me a lot of confidence and made me feel like I was a real chemist! (female UR alumnus, chemistry)

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A lot of things you do in school, like you do homework or whatever, and you never feel like you're really doing something real. And this was one of the first things that I did that, like, really encompassed everything and really brought things together. It was one of the first times I really felt like I was really doing something. (male UR student, engineering)

Clearly, being "real" is important to students. So what makes a research project "real"? As we will show, real research is an investigation whose questions, methods, and everyday ways of working are authentic to the field. The research questions are well defined so that they can be systematically investigated, but, importantly—and unlike most questions in a classroom—their answers are unknown. Research results may not be quickly forthcoming, but they constitute a genuine contribution to the field if and when they do emerge. The research methods are ones used in the discipline and seen as valid by disciplinary experts. As in any other research project, the choice of methods may be constrained by intellectual, technical, or financial resources. For an undergraduate research project, such constraints may arise from the involvement of novices and the educational mission of their institution—but the term *undergraduate research* does not inherently rule out particular approaches to the research question. Perhaps most important, as we shall see throughout this book, students and faculty work together in ways that are typical of their field and authentic to the profession. Thus, students learn the intellectual and social practices of science by doing it. By engaging deeply themselves in a particular question, they begin to understand more generally how scientists engage questions and construct knowledge, and that this is a human activity in which they too could participate.

As Merkel (2001) points out, the use of the term *undergraduate research* has not always been clear—indeed, the term *research* itself has different meanings in different disciplines and settings. The Council on Undergraduate Research (CUR, n.d) offers a broad-based definition: "An inquiry or investigation conducted by an undergraduate student that makes an original intellectual or creative contribution to the discipline" (see also