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Science **293**, 1624 (2001);
DOI: 10.1126/science.1062714

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VIEWPOINT

Undergraduate Research, Graduate Mentoring, and the University's Mission

Cristina González

Undergraduate research and graduate mentoring have received a great deal of attention in recent times. What do these activities have in common? They both speak to the primary mission of the research university, which is not merely carrying out research but training students to do research. The knowledge-based global economy, with its wealth of information and opportunities, has increased undergraduate students' need for research skills as well as graduate students' desire for personal guidance. As the research university matures, the boundaries between graduate and undergraduate education are blurring. Indeed, if we focus on the learning process, we find not two but five levels of learning at the research university: lower division, upper division, master's, doctoral, and postdoctoral. All five levels form a continuum, a series of gradual steps. The mission of the university is to introduce students to research, to inspire in them a passion for discovery at each of these levels.

In recent times, quite a bit of attention has been paid to two seemingly disparate activities: undergraduate research and graduate mentoring. Faculty members are integrating undergraduate students into the research enterprise in a more deliberate fashion than ever before. Undergraduate research programs are proliferating, and undergraduate research conferences and journals are becoming a permanent fixture on the university's landscape. For example, the University of California, Davis, which has an annual undergraduate research symposium and an undergraduate research journal, has just added two new undergraduate research programs: the federally funded AGEP (Alliance for Graduate Education and the Professoriate) and the University of California system–sponsored UC LEADS (University of California Leadership Excellence Through Advanced Degrees). These join a long list of existing undergraduate research programs at UC–Davis, including the McNair Scholars Program, the President's Undergraduate Fellowships, and the Summer Honors Advanced Research Program, to name a few.

By no means is UC–Davis the only research institution that fosters undergraduate research. Since its inception in 1987, the National Conference on Undergraduate Research has grown from a few hundred to thousands of attendees, and participation by research institutions is increasing. The 2001 conference, hosted by the University of Kentucky, included participants from such institutions as the University of California, Berkeley, the University of Michigan, and the University of Rochester. Today, most research institutions offer undergraduate research programs of various types. The Boyer Commission on Educating Undergraduates in the Research University recently articulated and endorsed the trend toward more vigorous engagement of undergraduate students in research by supporting the view that learning is based on discovery of new knowledge guided by advising, as well as transmission of existing knowledge and values (*1*).

As undergraduate students gain access to research, graduate students are requesting more and better mentoring. Universities have responded by creating graduate mentoring policies and awards to promote and recognize the importance of mentoring for the professional development of graduate students. Graduate mentoring policies are usually issued by the graduate council or by individual programs. Graduate mentoring awards tend to be administered by the faculty senate, although at some institutions, such as Harvard University, Washington University (St. Louis), and the California Institute of Technology, they are conferred by the graduate student senate. Graduate students' intense interest in mentoring is also demonstrated by peer advising programs, such as the University of Alabama's Graduate Student Peer Mentoring Program.

The mentoring needs of graduate students—including those of postdoctoral scholars, who as researchers-in-training should be considered advanced graduate students—have been highlighted by a series of recent reports. These include studies by such organizations as the National Science Foundation (*2*), the Committee on Science, Engineering, and Public Policy of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine (*3, 4*), and the Association of American Universities (*5, 6*). Graduate students' mentoring requirements have been further underscored by the Pew Charitable Trusts' graduate student survey on doctoral education and career preparation (*7*). The mentoring needs of postdoctoral scholars are being articulated by their newly created professional associations, which emphasize the importance of professional development. With a grant from the Alfred P. Sloan Foundation, *Science*'s Next Wave has recently established a Web site to coordinate the activities of these professional associations and to provide postdoctoral scholars and their mentors with resources to improve the postdoctoral experience (*8*). It seems clear that graduate mentoring is as popular a topic today as undergraduate research.

What do undergraduate research and graduate mentoring have in common? They both speak to the primary mission of the research university, which is not carrying out research but training students to do research. Research can be performed in many places: There are national labs, private labs, and research institutes. Much more research is done outside of the university than within its walls. The distinct mission of the research university, however, is to introduce students to research, to inspire in them a passion for discovery. This applies both to graduate and to undergraduate students.

Graduate and undergraduate students are usually seen as having very different goals and needs, a view that derives from history rather than from current realities. The American research university was established in the 19th century by adding a graduate school to the existing undergraduate college. This evolutionary process fundamentally combined the German scientific model, centered on research (the discovery of new knowledge), with the English residential model, focused on teaching and mentoring (the transmission of existing knowledge and values). Graduate students trained in the library and the lab through academic apprenticeships, whereas undergraduate students learned in the classroom and the dormitory through personal interaction. Accordingly, vice chancellors for research and graduate deans took care of labs and graduate students, whereas vice chancellors for students and undergraduate deans supervised dormitories and undergraduate students. Graduate and undergraduate education remained separate and distinct for the better part of a century. As the research

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university matures, however, a more integrated structure is beginning to emerge.

In the knowledge-based global economy, what students are capable of learning in the future is as important as how much they know when they graduate. Their ability to adapt quickly to new situations and to solve difficult problems is essential, and research skills greatly enhance that capacity. Thus, research—originally the purview of the graduate school—has penetrated the undergraduate college, which now concerns itself with the discovery of new knowledge.

At the same time, teaching and mentoring have found a great deal of appreciation among graduate students, whose needs have changed. The complexity of the knowledge-based global economy, with its wealth of information and opportunities, has increased graduate students' desire for help: The more decisions they have to make, the more guidance they want. Today, while vice chancellors for students and undergraduate deans find themselves supporting undergraduate research programs centered on academic apprenticeships, vice chancellors for research and graduate deans spend much of their time sponsoring graduate mentoring programs focused on personal interactions. More than ever before, graduate students yearn for the transmission of existing knowledge and values that personal interactions with the faculty bring.

With undergraduate students asking for the skills typically associated with graduate studies, and graduate students requesting the guidance traditionally accompanying the undergraduate experience, differences between these two populations are blurring. Indeed, if we ignore the historical distinction between graduate and undergraduate studies and focus on the true learning process, we find not two but five levels of learning at the research university: lower division, upper division, master's, doctoral, and postdoctoral. Research is undertaken at each of these levels, from lower division (where students learn the most basic research skills) to postdoctoral (where they acquire the most advanced research expertise). In terms of the learning process, there is no particularly sharp distinction between upper division and master's-level courses—the transition from undergraduate to graduate studies. Rather, all five levels form a continuum, a series of gradual steps taking students from high school to the workforce, which they can join after completing any one of these levels.

Educational requirements have increased in recent times. Today, most occupations call for at least 2 years more training than they once did. Jobs that used to require high school, bachelor's, or doctoral degrees now require lower division, master's, and postdoctoral-level education, respectively. Thus, we see the growth of associate degrees at community colleges, the rapid expansion of master's degrees at a wide variety of institutions, and the generalization of postdoctoral training at research universities. In addition, the quality of the educational process is being enhanced by strengthening the importance of research for the undergraduate experience and of teaching and mentoring for graduate students.

The lower division level is changing. In addition to taking courses of an introductory nature, many students at this stage are now being exposed to research through freshman seminars, participation in research groups, and the like. As recommended by the Boyer Commission report, the curriculum for students at this level should be inquiry-based and interdisciplinary.

The upper division level—the major, the traditional core of undergraduate education—is more heavily involved in research. Most undergraduate research programs are for students at this level. Regardless of their professional plans, many majors believe that research experience is desirable and actively seek to participate in relevant research activities, including fieldwork, internships, senior theses, and capstone seminars, or integrative courses within and across disciplines. Students at this level should be able to conduct research in a specific area of inquiry with a minimum degree of independence.

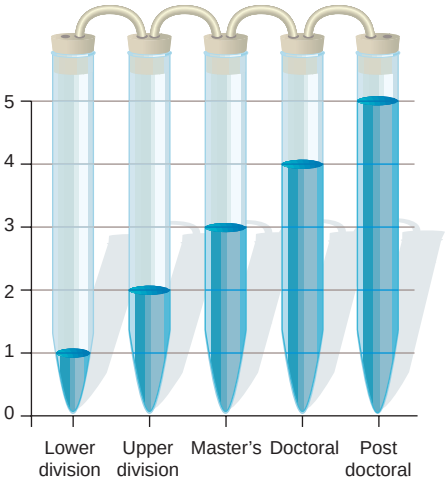
The master's is becoming more of a hinge degree, linking graduate and undergraduate education and displaying features of both. In addition to the long-standing master's/doctoral dual programs, there are many new bachelor's/master's combined curricula, such as the University of Colorado's concurrent bachelor's/master's degree in environmental, population, and organismic biology and the University of Florida's accelerated bachelor's/master's degree in mathematics. Such programs blur traditional administrative boundaries because these students are part of both the undergraduate college and the graduate school.

The doctoral level—the traditional core of graduate education—is now populated by students with a deep interest in teaching and mentoring, who want to acquire good teachers and mentors while becoming good teachers and mentors themselves. These students are quite outspoken with respect to their needs, as evidenced in the Pew report. Most graduate mentoring policies and awards focus on helping doctoral students.

The postdoctoral level, which until recently had not been recognized as part of graduate education, is now being conceptualized as one of the stages of learning for which the graduate school is responsible. Postdoctoral scholars, who are starting to voice their needs through their professional associations, are almost as interested as doctoral students in teaching and mentoring and want nearly as much guidance. Graduate mentoring policies and awards should include postdoctoral scholars, unless specific policies and awards for mentoring this segment of the student population are established.

Universities are beginning to take into consideration the complex educational requirements of today's students and to provide them with training commensurate with their needs. For example, the importance of writing is being emphasized at all levels. In addition to offering composition courses for undergraduate students, universities are creating dissertation workshops for graduate students. They are also emphasizing writing in their graduate and undergraduate research programs, where students are being introduced to the various literary genres of the academy, from PowerPoint presentations to grant proposals. Indeed, writing is starting to be seen as a crucial element in the process of disciplinary enculturation and professional advancement. Given the large numbers of scholars who are not native speakers of English, universities are also addressing the challenges of writing in a second language through both formal and informal means.

Another way in which universities are attempting to meet students' needs for research training is through interdisciplinary programs that emphasize professional development, such as the National Science Foundation's IGERT (Integrative Graduate Education and Research Traineeship), which aims to enhance students' communication and teamwork abilities as well as to offer them experiences relevant to academic and nonacademic careers. Examples of projects funded include "Learning and Action in the Face of Uncertainty: Cognitive, Computational and Statistical Approaches" (Brown University), "Urban Environmental Sustainability: A Multidisciplinary Doctoral Education Pro-



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gram" (University of Southern California), "Science and Engineering of Laser Interactions with Matter" (University of Virginia), and "Astrobiology: Life In and Beyond Earth's Solar System" (University of Washington). These topics serve to enhance students' professional development by coordinating various streams of intellectual and social activity, much as the newly created *Graduiertenkollegs* (sponsored by the Deutsche Forschungsgemeinschaft) do in Germany, or as the recently established *Journal of Graduate Education* (sponsored by the National Postgraduate Committee) advocates in England. On both sides of the Atlantic, universities are reflecting on, and experimenting with, ways to educate students in a more holistic fashion than in the past.

Universities must continue to make a concerted effort to integrate students, from the lower division to the postdoctoral level, into a coherent learning community. The historical separation between graduate and undergraduate education has obscured the connections among the research university's five levels of learning, as well as the university's mission, which is to introduce students to research, to inspire in them a passion for discovery through teaching and mentoring of the highest intellectual and moral caliber at each of these levels.

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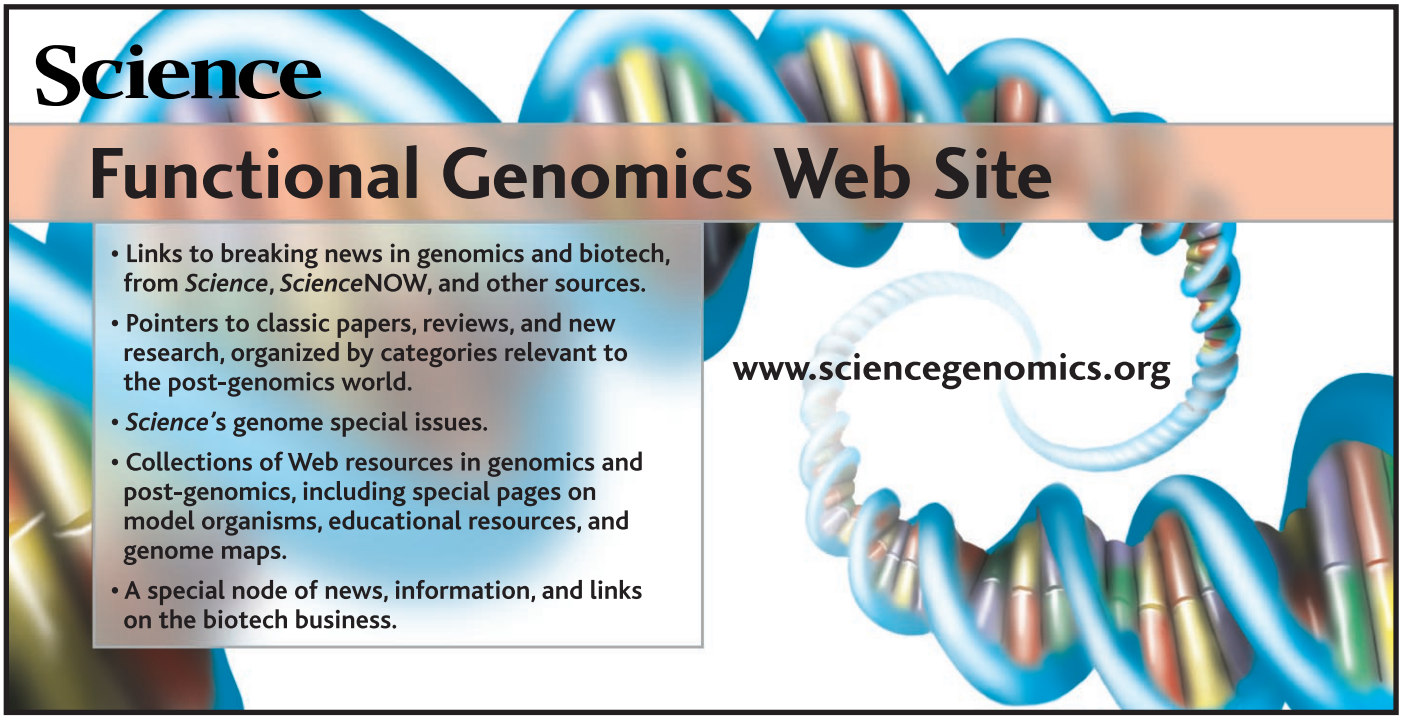
9. This article is based on my opening remarks for the first UC LEADS Symposium, held at the University of California, Davis, 9 to 11 March 2001. I thank D. Niemeier for her critical reading of the manuscript.



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