Rountable: Whither Now Our Research Universities?

Under financial and social stress, the nation's research universities are redefining their objectives. The roundtable panel gives the universities the close scrutiny that physicists usually apply to their own science.

Lubkin: In our letter inviting you to this discussion, we stated: While the commitment to research and scholarship at American universities is probably greater than ever, the reputation and resources of the institutions are deteriorating. There is no doubt that more is being asked of research universities than in the past but the ability to respond is under severe stress. I'd like to begin by asking Don Langenberg if you believe the mission of the research universities is changing and, if it is, in what ways?

Langenberg: The research universities are changing fairly rapidly, though I don't think they are forsaking their fundamental research missions. They are clearly rebalancing their programs and practices in response to all sorts of pressures. Perhaps the most obvious one is financial—the squeeze between reduced Federal grants and overhead reimbursements and higher research costs. Then there are the pressures of declining enrollments and of rising tuitions. There also are pressures on the universities to serve an increasingly heterogeneous student clientele, both domestic and foreign. There are pressures to put more emphasis on teaching, by which is usually meant undergraduate teaching. There are pressures to become more engaged in what is labeled technology transfer—to conduct strategic research, which is defined by some to mean utilitarian research. And there are pressures arising from the rapid advance of information technology— the pressure of new tools becoming available.

Goodwin: Isn't that similar to the health field, where physicians and surgeons are under pressure from their patients and the manufacturers to use the latest technologies? And just as in the practice of medicine, new technologies and equipment tend to raise the cost of teaching and research.

Langenberg: In the short term, yes. In the longer term, however, it has the potential of lowering per-unit costs. We're all being asked to increase productivity, the faculty included. Universities have got to find ways to do that. For universities this means fewer people producing a higher quantity and quality of students and research. If the output is to be increased, the mission of research universities, with virtually flat budgets and continually improving technology, calls for boosting output at a faster rate than we are able to add faculty and staff. In fact, the rate for additional faculty and staff may be zero.

Lubkin: Are you suggesting that universities in such circumstances might need to repackage lectures as videos so that more students might be taught by the same number of faculty or even fewer?

Langenberg: That's only a tiny part of what the new technology may make available to us. I think universities will require much more profound changes. One of the best thinkers on this subject is not a technologist and, for that matter, not a scientist or an engineer. He's a Shakespearean scholar named Richard Lanham, who makes the powerful point that the transition from print technology to electronic technology will change the very way we think and therefore the way people learn and the
CHANGING TIMES at research universities is the topic of PHYSICS TODAY’s roundtable discussion in Washington on 29 November 1994 by a panel consisting of (left to right) Peter Eisenberger, Sean Solomon, Kurt Gottfried, Bob Byer, Gloria Lubkin, Ernest Moniz, Laura Greene, Donald Langenberg, Irwin Goodwin and Duncan Moore.

way people teach.

EISENBERGER: I guess today’s technology is making an already fragile connection between faculty and universities even more fragile, because it facilitates collaborations with faculty from outside institutions, making this much more feasible than in the past. At a recent conference held at UCLA some people introduced the radical notion of virtual universities dispensing knowledge by cable or e-mail. Consider the effect of packaging the best lectures of a creative and charismatic figure like Richard Feynman on film for a broad audience as an alternative to an immutable textbook or a lecture series, no matter how excellent the text or lectures happen to be.

LANGENBERG: I think the most radical prediction I’ve heard on this subject comes from Arthur Levine, dean of Columbia University’s Teachers College. He argues that by the year 2050 there will be some research universities and some liberal arts colleges but the other 3200 or 3400 American institutions of higher learning will have ceased to exist in their present form.

GOODWIN: Does Levine suggest that after identifying the very best liberal arts and research universities all the rest might be called open universities or higher-education

### ROUNDTABLE PARTICIPANTS

Robert L. Byer, professor of applied physics at Stanford University and former director of research at Stanford

Peter M. Eisenberger, professor of physics at Princeton University and director of the Princeton Materials Institute; former director of Exxon Research and Engineering Co.

Kurt Gottfried, professor of physics at Cornell University

Laura H. Greene, professor of physics at the University of Illinois

Donald N. Langenberg, chancellor of the University of Maryland system and former chancellor of the University of Illinois Chicago campus

Ernest J. Moniz, professor of physics at MIT and former director of MIT’s Bates Linear Accelerator Center

Duncan T. Moore, former director of the Institute of Optics at the University of Rochester, on leave from the university as an American Physical Society Congressional Fellow to be science adviser to Senator John D. Rockefeller IV; founder and president of Gradient Lens Corp.

Sean C. Solomon, director of the department of terrestrial magnetism at the Carnegie Institution of Washington; former professor of geophysics at MIT

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institutions that don't require face-to-face contacts with professors and researchers? Wouldn't that radically alter the nature of our universities?

LANGENBERG: I think Levine's referring to something you might easily label a virtual university. It's not hard to appreciate this concept if you start with what I consider Thomas Carlyle's entirely appropriate characterization of a university as a community of scholars gathered around a great library.

GOODWIN: What are the implications for the future of research in a virtual university?

LANGENBERG: In many ways, we're there already—physicists in particular. Consider, for instance, the informal research groups clustered around special topics so that the researchers are fully engaged as collaborators yet are physically dispersed around the world. It's a little hard for me to see how you can conduct physical experiments in such an environment, but there are a lot of other things you can do—and people are doing them.

BEYER: One of the distinctive changes I've noticed among my students is how they use the library or, rather, how they don't use the library. Students no longer go to the library to gather information. They no longer read the journals. What they do instead is access Internet or read their e-mail to find what they want. This came back when a graduate student asked me if a reference I gave in class was published or before 1987. I wondered what difference that made. And the answer came back, "If it's before '87 I can't get it free on Inspec, but if it's after '87, I can search it at no charge to me."

[Laughter]. So I began asking students: "How do you get your scientific information? Do you read the journals once a week? "No. do you go to the library? "No. "So how do you find out about developments in your field? "I just sit at my PC and search for it." So it appears that the younger generation views libraries as too slow and inaccessible as an information search system.

GOTTFRIED: In physics, libraries have been neglected for quite a while, predating the electronic revolution. Those communities that were at the forefront of research relied on personal contact and ditto or mimeographed preprints. Back in the '20s and '30s if you couldn't get galley proofs from a physics journal in Germany or elsewhere, you relied on personal correspondence. The generation that pioneered quantum mechanics and nuclear physics in those decades had very rapid communication, first of all because the mail was a whole lot faster than it is today and, second, because they knew how to write. So they would send each other letters and proof sheets. Certainly most of the people I know in research have not been reading journals for a long time, because they hear so much by word of mouth at seminars, over the telephone or at conferences. I think libraries have been much more important for research in fields other than physics, especially in the humanities and social sciences. Still, I believe that electronic communication will change higher education, but we're a long way from doing away with the human contact of a teacher and a student. That may not be so important for a professional scientist who can communicate with a research colleague working in Darmstadt or Beijing or Berkeley, because we have a common language we can use extremely efficiently. I don't think it would work with teaching.

GOODWIN: Does that suggest that teaching requires a certain charisma, an ability to convey the excitement and wonder of a field?

GOTTFRIED: We're not even close to achieving that for most teachers. At Cornell, we're trying some innovative ways of teaching physics to upper-level undergraduates, thanks to a grant from the Sloan Foundation. We're doing things that could not be done without modern technology. What I'm thinking of in particular is a senior-level course in solid-state physics in which we use computer simulations of phenomena that you could not possibly teach seniors (otherwise). Many of the principles and techniques could be shown in the old-fashioned way, but we also teach aspects of phase transitions that are quite sophisticated and go beyond mean-field theory. They couldn't be taught the old way at the first-year graduate level. In fact, the students ask, "How did you teach this stuff before you had these simulations?" I say, "We didn't." But I think it's also very clear that if Bob Silsbee and his talented teaching assistants weren't in the room to discuss the simulations, the undergraduates wouldn't be getting very much out of it. So it's a combination of the gifted human contact and powerful technology that makes all the difference.

LANGENBERG: I would agree. What Lanham is saying, among other things, is that the learning process for students may come to look a lot more like what Silsbee is doing at Cornell. Both teaching and research will be much more individually tailored. It will be a system that is not serial, from lecture 1 to lecture 30, from the beginning of the textbook to its end. It will be matched to individual students, using all of the resources of the modern university, including, for instance, Silsbee's simulations, and available to professors and students in Ithaca and Fargo and Tokyo. It will enable faculty and students to access information on Internet, learning the way research is done, getting a handle on whatever piece of the problem is ready at hand, just exploring their way around.

SOLOMON: I think it's important to remember that most of us are one generation or more away from the kids who are coming up today, cutting their teeth on video games and computers. They possess a literacy with those techniques and a fearlessness that make for a future in research that's hard for us to fully comprehend. There was a wonderful example of the changes taking place in research that occurred last summer when the Shoemaker-Levy comet collided with Jupiter. All the observers around the world communicated by e-mail. The University of Maryland set up a home page on Internet. Images were available digitally within hours, and people were swapping ideas in real time. Maryland's home page got two million inquiries over the course of one week. That's how we're going to reach a very broad community instantly with some of the science we do. It's going to completely change opportunities for education.
MONIZ: While technology will undoubtedly strongly influence the delivery of educational services on a large scale, I believe that the impact on advanced education will be modest. The community of scholars Langenberg spoke about hasn't changed in its essentials from that which we old fogies experienced as graduate students. Even with all the technology at their nimble fingertips, students still do a bit of their learning by mutual interaction, particularly in their advanced undergraduate and early graduate year when a relatively small group is largely focused on common foundational courses. Returning to the library issue, we found at MIT that students do still use a library, but not so much the central library as reading rooms where the services are tailored to the special field and where educational materials are assembled for the students. Of course, advances in information technology will make more and more of this available to students—once the faculty catch up—with their workstations in their own labs, as is already the case with preprints. Still, the community aspect, particularly with regard to graduate education, may extend the need for such physical places well beyond the capability and availability of technology. Also, while most of the discussion about technology's impact on education focuses on computers, we should note that possibilities exist for low-tech advances in education, especially at the high school and college levels. One development that has been pushed at MIT by Tony French, John King and Tom Greytak is the integration of "take home" experiments in the freshman and sophomore curricula. Total kits in the $50 buck range now open up fairly sophisticated experiments that students build and carry out in their dorm rooms. It's a different type of example of technology driving hands-on learning. It strikes a resonance with those of us who are computer challenged.

EISENBERGER: In talking about science education, we shouldn't focus on those who are destined for research careers. Much of this discussion is about what I call the end of the distillation process—those people who are going to become professionals. These are actually a minority of the people that we educate. For those who are never going to have anything to do with science at all, but need science as part of their general education to be constructive citizens, I think the argument changes or the issue changes. I find that we are fairly ignorant, if I can use that charged word, as to what we really need to do for those people. Our educational process in the research universities is fairly rigid in its approach and pretty much focused on the group who are ultimately to be the professionals. One of the challenges is to look more carefully at each of those groups and to compare what we're doing with what is actually needed to be a success.

GOTTFRIED: Increasing scientific literacy is really where our bread is buttered. It is the public, the taxpaying voters, who determine the budgets of academic science in one way or another. At Cornell, the major task of the physics department is to instruct engineers, premedical students and so forth. We have a fairly sizable graduate physics program, and much of the time put in by faculty members and graduate students is to teach undergraduates who have no intention of becoming professional scientists—least of all physicists. Teaching science literacy at all levels of the education system is a much harder problem and one we as a country don't do very well, to put it kindly.

BYER: A conversation on this issue is going on at Stanford. It emerged from a year-long study of our commission on undergraduate education, which concluded in one of its recommendations that we needed to create a science curriculum for all undergraduates. The commission found that many undergraduates get no science at all in their four years. About 600 out of every 1500 undergraduates have no contact with any science course. So our faculty senate is debating what to do. We recognize that some knowledge of science, in whatever form, is a reasonable expectation of an educated citizen passing through our university system. The health of our research system and our national society depends on an appreciation and understanding of science. How to accomplish this is much more complex. The issue is not whether it should be done. There's agreement that science should be in the repertoire of every educated person. But it's not easy to implement a set of courses that can achieve that goal.

GOODWIN: At the University of Chicago in the 1940s, Robert Maynard Hutchins introduced a two-year survey course of the sciences for all freshmen and sophomores. But Hutchins's successor as president changed all that. So, we have to ask ourselves how to know if the experiment worked.

BYER: At Stanford we have a requirement to take science, though the course may not be in the so-called hard sciences—that is, a rigorous science course is not a part of the distribution requirements. There are ways to satisfy the requirement with a set of courses that are about science, but that are not science. That's part of the debate. You may end up requiring a student to take a course in science and what you end up with is a student taking a descriptive course about science. That's not what was intended by the commission's recommendation.

SOLOMON: Setting a requirement, however well intentioned, is really only a partial answer. The challenge is to motivate those students who get no science at all to recognize that they need some scientific background to enter into discussions on important topics in today's society.

GREENE: That's very important. Most of us got into science because we were very excited about it and we had a certain passion for it. Nowadays a course that's designed as "physics for poets"—to determine why the sky is blue—isn't attractive to young people. There've been suggestions: physics for business majors, physics for lawyers and so forth. People are working on curricula for
such courses at Illinois and other places.

EISENBERGER: There's been little scholarly study on what works or doesn't work to attract young people into science. Even surveys of graduates who didn't go into science end up being essentially anecdotal.

GOTTfried: Some studies have been done. Two physicists, Priscilla Lews at Dickinson College and Lillian McDermott at the University of Washington, have written papers on techniques that seem to work. But the number of studies on this topic is small compared with the amount of work that goes into research, say, on neutrino oscillations, and the papers aren't particularly well known. We have followed the work of people like Lews and McDermott, and it has strongly influenced us at Cornell. It has led us to turn upside down our physics course for biologists and premed people. I must confess that until I become department chairman I didn't know the studies. [Laughter]

EISENBERGER: I guess my point, which you've just made for us, is that the people making decisions about improving science education are not aware of the studies in the field.

MOORE: I'd like to turn to a different issue about changes taking place at our research universities. In his opening remarks, Langenberg noted that universities are under increasing pressure to be instruments of economic development. Many universities have been placed in a situation where through state programs—in New York State, in particular—and through Federal centers of science and technology they are able to boast about the number of jobs they have created. Then there is the phenomenon called academic earmarking or what is more commonly known as political pork. The more that universities try to justify themselves as engines of economic development, the more earmarking is bound to increase, because politicians are elected to bring home the bacon, which means creating jobs for their districts. Universities need to ask themselves about their proper role in economic development. Some universities have found that with the help of Congress they can rise from the ranks of those 3300 "other" universities into one of the 170 or so research universities. We all know of universities that languished in the ranks until they engaged the political system for promotion into the front tier.

EISENBERGER: All of us at this table are with first-tier universities.

MOORE: Except me, right? [Laughter] When I came to Washington from the University of Rochester, I held a parochial view, like one of those naive heroes in a film by Frank Capra in the 1930s. In Senator Rockefeller's office, where I worked, there was no earmarking. But the senior senator from Rockefeller's state [Robert Byrd], as chairman of the Senate Appropriations Committee, is famous for bringing bacon home to West Virginia. And the new Senate Appropriations chairman [Mark Hatfield] is equally known for helping raise the level of higher education in his state of Oregon. There are other examples: Warren Magnuson and the University of Washington, Lyndon Johnson and Texas, and on and on. Universities, lawmakers and governors know that earmarking works. They also believe an MIT can spawn a Route 128 and Stanford a Silicon Valley. So there's a history of local economic benefits derived from universities, going back to the Morrill Act of 1862, which provided grants of land to each state to build colleges that would offer the knowledge and training that a rapidly developing nation really needed. These days, Federal and state budgets don't allow for that kind of generosity for aspiring colleges and universities. Sometimes Congress has come to the rescue.

LANGENBERG: I thought the Morrill Act settled the question about the role of universities in the nation's economic development. It made a major contribution to the rise of many universities and to the development of the country's agricultural and industrial progress.

MOORE: Are we going through that process again? History repeats itself.

GOTTfriED: Not in the same way. The job market in our own community, to cite something we're all familiar with, is not expanding, which was true for almost every profession and pursuit in the 1860s.

BYER: Some numbers on the issue of economic development and job opportunities might illuminate this discussion. At Stanford we spent three years doing a survey, asking such questions as who started companies in the [San Francisco] Bay area, were those startups associated with faculty, students or staff from Stanford, and what fraction of the technology used by the firm originated with Stanford either directly or indirectly. We learned that out of some 3000 small companies in the Silicon Valley area, one-third were started by someone associated with Stanford at some time. As for the use of Stanford technology, guess what fraction was attributed to Stanford?

MOORE: Ten percent.

BYER: One in 20. Five percent.

MOORE: But they use the students, the Stanford-educated brainpower.

GOODWIN: The myth is that universities have inspired—nay, created—America's marvelous economic ventures, such as Hewlett-Packard and Xerox and Microsoft.

BYER: In fact, though, the only role we've played is to provide an educated workforce that wants to stay in the area and create value for new businesses. The results of our survey came as a shock. But it told us that the principal business of universities is educating people.

MOORE: Universities create an infrastructure for new businesses and new jobs. The problem is there aren't that many places in the United States where the infrastructure works. We aren't going to create 3000 new companies in West Virginia, say, or in Arkansas.

LANGENBERG: Let me add another number to those we just heard. Like many institutions my university has recently completed an economic impact study. We wanted to know what Maryland receives through taxes as a result of our activities as a university system. The answer came
from tracking each and every member of a given graduating class, comparing our records with the state workers’ compensation records to find out who’s employed in the state. Our survey left out Federal workers and the self-employed. So it’s a conservative estimate. The net result is that for every dollar the state gives us, the state treasury gets back $1.28 at least, directly, in taxes. And the principal factor is the added value of the education that these people receive, whatever they may be doing. With higher salaries, they pay higher taxes. The conclusion is that our university is a moneymaker for the state.

EISENBERGER: What we’re saying here is that the research impact of a university is not necessarily local, though the economic impact can be local. If one then asks the question about taxpayer support for research done at universities, the idea of trying to make the research yield benefits that are local or immediate is the wrong way to go. It would appear to be contrary to the basic mission of the university and the basic reality that is driving many companies not to support basic research. Neither universities nor corporations can control the utility of research. So the idea that you can invest in a research center or university in a fixed geographical place with the intention of benefiting the locality is clearly incorrect. What it does suggest, though, is the virtue of creating some centers of excellence that will generate knowledge at the frontier and produce educated scientists and technicians.

MONZ: We need to be careful not to give too much credit to research universities and an educated workforce as economic drivers for local business development. The fact is that economic development requires the right context, including a broad set of healthy institutions, environmental factors and venture capital. So academic earmarking and research universities do not in themselves ensure economic development.

EISENBERGER: In the debates about basic research and strategic research, we need to avoid promising we can do something in the short term to solve the country’s problems. On the other hand, we have to be sophisticated enough to say we want an educational enterprise that’s going to provide the knowledge and skills that will help the country meet its problems and fulfill its opportunities in the long run. That’s not an easy line of reasoning, because the argument tends to get polarized: Either solve some immediate problem by applying scientific research that will gratify the community or nation and satisfy the politicians, or do something that is inspired by our own scientific interests and has little or no immediate relevance but may well pay off later on. Between those extremes is a middle ground in which we need to stabilize the relationship of the research university and the society that supports it.

LABON: Peter, are you suggesting that the Federal government should be the sole support of basic research?

EISENBERGER: I’m saying that basic research is one of the strongest justifications for investing in the research universities. Society will come to expect more from the universities because of what’s happening at the corporate giants that build their industries on the results of their homemade basic research. To meet the pressures of global competitiveness and near-term profitability such technological powerhouses as IBM, GE, Xerox and AT&T Bell Laboratories have downsized their research programs and research staffs. But as a nation we still need to generate the basic knowledge and understanding that will deal with the issues and produce the technologies of the 21st century. I see no other entity except America’s research universities with the capability of doing this. And because there is no way of predicting the precise locality or particular sector that will benefit from research, it’s the proper role of government to help support university research.

LANGENBERG: Just to play devil’s advocate, I ask you, Peter, why can’t the national laboratories provide the nation’s basic research? Why get it all tangled up with education?

EISENBERGER: There are two reasons: Much of the scientific talent resides in the universities, for one thing, and for another the longer term problems are going to involve a much greater integration between the physical and biological sciences and the social sciences and humanities. Many of the problems we’re facing are at that intersection. Many problems in the 21st century are not going to require purely technological solutions. They will require human-systems solutions that involve economics and behavioral sciences. The research universities have the culture and resources to address the issues. Whereas I think the government laboratories could more appropriately fill a niche in the near-term or intermediate range.

GOTTFRIED: All the Labs have fairly well-defined missions, whether they work for the Energy Department or NASA or the Defense Department. They do not have anything like the intellectual flexibility and the response readiness that can be found in a university setting. So even if academic scientists are suffering financially, even if our freedom of action is more constrained by the body politic, the scene at a university is infinitely more conducive than at a government lab to investigate things as we see fit, without worrying about near-term payoff.

EISENBERGER: If I understood Don’s question, he was alluding to the Energy Department’s formulation of a strategy to enlarge the mission of some of its labs to meet the changing times.

GOTTFRIED: When you examine the spectrum of science at the labs and compare this with what exists at the universities, the universities have the kind of culture and responsiveness that neither the government labs nor the corporate labs possess.

GOODWIN: Nevertheless in Germany, Russia and some other countries, most basic research is done at special institutes, which operate like national laboratories. Universities in those countries are essentially teaching institutions. Are Europe’s institutes the models for our Energy Department?

LANGENBERG: When I asked whether the national
labs might be responsible for most of the country's basic research, I was rephrasing what I hear from time to time—not infrequently—and I find it hard to explain. I'm asked, "Why do you mix up two different functions—education and research?" To a lot of people the function of the university is training students for a career. Yet the university allows its faculty to go off and do research on arcane subjects. As John Q. Citizen often sees it, "Why don't you simplify your functions so I can tell where the money is spent? I want it to go to educating students, not an esoteric investigation."

BYER: At Stanford a couple of years ago we asked ourselves the question, Where will the research university be in a decade? Is it a weekend retreat one of the answers came back: We have to find a way to deliver the research we do to the undergraduate students. The reason we need to make that coupling is that the best indicator of whether an undergraduate student considers an advanced degree is to have the undergraduate participate in some research project.

LANGENBERG: It's now pretty well established that the lecture environment, the "sage on a stage," is one of the least effective ways to learn. By contrast, the research environment, engaging in something real, such as a medical student working with patients or an engineering student with actual design and construction, can be the most effective, rewarding way to learn.

DISENBERGER: At a recent conference at UCLA, we debated the notion that research universities are often considered as a monolith, with every university taking the same path. One of the common problems is the perception of a singular value system so that US News and World Report can rank all universities on some supposedly rational scale. For the health of the enterprise, we have to encourage diversity. We have to encourage specialization and pick out different segments of the educational agenda and develop excellence in it. Part of the reason we have failed to do these things is that as research universities we haven't thought more deeply about what it takes to be truly excellent. That has happened because we have templated most of what we do educationally on research excellence, so that our standing is based on our ability to attract the best faculty to our campuses and to make sure whatever we do do not disturb our particular optimization or value. It seems to me that we're going to have to put more effort into being successful in the educational process. As a first order, we need to decouple education from research and ask what's necessary to making education excellent and what strengths we have to offer as an educational institution. Once we are satisfied that we have got those answers right we can then think about the interface with the research process.

LANGENBERG: We always need to remember that most universities are not research universities. Only about 3% of American institutions of higher education are what could truly be called research universities. And the great majority of students in this country are educated at some other kind of institution. I think your point is right: Somehow we've got to strengthen our undergraduate education.

MONIZ: Our discussion has returned to the first question, on whether the research university is changing its mission. How do research universities couple into the country's broader educational system? What are the obligations of the research university with respect to the private sector, both in research and education? We need to reexpress a shared commitment to society's great challenges within a realistic assessment of the university's ability to respond.

MOORE: The answer depends on whether people in the system are willing and able to change. Some people believe they have a contract by virtue of being granted tenure to continue doing their own research until they retire or die.

MONIZ: An attitude change on the part of the academy is essential. An example is our collective tendency to disenfranchise young people who have PhDs and want to go off and teach or go into another field. The university tends to discount them. This erodes public support and, more importantly, our own values.

LANGENBERG: The answer is, yes, there will be change. One of the most encouraging things I've seen in recent years is a report of a National Science Foundation conference that brought together a group of Presidential young investigators to talk about undergraduate education. They didn't look or sound anything like the caricatures of old fogey professors concerned about their research and nothing else. Today's young faculty are not living up to the old stereotype. Somebody once told me there are some problems only a funeral will fix.

[Laughter]

MONIZ: We call it natural retirement. [Laughter]

GOTTFRIED: In my experience, while research is a sine qua non for tenure, it is no longer sufficient.

BYER: There's a joke at Stanford that if you win an award for teaching, there goes your tenure.

MONIZ: The dominant factor is still research in the sense that accomplishment in research is a necessary condition for advancement at a research university. On the other hand, the threshold of what is considered very good research has a large dynamic range and includes teaching.

BYER: We have a difficult time measuring the quality of teaching.

GOTTFRIED: We solicit letters from all the classes the teacher has taught and from graduate students who were supervised to determine quality. The people we've appointed to tenured positions in the past five years are among our best teachers. Whereas research was the only factor determining tenure 20 years ago, the balance has now shifted.

LUBBEN: Most people here would agree, I think, that interdisciplinary research has become increasingly important, and yet in the current university environment people in "interdisciplines" find it difficult to get tenure. Have universities come to grips with this problem?

GREENE: The problem is very real. As young PhDs looking for jobs several years ago, we were often told by
the universities that they wanted interdisciplinary researchers. The PhDs responded by listing chemistry, physics and maybe a bit of electrical engineering on their resumes. The universities hated that, much to our surprise. The physics department would say, if you can do chemistry, why should we fill a line in our department with a chemist? We quickly rewrote our resumes and submitted one to each of the disciplinary departments. So what we PhDs thought was our strength turned out to be a weakness. But two or three years after our unhappy experience, people I know have gotten interdisciplinary appointments. Their positions are supported by several departments. Universities now seem to recognize the value of chemists and biologists talking to each other or of a chemist and biologist being the same individual. We need to think about this trend when we're writing our freshman physics courses. We also need to figure out ways—I don't know how yet—of educating researchers who aren't afraid to risk jumping into another field.

LANGENBERG: Would you suggest abolishing the disciplinary department?

MOORE: If you really want to go multidisciplinary, I think that's the only way to do it.

BYER: No. The way to do it is to build strong disciplines to retain quality.

EISENBERGER: Talk about stereotypes! [Laughter]

MOORE: We're faced with an interesting problem right now, in that we've been given an endowed chair in medical optics by a medical company. The chair is in Rochester's Institute of Optics, so we ask ourselves what kind of person should we seek. People in the department argue that the person should be able to teach courses in our regular curriculum. If we were to do this we would probably fail to reach out and do some interesting things with our medical school. And yet, if we go too far on the medical side, we won't be able to talk with this person. We must face up to parochialism.

EISENBERGER: The answer, I think, is not at either extreme. It's not an either-or situation. I'm personally convinced that you need the disciplines to teach, in the case of physics, the methodology and the solid core of the field. To go beyond that, to help build bridges to other disciplines and to help build bridges to broader career options, you have to find a way to be more flexible. So you need to allow interdisciplinary appointments and allow people with a variety of skills to become part of the community. So I would keep the pedagogical core, because I consider it essential, and I would work very hard on the boundaries. I know there is resistance at those boundaries.

LANGENBERG: We make it difficult for joint appointments.

MOORE: And we hold out no incentives for untenured people.

BYER: A single department needs to be responsible for an untenured faculty appointment. Once tenure is achieved, faculty can arrange for joint appointments.

MOORE: How do we get around that?

BYER: What we've done is build scaffolding across those steeples called disciplines. They're called independent labs or interdisciplinary centers and they work extremely well. Our rule is that they come and go. They may be around 10 years or 20 years. But they're not permanent. Generally the best people work together to create these structures, which span department and school boundaries. However, the university must evolve its policies to allow cross-disciplinary structures to exist and flourish as long as they serve the interests of the faculty and the students and the fields.

GOTTFRIED: We are changing. There's no question that Cornell and Stanford and MIT, for example, are doing much more interdisciplinary research today than they were 15 or 20 years ago. But humane universities don't allow a young person to hold a joint appointment in three different departments. That's just not going to work. It doesn't mean, though, that a person cannot come in, say, to the physics department, and do biophysics, yet be a physics department appointee 100 percent. We have one of Ken Wilson's former postdocs who's now a professor of cancer research.

EISENBERGER: Are the modifications we're making in terms of new courses, or in the appointments and tenure process, really up to the task of getting where we want to be in the next few years? Will these changes optimize our educational and research products? I think we all share some apprehension about the way we're making the changes. Duncan is asking whether these small perturbations are enough to get you there, or do we need something more significant? I'm suggesting that you may need something more significant, though not as significant as removing the university's core foundation, which rests on the basic disciplines. Still, we probably need to be more aggressive, both educationally and in the whole culture, if we're going to ensure the high quality that served us so well till now in meeting the diverse scientific and educational challenges in the future. Whether some of our research universities will survive the changes we see coming is not certain. As I go around the country, I see some institutions that score high in dealing with the changing scene. Those universities that have started to break down some of the old walls not only will survive the changes but will flourish.

LANGENBERG: Edison was once asked what his incandescent light would do to the candle industry, and he is said to have replied, "We will make electricity so cheap that only the rich will burn candles." [Laughter] It strikes me that both Kurt and Duncan are right. The research universities aren't going to change radically. They are not going to be totally transformed. In part the faculty won't want to do it, and in part research universities don't need a great transformation. They are a rather successful model, albeit a model limited to a small segment.
of higher education. And in 50 years, they will be recognizable related to what they are today. I also think it's true that for the great majority of students, other institutions are going to come from out of left field and meet their needs in new ways that will have little or nothing to do with what the research universities are doing.

Goodwin: Can you give us examples of such places?

Langenbern: One is the New Jersey Institute of Technology. It has no grassy lawns or tenured faculty. It is a virtual university in interesting respects—and rather innovative. Another is a University of Maryland institution that in enrollment is the largest in our system. It's bigger than College Park. It has no tenured faculty. It has no campus. It has no library. It has no intercollegiate athletic program. And it's becoming considerably virtual, as we speak. Yet it's totally self-supporting. Indeed, except for two small religious colleges, it's the only institution of higher education in Maryland that gets no state money. It is called the University of Maryland University College and it has only one purpose. Its mission is providing continuing education for working adults. Its faculty consists mostly of practicing professionals, such as the guy from Comcast who teaches communications management. In this institution clinical psychologists are sent into the classroom to watch the faculty–student interaction. They watch the faculty to make sure the needs of the students are met.

Goodwin: What you're describing seems like a vocational school and not a research university at all.

Langenbern: It's neither. It's something else entirely. A little research goes on, but the main job is to educate a lot of people. And it's very successful. There was a time when three of the members of the Joint Chiefs of Staff in the Pentagon were alumni of University College.

Solomon: Even at the top research universities, students are as aware of marketplace forces as those students at Maryland's University College and the New Jersey Institute of Technology. If students get the message that graduate training is marketable, the best and brightest will go for advanced degrees. If the opposite message is heard, they'll vote with their feet.

Goodwin: We have the responsibility not to overproduce graduate students, particularly PhDs.

Byer: Are we overproducing PhDs? I don't see any evidence of that. The unemployment rate for physicists is below 5% nationwide.

Moore: That may be so, but newly minted PhD physicists are not finding work in their own subfields.

Byer: I've never had any trouble placing students in our applied physics department. They're being pulled out, not pushed out. So I keep questioning statements about overproduction.

Langenbern: Stanford probably is not overproducing.

Byer: The question hinges on the economic value of a research degree. Students themselves will recognize very soon that some field or some university is not where they want to go.

Eisenberger: What I hear increasingly from industry is that they're increasingly interested in PhDs, more interested in those with a bachelor's or master's degree. In addition, the product they're looking for today is different from those we packaged in the past. So I wouldn't be quite as sanguine about the product of research universities having an automatic ticket to the future as you may think. I think the feedback will be very fast. Once students hear that investing years and thousands of dollars in a PhD has little or no economic value or intellectual satisfaction, they will change their plans. In fact, it's starting to happen: In looking for a job, some PhDs and postdocs are hiding their degrees because they've heard that they'll be considering overtrained for the majority of positions out there.

Byer: That's happened to English and history graduates for a millennium, right?

Eisenberger: But they don't get public support while graduate students in physics, chemistry and biology do at research universities.

Gottfried: Cornell graduate students are having a much harder time today finding jobs in traditional fields, no question about that.

Green: We are overproducing PhDs. People are getting postdoc after postdoc for five, six or seven years. Maybe it's different in Byer's lab at Stanford.

Goodwin: Is the postdoc a convenient holding pattern?

Byer: This issue should be placed in historical perspective. I've heard it put best by a friend, a former dean of the School of Earth Sciences. He once plotted the production of PhDs against the price of a barrel of oil. The plot lines correlate perfectly with a one-and-a-half-year delay. As the price of the barrel of oil went up, the number of PhDs in Earth sciences went up. As the price of oil came down, the PhDs came down. Why? Because students looked ahead and asked: "Is there opportunity for a career there?" The market was the determinant.

Green: What we have overproduced is people who believe they're going to get jobs doing academic research in physics. There's a large number of young physicists who tell themselves: "I've fulfilled my part of the contract. I'm very, very smart. I've worked hard. I've published a lot of papers, and I work for this famous professor. I've earned a good job, but that's not going to happen." Over the past two or three years graduate students have become very depressed.

Moore: From a public policy standpoint, we have managed to keep the enrollments up with foreign students. So the question then becomes, How many foreign students should the United States government support?

Gottfried: This is a very complicated issue. If I look at my physics department faculty, a substantial fraction of them arrived here as foreign students and made considerable contributions to America.

Moore: It's important to make that case in Washington and the rest of the country.

Byer: We've asked ourselves the question of support for science students at Stanford and wondered how much longer this will continue as government grants become scarcer. We've challenged ourselves, in fact, to find ways to support our grad students solely with university funds.

Moniz: We do have a responsibility for our students, and it's clear that there has been a big change in the industrial opportunities for physicists. On the other hand, our own internal, anecdotal survey indicates that rather
then an evaporation of opportunities there has been a radical change. There’s no more pipeline to Bell Labs, IBM or wherever. What’s happening now is eye-opening. When we surveyed where our graduates went in the private sector, we discovered a long list of individual companies, each hiring one graduate. I hadn’t heard of many of the companies. One of the only places hiring more than one was, in fact, a Wall Street investment house. In most other cases, though, the student is the only MIT graduate in the company. So the survey showed there were jobs, but not in the traditional places. Students need to be more entrepreneurial now. We are responding by helping them gain a broader perspective, with career roundtables, new courses and the like, and by redefining our department’s relationship to industry.

EISENBERGER: The United Kingdom is considering revamping the PhD program and introducing a master’s level that would combine physics with business or law. It seems to me that if the marketplace for physicists doesn’t improve considerably, we need to think about restructuring our educational program for physics majors.

GOODWIN: You will recall that Neal Lane [Director of the National Science Foundation] suggested last year at this roundtable [PHYSICS TODAY, March 1994, page 30] that America’s universities consider something like that and make the master’s degree the top level for all but a few who are encouraged to pursue the PhD.

BYER: At Stanford the largest degree class is the master’s, not the PhD or even the BA or BS. There’s an increasing demand, particularly from corporations outside the US, for master’s degree students in physics. The applied physics department has responded by increasing the numbers admitted to the master’s program.

GREENE: We all know that if we stop supporting physics graduate students and they have to find their own money to go to graduate school, the number will drop precipitously. Physics students are not able to get the kind of loans available to medical students, who face a different job market after graduation. If physicists drop below a critical mass in graduate school, the country will be harmed intellectually and industrially.

GOTTFRIED: You’re painting a picture that is darker than it really is. Even before the war Cornell had something like 35 graduate students on average. Most of these did not pay their own way. There were some private fellowships, maybe more than today. And some were there on National Research Council fellowships. There were a much smaller number of research universities, of course. But still, a generation of extremely outstanding people were produced in the ’30s. If we look at the situation over a long historical time scale, the period after the war was an anomaly, because of the demand for physicists in the cold war. It was an artificial situation. And there was no reason, I have believed for a long time, that it could go on forever. So I think we have to expect that our community, the research universities and the government labs, are going to be downsized to a condition somewhere between 1939 and 1955 in terms of Federal support and in terms of the number of students. I’m not saying that we will go all the way back there. But we will go some way back. It’s not just a matter of money. Bright young people went into physics throughout history not just to go into a profession. They went into physics for some of the same reasons others study history or literature—as an intellectual pursuit. As long as they can get some crummy fellowship or crummy assistantship, they will do it. They know that it’s a high-risk enterprise, but that’s what they want to do, like somebody who wants to paint pictures. Even if they are told they are not going to earn a living wage, they’ll do it. The problem we now have—and it’s very understandable—is that students have expectations that were made at a time that is now history. When those expectations are brought up to date, in today’s real time, I think students will fare much better in many programs.

LANGENBERG: I think Kurt’s right. That’s because he agrees with me. [Laughter] There is nothing like an education in physics to teach people how to address and to solve problems. Now, what I hear from folks in the industrial world is they want problem solvers. They don’t necessarily want people with a particular disciplinary label. They want somebody who can deal with complex, multidisciplinary technological issues. So it seems to me that if we’re going to continue to get the kind of people that Kurt’s talking about, our best solution is not to reduce the number of those who want to be physicists, but to try to alter some attitudes. To begin with, we ourselves need to make an attitudinal change, and then the students need to make a change. We senior people must help students understand that this is not a ticket to a position in academic research or in a corporate lab doing exactly what they did for their thesis. They are not likely to get a post at Stanford or MIT and they are not going to wind up at GE or IBM. Rather, they may get a job solving problems and using physics. And that may be a lot of fun, and it may even be very profitable. But we and they need to be honest and open about the future of physics and of physicists.

EISENBERGER: The irony in the situation is that our research universities and our demand for scientists, physicists in particular, burgeoned for reasons of national security. Now that we’ve helped win the cold war, the universities and the scientific communities could help provide a more sophisticated, technically trained population to help make America a more prosperous, more egalitarian land. You don’t need any complicated myths or dark threats. We can be economically stronger with a technologically capable and scientifically literate citizenry. What sometimes frustrates me is that we don’t need to rationalize our university system and our research communities to earn political and public support. The reasons to support both are plentiful—almost obvious. If we stay true to our mission, we have important contributions to make to society. It’s the tension between the old paradigm that science and education are needed for national defense and the new opportunities for science and education that lie in the future that we’re struggling with in our discussion today.