

# SCIENCE AND TECHNOLOGY



# *New Technologies and Their Promise for Higher Education*

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*Address to the First Harvard University Conference on the Internet and Society  
May 29, 1996*

I WANT TO TALK today about the Internet and higher education. What changes are taking place in universities as a result of this recent advance in information technology? Are the changes significant, and are they likely to be long-lasting (as I believe they are)? If so, why?

The questions are obviously important, in part because our conclusions will determine whether Harvard and other institutions should make very large financial investments in the next five to ten years, at a time when flexible resources are clearly constrained.

But more important than the financial issues are those of educational substance. Any deep transformation in communications – in our ability to gain access to data, information, and ultimately knowledge, and in processes that can help us to discover, invent, teach, and learn – holds the potential to have profound effects on higher education. So as we assess the new information tech-

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nology – the Internet – we have to make the right bet, because the stakes are high.

When I refer to the Internet, I mean to use the term as shorthand for a cluster of technologies that includes networked personal computers, hypertext and hypermedia, the World Wide Web, and other adjuncts.

This cluster has, during the past few years, already begun to have a dramatic impact on the ways that many students and faculty are approaching the whole activity of teaching and learning. In the context of Harvard and at least some other universities, these changes are more dynamic and pervasive than any previous breakthrough in information technology during this century – including the introduction of the personal computer itself. The effects are visible in nearly every part of our own campus, as well as elsewhere in higher education.

From one point of view, the Internet marks just one more point on a long continuum of inventions – one that has unfolded over the course of the last century and a half – from the telegraph and cablegram, through the telephone, radio, recorded sound, film, television, early calculating machines, and then the earliest computers.

But we know that certain events along a continuum can represent much more than another simple step in a natural, gradual progression. There are moments of real transformation, and the rapid emergence of the Internet is one of them.

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Many inventions (such as radio, film, and television) have of course had a massive effect on society – on how people spend their time, entertain themselves, and even gain information. But, in spite of many predictions, these particular inventions have had little effect on formal, serious, advanced education. Why should the Internet be any different? Is there any evidence – or a reasoned explanation – for betting on the Internet, when so many earlier inventions have fallen short of expectations?

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Let me mention a few facts.

In our Faculty of Arts and Sciences, as well as nearly all of our nine professional schools, teachers and students are on-line, with easy access to the network. E-mail is commonplace. Activity on the Net is heavy at nearly all times of day and night, with the only major slowdown occurring between 3:00 a.m. and 6:00 a.m.

In 1992, we began a retrospective conversion of the catalogue for Harvard's entire library system – the largest university library system in the world – at a projected cost of \$22 million. By next year, full catalogue entries for the approximately thirteen million volumes in our ninety-two libraries will be on-line and searchable in any number of ways. In addition, there are, of course, more and more actual texts, images, and other materials on the Net.

The rate of change and growth is exceptionally fast. A year ago, the Arts and Sciences Web site (which includes many subsites) experienced about 150,000 "hits" in the single month of March. This March, just one year later, the number of "hits" had increased from 150,000 to 2.3 million. There is no sign of a slowdown.

In 1995, the volume of e-mail traffic on the Arts and Sciences network was about 80,000 transactions per day. Twelve months later, the number had grown by about 170 percent, to about 215,000 per day – or about 6.5 million per month.

These figures, let me stress, are only for Arts and Sciences. They do not include our Schools of Business, Design, Dentistry, Divinity, Education, Government, Law, Medicine, and Public Health – or our central administration and various other units.

So if I am asked whether something very unusual – something qualitatively and quantitatively different – is under way, the answer is a clear "yes." And we are only at the beginning.

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In purely economic terms, we expect to spend something in the range of \$75 million to \$100 million over the next two to three years on academic-related information technology – above and beyond the substantial investments already made since the early 1990s.

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The last time universities experienced such far-reaching change in information processing, along with exponential expenditure growth, was during the last quarter of the nineteenth century and the first quarter of the twentieth. It was then that the huge information systems that we call university research libraries reached their point of “takeoff” in accelerated development.

At Harvard, the moment of takeoff came during the 1870s and 1880s. When that moment arrived, universities were forced to confront many problems – including that of information overload – similar to several of the “electronic” problems we now face.

In 1876, for instance, Harvard’s President Charles Eliot reported that the main library building had become completely inadequate to accommodate the sharp rise in acquisitions. Books, he said, “are piled upon the floors.... Alcoves are blocked up.... Thousands of [volumes] ... have been placed in temporary positions.” He later noted that large numbers of books were being stored haphazardly: “42,000 volumes scattered among twenty-nine [locations] ... in sixteen different buildings.”

The real challenges, however, were not those of space and money. They were organizational and conceptual. How should books be arranged for optimal use? What kind of cataloguing system could be invented to allow rapid access to the huge number of volumes that were now being acquired? How could convenient linkages be created among books and articles in different but related fields? How should library books be integrated into the University’s programs of instruction – especially if the library owned only one or two copies of a book which fifty or sixty students were asked to read for class discussion?

Finally, what was to prevent students (and even faculty) from disappearing into the stacks for days on end, pursuing a subject from book to book, shelf to shelf, unable to discriminate easily among the unlimited number of volumes, or to absorb more than a small fraction of the information available on a given topic? And what could possibly prevent less industrious students from simply browsing their lives away in sweet procrastination?

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Some of these fears were not completely new. Anxieties had been building for some time. As early as the eighteenth century, Diderot remarked that “a time will come when it will be almost as difficult to learn anything from books as from the direct study of the whole of the universe. . . . The printing press, which never rests, [will fill] huge buildings with books [in which readers] will not do very much reading. . . . The world of learning – our world – will drown in books.”

Meanwhile, a treatise on public health, published in Germany in 1795, warned that excessive reading induced “a susceptibility to colds, headaches, weakening of the eyes, heat rashes, gout, arthritis, asthma, apoplexy, pulmonary disease, indigestion, nervous disorders, migraines, epilepsy, hypochondria, and melancholy.”

People were warned not to read immediately after eating, and to read only when standing up, for the sake of good digestion. Fresh air, frequent walks, and washing one’s face periodically in cold water were also prescribed for habitual solitary readers. Most of all, it was feared that excessive reading would make people socially dysfunctional, would take the place of direct human contact, and could well lead to a society composed of certified misfits.

Historical parallels are never exact, but the story of university research libraries, and of the habit of solitary reading, has some obvious relevance to modern information technology – especially to the Internet’s ability to give individuals unbounded access to a new universe of information that they do not yet know how to manage at all well.

There is also the serious problem of the very mixed quality of the information available. How do we sort it? How do we gain maximum return on the time and energy invested in searching?

Given this situation, it is not surprising that many people are now asking some of the same questions that were raised in the early days of research libraries – and expressing some of the same fears. The Internet is in fact not easy to navigate; much of its available information is trivial; it appears to be hazardous to the health of at least some people; and it also has the capacity to distract

many people from following what others regard as more serious pursuits.

Some of these concerns can be alleviated by recalling the story of our research libraries and their evolution. Other concerns – such as the worry that the Internet may turn out to be no more educationally useful than radio or television – need to be answered differently.

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Why is the Internet likely to succeed as a vehicle for real education, when so many other inventions have faltered? Why isn't it simply one more in a long train of distractions? Doesn't it, ultimately, take students and faculty further and further away from books, from the hard work of sustained study and thought, and from direct human contact with other students and faculty?

Let me suggest some of the main reasons why I believe that the Internet is fundamentally different from those earlier electronic inventions, and why I believe it is already having – and will continue to have – such a major effect on higher education.

To begin with, there is the steadily mounting evidence of dramatic change and intensity of use, as I mentioned just a few moments ago. All of this is certainly not a mirage.

More fundamentally, there is in fact a very close fit – a critical interlock – between the structures and processes of the Internet, and the main structures and processes of university teaching and learning. That same fit simply did not (and does not) exist with radio, film, or television. This point is in many respects a remarkably simple one, but – in the field of education, at least – it makes absolutely all the difference.

If I say there is a critical interlock or fit here, I mean nothing more complicated than the plain fact that students can carry forward their work on the Internet in ways that are similar to – and tightly intertwined with – the traditional ways that they study and learn in libraries, classrooms, lecture halls, seminars, informal

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discussion groups, and laboratories, and in the writing and editing of papers or reports.

Some of these activities are more cumbersome and less successful when transplanted to the Internet environment. Others are substantially improved. In most cases, however, the new technology acts primarily as a powerful supplement to – and reinforcement of – the major methods that faculty and students have discovered, over the course of a very long period of time, to be unusually effective forms of teaching and learning in higher education.

Specific examples can be helpful here, so that we can see more clearly how the capacities and processes of the Internet relate so closely to the university's traditional forms of education.

For instance, the Internet can provide access to essentially unlimited sources of information not conveniently obtainable through other means. Let us assume for the moment that most of the technical and other problems of the Internet will in time be solved: that there will be, as there are now in the research library system, efficient ways of helping users to find what they want; that there will be procedures for information quality control, and for creating more effective linkages among different bodies of knowledge in different media.

At that point, the Internet and its successor technologies will have the essential features of a massive library system, where people can roam through the electronic equivalent of book stacks, with assistance from the electronic equivalent of reference librarians. In short, one major reason the characteristics of the Internet are so compatible with those of universities is that some of the Internet's most significant capabilities resemble, and dovetail with, the capabilities of university research libraries. Just as the research library is an extremely powerful instrument for learning, so too is the Internet – and for much the same reasons.

In fact, the library and the Internet are being viewed increasingly as a versatile unified system, providing an enormous variety

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of materials, in different formats – so that data, texts, images, and other forms of information can be readily accessed by students and faculty alike. Indeed, we are already well along this path.

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If we now shift for a minute from libraries to the formal curriculum, we can see that the Internet has another set of highly relevant capabilities: it can provide unusually rich course materials on-line.

For instance, traditional text-based Business School “cases” are already being transformed. I recently reviewed one of the new generation of multimedia cases, which focuses on a small sock-manufacturing plant in China – an Australian-managed plant plagued by serious production and delivery problems, and losing money much faster than it could make either toes or heels.

The materials for this case began with a video tour of the plant, close-up moving pictures of the workers operating their machines – or not operating them – followed by interviews with several managers at different levels in the company’s hierarchy. Detailed production and supply data, financial spreadsheets, and a company report – all of these and more were obtainable in the electronic course-pack.

What one saw, of course, was that the interviews with different people revealed totally different perspectives on the plant’s problems, and the data were anything but conclusive. The company’s official report, meanwhile, served only to complicate the picture further. Students who were taking this course had to analyze not just a text and statistics, but also the whole range of attitudes, expressions, and behavior – recorded on video – of the different executives, as well as the workers.

How many of the plant’s problems were basically cultural – since the key Australian manager spoke no Chinese, and had to communicate with the workers through interpreters? How many problems were the result of a more general human systems failure,

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given the fact that the plant was embedded in a larger surrounding bureaucracy? How much of the difficulty stemmed from internal inefficiency, bad organization, and managerial blundering?

What is so effective about cases presented in this way is that far more of the entire human and social – as well as operational and financial – situation can be revealed, and this requires students to deal with a vivid dramatization that is much closer to the complicated reality of an actual company functioning in a particular culture. Suddenly, the case becomes three-dimensional or multidimensional. The viewer has to bring to bear all the skills of a careful observer of human nature, along with those of an operations analyst, a financial analyst, and a scholar of organizational behavior.

In short, the Internet turns out to be an exceptionally fine tool for the creation of densely woven, multilayered, and highly demanding new course materials that are in several respects superior to traditional case studies. Once again, an important component of university learning, the course and its texts, can now be reinforced – in this instance, considerably enhanced – by the introduction of Internet technology.

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Another point of compatibility between the processes of the Internet and those of the university concerns the basic activity of communication. We know that the constant exchange of ideas and opinions among students – as well as faculty – is one of the oldest and most important forms of education. People learn by talking with one another, in classrooms, laboratories, dining halls, seminars, and dormitories. They test propositions, they argue and debate, they challenge one another, and they sometimes even discover common solutions to difficult problems.

The Internet allows this process of dialogue – of conversational learning – to be transferred easily and flexibly into electronic form. Communication can be carried on at all hours,

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across distances, with people who are on-campus or off-campus. Student study groups can work together on-line; faculty members can hold electronic office hours, in addition to their “real” office hours; and teaching fellows can make themselves available for after-class electronic discussions.

In all these ways, the Internet works to create a significant new forum – a limitless number of electronic rooms and spaces – where one of the most fundamental educational processes – energetic discussion and debate – can be carried on continuously.

It is also worth noting that recent experience suggests that student participation levels tend to rise in the electronic forum. Students who are consistently reticent in actual classrooms are more likely to speak out, regularly and confidently, on the network.

No one should believe that electronic communication can be – or should be – a substitute for direct human contact. But the electronic process has some features that do permit an actual extension of the scope, continuity, and even the quality of certain forms of interaction, even though communication over the network lacks other absolutely essential aspects of “real” conversations in the presence of “real” people.

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Finally, the Internet may well be having – it is not altogether easy to tell – a subtle but significant effect on the relationships among students, faculty members, and the subject or materials that are being studied in a course.

Let me oversimplify for a moment. The direction of movement in teaching and learning has, for more than a century, been shifting away from a previously established model that viewed the faculty member (or an authoritative text, or a canon of texts) as the dominant presence – as the transmitter – with the student as a kind of receiver.

Since at least the 1870s, the emerging theories of education have stressed the role of the student as an active agent, an ener-

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getic learner: someone who asks questions, searches for information, discusses ideas with others, and generally moves ahead as an investigator, discoverer, or adventurous scholar-in-the-making.

In this model, the faculty role, more and more, is to draw students out, to steer but not explicitly control the discussion unless it becomes necessary to do so. The faculty also organizes the structure of the curriculum, individual courses, and class assignments. But the course materials are not likely to be treated as authoritative texts that offer definitive solutions. They are intended to be approached critically, and they are usually arranged in a point-counterpoint way.

This arrangement inevitably suggests that many or even most of the important questions in a course are still open and unresolved, waiting to be discussed and addressed and answered. Faculty play an absolutely vital role in this process, stimulating students to ask the right questions, to search in rigorous and imaginative ways for answers, and to connect their thoughts to a larger set of principles and ideas. But a very large part of the positive charge comes from the students themselves.

We do not have to agree fully with this theory of education in order to see that it has in fact produced very potent results in colleges and universities. We can also see why the structure and basic processes of the Internet technology appear to be so closely linked to – so compatible with – the approach to education that I have just been describing.

The Internet essentially *requires* that the user be an engaged agent, searching for information and then managing or manipulating whatever is found – solving problems, buttressing arguments with evidence, and exploring new, unknown terrain. Students are invited to trace linkages from one source to another. They can easily share ideas with others on e-mail. They ask for comments and criticisms. Their posture or attitude, seated in front of the computer, is to make something happen. And they generally act or pursue, rather than merely react and absorb.

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So, if we step back and look at the full picture that I've tried to sketch, we can, I think, start to understand why the Internet and its successor technologies will not only have a profound effect on society in general – as radio, film, and television previously did – but why it has so quickly and dramatically begun to transform significant aspects of higher education, in a way that previous inventions simply did not.

As I have tried to suggest, the cluster of technologies that we call the Internet has very distinctive powers – a unique ability to complement, to reinforce, and to enhance many of our most powerful traditional approaches to university teaching and learning. We will still need our libraries, our seminars and tutorials, our faculty, books, laboratories, and residential environments. But the new technologies will strengthen much of what already exists, and also extend our capacities.

The Internet is new, it is different, and there is always reason for caution when things are changing so quickly. We need to find the right pace in order to achieve the best possible results for education – and those results will require an intense focus on the substance of what the new technology can deliver, as much as on the process.

It takes time and money to create superior course materials. It also takes considerable faculty expertise – technical as well as scholarly. It will take time before the Internet is easily navigable, and before it holds a large enough store of rich material to rival our greatest research libraries.

But these things will happen, and as they do, education will be enriched. Meanwhile, I believe that universities have a special responsibility to exert real leadership in this sphere: not necessarily in the development of the technology itself, but in the imaginative and thoughtful uses of the best technology for the purposes of better teaching and learning.

We must be prepared to do now – over the course of the next ten to twenty years – what our predecessors achieved during the

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late nineteenth century, when they made a conscious decision to create unrivaled university research libraries, new curricula, and new teaching methods. It can be done, and now is the time to begin.

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Is there a cautionary note on which to end? Certainly. Good data, new information, and excellent vehicles for communication are all critical to virtually everything that we do, in universities and in life. But they do not in themselves constitute the essential stuff of education.

All the information in the world will be of no avail unless we can use it intelligently and wisely. In the end, education is a fundamentally human process. It is a matter of values and significant action, not simply information or even knowledge. The Internet will not tell us what to do about individuals and societies that cannot afford to be on the Net. It will not tell us how to pay attention to those who are left out of the race – or who appear to have already lost the race. It will not show us – any more than our libraries full of books will show us – how to create a humane and just society. For this, we need – as we have always needed – human minds, human values, and human determination.

As we think in this conference about the implications of the Internet, not just for education but for the larger society, let us not forget what we mean by a “society”: what it is that we want to have an effect on – and what kind of an effect we want to have. It is how we address these questions – of purposes, of aspirations, of the consequences of our choices on real human lives, all lives – that will finally determine the effectiveness of our new technologies for education, and for people and communities around the world.

## *The Fruits of Science and Serendipity*

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*Commencement Day Address*

*June 8, 1995*

FIFTY YEARS AGO, as World War II was coming to an end, Harvard graduates and their families gathered in this Yard for Commencement. Victory had been declared in Europe, but we were still at war in the Pacific. The Commencement audience was much smaller than usual, and so the gathering was held in the Sever Quadrangle. President Conant explained that more than 25,000 Harvard graduates and students were still in uniform. The Harvard Commencement of 1945, he told the audience, was a purely local gathering because of national restrictions on wartime travel. The usual daylong activities of Commencement were condensed into two hours.

And yet the day, while in some ways solemn, was essentially one of affirmation and hope. One of the honorary degree recipients – and the principal speaker – was Sir Alexander Fleming, the renowned British bacteriologist. It was Fleming, in 1928, who had discovered penicillin. And it was penicillin that had saved thousands and thousands of lives during the war: a war in which so many Harvard students, faculty, and alumni served with great courage and distinction – and in which so many gave their lives.

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But on Commencement Day fifty years ago, Fleming did not speak about conflict and destruction. He spoke instead about the importance to society of scientific discovery. He talked in an unassuming and personal way about the role of chance – of serendipity – in research, as well as in his own life.

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As a young man, Fleming had spent five years as a shipping clerk. He couldn't afford the medical education he wanted. Then fortune intervened: a relative left him a legacy that was enough to launch him in his medical studies. He earned his degree, served in World War I, and went on to a career in biological research, studying bacteria.

Within a decade, fortune intervened again, this time as Fleming was working in his laboratory. "I did not ask for a spore of *penicillium notatum* to drop on my culture [plate]," he said. "When I saw certain changes I had not the slightest suspicion that I was at the beginning of something extraordinary. . . . That same mould might have dropped on [any one] of my culture plates, and there would have been no visible change to direct special attention to it. . . . However, somehow or other, everything [fit] in. . . . There was an appearance which called for investigation – with the result that now, after various ups and downs, we have penicillin."

Why did Fleming tell this story on that particular Harvard Commencement day? He said he wanted to offer some advice to young researchers in pursuit of new knowledge. "Never," he said, "never neglect an extraordinary appearance or happening. It may be a false alarm and lead to nothing. But it may, on the other hand, be the clue provided by fate to lead you to some important advance."

We can now see, from our own vantage point, that there was also another significance to Fleming's remarks: he was already helping to shift our focus from the war that was ending to the peace that was about to begin. His own experience reminded

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everyone that research and discovery could lead to dramatic and unpredictable advances for society, and for all individuals.

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In fact, our own nation began to invest heavily in basic and applied research during the war years, and increased that investment afterward. Our major universities were seen as senior partners in this enterprise – and not only in research, but in the training of graduate and professional students in many different fields. We need to remember (and it can hardly be stressed enough) that advanced education – providing the constant stream of physicians and health professionals, educators, architects, business leaders, religious leaders, lawyers, government officials, and other public servants – such advanced education depends most of all on a creative faculty engaged in significant research and discovery at major universities.

Without such a faculty, and without support for its research, neither Harvard nor any other university can carry out its fundamental mission, or achieve its own goals and those of society. Research and advanced education are inescapably linked to one another. Neither can flourish without the other.

I want to stress this point because we have reached what may be a critical turning point in our nation's commitment to the creation of important new knowledge and understanding. Decisions now being made in Washington will have a profound effect on the future of research and education in this country. The stakes are very high. And the issue is not receiving the urgent and widespread attention it deserves – because this is certainly the most hazardous moment with respect to federal support for higher education in this country during the postwar period.

In the fifty years since Alexander Fleming spoke at Harvard, it is no exaggeration to say, basic research at universities has done much to transform our world.

We should remember, for example, the discovery of the

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structure of DNA – in 1953 – which has increased our understanding of almost every aspect of our biological nature, which began the revolution in genetics, and which led to the creation of the entire new industry of biotechnology.

We should consider the computer revolution – the ways in which it has changed how we learn, how we transmit and access information, how we solve problems that were previously insoluble.

Think about microwaves, plastics, optical fibers, laser disks, superconductors, weather and communications satellites, and many other devices and new materials that have become so much a part of our daily lives that we hardly even notice them any more.

Or the advances in understanding cancer, heart disease, and other illnesses – including mental illnesses. Think how much has been accomplished, but how much more work there is still to be done.

How we travel, how we communicate, what we eat, what we do with our free time, how we protect our environment, how we make a living – all these aspects of our lives have increasingly come to depend in essential ways on the discoveries that flow from our basic and applied research.

The driving force behind this steady advance – as I suggested – has been the cooperation, for a full half century and more, between our universities and the federal government. This joint enterprise has been based on a simple premise that was spelled out in a famous report whose fiftieth anniversary we are also marking this year. The report was titled *Science: The Endless Frontier*. Its author was Vannevar Bush – who also received a Harvard honorary degree, in 1941, when he was the principal speaker at our Commencement.

“Progress in the war against disease depends upon a flow of new scientific knowledge,” Bush wrote in 1945. “New products, new industries, and more jobs require continuous additions to knowledge . . . and the application of that knowledge to practical purposes. Science . . . provides no panacea for individual, social, and economic ills,” he continued. But “without scientific progress,

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no amount of achievement in other directions can insure our health, prosperity, and security as a nation in the modern world.”

These words are no less true today than fifty years ago. But our national mood, and certainly our sense of perspective, have changed. We are more skeptical about institutions and what they can achieve. As a society, we have much less patience for long-term investments and long-range solutions. In fact, we have less patience for many things that require it. It is true, in addition, that the financial resources at our disposal are more constrained, and we face difficult choices about how to spend these resources. In such a climate, basic research, which has no broad or obvious constituency in our national politics, finds itself very seriously at risk.

A scientist spends weeks, months, even years studying the genetic makeup of baker's yeast. It sounds completely irrelevant and might at first seem to be an easy target for ridicule. Later, we find out that the results of this work will help pave the way for a breakthrough in understanding the basis of colon cancer.

A team of physicists studies how protons shift energy levels inside the nuclei of atoms – not something that most of us worry about very much in our daily lives. But years later, the work leads to magnetic resonance imaging – MRI – an astonishingly precise tool that allows us to picture and to study normal and abnormal structures inside the human body. With other imaging devices, we can now watch parts of the brain and other organs in action; and we can begin to diagnose many diseases in ways that we could hardly have imagined before.

This is only the smallest handful of possible examples, illustrating what has been accomplished in the last half century, thanks to our national conviction that discovery and increased understanding will constantly lead to real and tangible benefits, of many kinds, for all of us. Now, at a time when our ability to solve increasingly complicated problems – in the economy, in international affairs, in health, in ethnic relations, in technology – depends so much on intelligent leadership, on people who can

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both analyze and act, on research that can illuminate patterns in behavior or the deepest puzzles in nature: at such a time we cannot afford to give up on the basic commitments and investments that have been so much a source of our collective human and economic strength.

The question many people are asking is whether we can afford to make such investments in research and education. This is now – and always – an essential question to keep before us. But the other question we must ask as we look to the future of our society as a whole is whether we can afford *not* to make such investments.

We dare not underestimate the dangers, even if they are not immediately apparent. If, for instance, the enterprise of basic science is seriously damaged at the National Institutes of Health, the National Science Foundation, and other agencies, we may not see or feel the most profound effects either today or tomorrow. After all, it has taken fully forty years since the discovery of the structure of DNA to begin to realize what it will finally yield in terms of medical, social, and economic benefits. We may well persuade ourselves into thinking that today's budget cuts will really have no profound impact. But that would be a very great mistake. The total impact will be felt later – in a decade, or even two. And then, it will be too late to turn back the clock, and it will cost a very great deal more to rebuild something that now needs only to be kept in good repair.

Many people in the Congress and the Executive Branch understand this. Many have been working hard, helping to follow the thoughtful, careful approach that is needed – and they have done so courageously, and with some real effect. The effort is bipartisan, and continuous. But our many leaders in Congress need to know that all the rest of us care, and that we too want to help. They cannot, in the current national climate, manage this entire formidable job on their own.

With them, we should remember another of Alexander Fleming's remarks fifty years ago. "The unprepared mind," he said, "can not see the outstretched hand of opportunity." Curiosity alone

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does not produce new knowledge. Fortuity alone does not produce new knowledge. Rather, significant new knowledge depends on the rigorous work and imagination of prepared minds. It depends on excellent education. It depends on a climate of free inquiry, in which individuals have the flexibility and support that they need to follow their deepest insights and intuitions, in discovering new knowledge about human nature and the natural world.

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In closing, let us remember, too, that Alexander Fleming almost did not make it to medical school. A small legacy from a relative happened to come his way. Without that financial help, we might well never have heard of Fleming, and we might never have had the benefit of his own well-prepared mind.

In the years since World War II – though we sometimes forget this fact – higher education in America has become far more accessible than ever before. Our society’s conviction about the importance of educational opportunity – as expressed in our public policy and in the constant generosity of so many individuals – has steadily opened doors to women and men of talent and energy from all backgrounds and walks of life, even when their financial means have been very modest. The commitment to provide financial aid to students in need – the commitment to openness and inclusiveness in our colleges and universities – has been one of the defining achievements of American society in the last fifty years.

For example, the Harvard class of 1945 included the first Harvard graduates who were supported by scholarships under the GI Bill of Rights, one of the great steps forward in expanding access to American higher education. In the following decades, we have seen even broader efforts to open the doors of our colleges and universities. Here, as in the case of scientific research, the key to progress has been a powerful partnership between educational institutions and the government – as well as generous private donors and, of course, our students and their families.

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Here, too, we have arrived at a major crossroads. There are proposals in Washington that would turn back the clock in significant ways. There are deeply troubling signs that an immensely productive investment in financial aid and access to education is in increasing danger.

For instance, the idea of beginning to charge interest on student loans from the moment a student enrolls in college would – if adopted – add very substantially to student debt, for graduate students as well as for undergraduates. The proposals to freeze or cut campus-based aid programs such as work-study, or to freeze the Pell Grant program, are no less disturbing.

We must not let these and similar reversals take place. President Conant told us why, when he spoke here fifty years ago. Broad access to education, he said, “is the great instrument created by American democracy to secure the foundations of a republic of free [people].” He remembered the many Harvard alumni who had given their lives to secure that freedom. And he pledged that we would honor their sacrifice – that we would work even harder, in times of peace, to serve society by continuing to advance knowledge and by keeping the doors of educational opportunity open to everyone.

We must not, at this important moment, turn our backs on that pledge – for *all* of our sakes, and for the health of the nation. We have made good on our shared commitment to education, year after year, decade after decade, for these past fifty years. Let us not begin to falter now.

## *Our Pursuit of Science and Health*

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*Dinner Remarks at the School of Public Health "Healthier World" Conference  
October 14, 1994*

ANY SCHOOL that cares seriously about the public and its welfare, that sets out to improve the general health of all peoples, and that concentrates on prevention rather than on convalescence must be inherently optimistic, very smart, quick off the mark, and the very opposite of value-neutral. That's the kind of school – if I only were bright enough to be admitted – that I would like to join. But if I cannot be a true participant, I am delighted at least to be an interloper.

I read carefully through the program of presentations and discussions. It does sound, I admit, wonderfully upbeat. John Spengler's talk, as I remember, is entitled, "Every Breath You Take: Toxins in the Air." Then Tim Ford will entertain you with "Water, Water Everywhere: Is There a Drop to Drink?" Then Walter Willett: "Red Flags on the Menu: Finding Your Way through the Nutritional Maze." Later, Mary Wilson will say something about the health hazards of travel – namely, that we humans seem to be extremely attractive food for every conceivable kind of parasite in every part of the globe.

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All of this, I know, will be stimulating, illuminating, and intellectually exciting – as well as important. But, I am glad that my own remarks at this dinner, held in the darkened and no doubt polluted air of downtown Boston, a city surrounded by undrinkable harbor waters that must be inhabited by invisible parasitical marvels beyond our most fertile imagining – I am quite glad that this dinner is happening now, before you learn later that it may be a colossal mistake for you to breathe, travel, eat, or even sit next to one another.

This particular ordering of events – dinner tonight, warnings of nutritional disaster tomorrow – should be taken, therefore, as testimony to our humility, wisdom, and relish of festivity, as well as our pursuit of science and public health. Because while we care deeply about the environment and its effects on human beings, we also do recognize that we cannot control everything during every one of our waking moments. Let us, therefore, be mildly irresponsible gourmets and moderate imbibers this evening, oblivious to the invisible noxious environmental gremlins that are certainly everywhere in our midst at this very moment.

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Many of the problems – and potential solutions – that you will be hearing about are new. But they also represent something of the School's continuity and its historical mission. For instance, in 1936, at Harvard's 300th anniversary, this school had a major symposium called "The Environment and Its Effect upon Man." What were the topics? They included a panel on "Airborne Infection"; another on "Industrial Fatigue" – I'm not sure whether we've actually cured that problem, or whether we've simply resigned ourselves to living with it; then there was "Toxic Dust or Fumes"; and then something quite ominous and fancy called "Toxic Organic Vapors and Gases," which apparently infiltrated themselves everywhere at that time.

Yes, there is real continuity and some similarity in the topics

and concerns of the School, in spite of the obvious differences in nomenclature over the past sixty years. Is there also a significant change, beyond the nomenclature? I believe so. An important emphasis – not the only one, but a strong one – in some of the titles of tomorrow’s presentations, introduces the active agent “you” as well as the external objective, environmental objects around you. The focus, in other words, is not simply on the environment but also on what individuals can do through knowledge, awareness, habit, exercise, attention to nutrition, personal choice – through our *behavior*, in other words – to improve our own health and that of the larger population. We are clearly seeking ways to help purify the world outside ourselves. Yet, equally, we are trying to discover what we ourselves can do – through our behavior – to make life more healthy, productive, and satisfying.

This sense of vitality and activity – of emphasizing the active and purposeful individual and our ability to alter conditions in the world, not simply be victimized by them – pervades the spirit of the School of Public Health and its many activities. Let me offer just a few more – somewhat different – examples:

Within the last year, teams of researchers from the School of Public Health have conducted fact-finding missions to Bosnia, Iraq, Haiti, and other trouble-spots, to study and document the different ways in which political upheaval takes a toll on the health of innocent people.

Next, the School is sponsoring a pilot program in a Baltimore public school, for students in grades four through eight: it is called “Eat Well and Keep Moving.” The hope, of course, is to teach young children about nutrition, exercise, and healthy habits that can last them a lifetime.

Finally, there is a new initiative, using the media – especially television dramas – to try to have an impact on teenage gangs and violence. The initiative is aptly called “Squash It”: when individual teenagers or gangs dare one another to fight, the cool thing to do is for someone to say, “Squash it” – to interrupt the dynamics, call

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the situation to a halt, and allow the young people to disengage “honorably” by agreeing to follow a new set of rules. This program is in its early stages, but it is a promising new start.

And so I am pleased that we are gathered together this evening to celebrate this school and its programs, its commitments, and its care. As the very opposite of value-neutral it points us – and leads us – in the very directions that we ought, as a University, to follow in our various pursuits, including those of science and of health.

# *This Astonishing Technological Phenomenon*

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*Address to the Third Harvard University Conference on the Internet and Society  
May 31, 2000*

AS WE BEGIN this conference on the future of the Internet and society, we can be reasonably sure that whatever we predict is almost guaranteed to be wrong, probably by quite a wide margin. Even if, by chance, some of our ideas are right, few of us, if any, will have the wit to know it. Winston Churchill once said about Stanley Baldwin that he “occasionally stumbles on the truth, but he always picks himself up and hurries on as if nothing happened.” In thinking about the Internet, we shall do well if we can see our way to making sensible choices – and understanding at least some of their implications – to guide us over the course of the next two to four years.

Let me begin by saying that my own view is that the Internet, with all of its related technologies, has introduced the most profound and far-reaching technological revolution since the nineteenth and very early twentieth centuries, when there was a dramatic transformation in fundamental modes of communica-

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tion, in access to immense quantities of new information in new as well as old formats, and in more rapid means of travel in a more open, internationalized world. Throughout the nineteenth century, there were major shifts in the means of production, and in the structure of business enterprise and the patterns of commerce – and, with respect to universities, dramatic changes in teaching, learning, research, and the very structure of fields of knowledge.

The major inventions, discoveries, and innovations that led to this set of transformations more than a century ago are on the whole very well known. They included wired-cable, then telephonic, and then radio communications; new sources of energy that powered railroads, steamships, automobiles, airplanes, and the machinery used in the production of manufactured goods; the design of modern factory systems, which led to new conceptions and patterns of work, of management, and of productivity; and – in the world of universities, information, and learning – the invention of inexpensive large-scale book publishing, using wood-pulp paper and inexpensive binding, which soon led to the creation of massive research libraries with infinitely more information freely available to students, faculty, and others than ever before. At about the same time, modern scientific experimental laboratories began to be created for research and teaching in colleges.

These last two innovations, the creation of major research libraries and modern scientific laboratories, transformed the nature of study and learning. In fact, they changed the whole experience of, and the approach to, education. For the first time, students could be asked to do library and laboratory research on their own, to write more complicated and extensive papers. There was a much greater emphasis on teaching students to learn how to be apprentice scholars, to work more actively as explorers, rather than passively as the “receivers” of established knowledge. All of these changes created massive shifts in how universities functioned.

Nearly all the transformations that I have just described were

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accompanied by hymns of praise extolling the marvels to be wrought by the new technologies, as well as by predictions of the mass disaster we would all suffer at the hands of the new machinery. As it turned out, the human race absorbed and adjusted to everything that took place, although it might be difficult to create a thoughtful balance sheet – a calculus of credits and debits – to evaluate the net effect on society of all that happened in that era.

We know that many of the adjustments were certainly not easy. Untold numbers of people, in various forms of cottage industries and handicrafts, were put out of work. Even apparently simple things, such as learning how to travel by railroad, took more time than we might think. Many passengers tended, for example, to look out of their windows at close range, watching objects flash by rapidly, because they had previously looked out of their much slower horse-drawn carriages in exactly this near-range way. The result for large numbers of people on trains was a kind of perpetual vertigo – dizziness accompanied by uncheerful nausea. Finally, passengers began to develop and use what has since been called “panoramic” vision, a concentration on the middle and far distance, where objects and the horizon remain relatively stable and caused only modest – if any – metabolic mutations.

It is worth remembering some of the ways in which the new information and other technologies affected people’s lives, and their sense of coherence – or incoherence – a century ago, because it provides at least some perspective on the present moment. As we think about the next quarter century or half century in relation to our own set of new technologies, we can be certain that there will be some adverse changes, but we may take some heart from the fact that other eras have confronted similar problems, and yet we have, it seems, apparently survived.

In higher education, I would venture to bet that as a result of the new technologies, there will, in the next few decades, be many

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more institutions – and more different kinds of institutions – devoted to education and training. Some will be more virtual than not. Some will reach entire populations of students, at different age levels, that are mainly beyond the reach of our present education system.

In addition, the ability to deliver vital medical information, for example, about new treatments for disease, or better knowledge about serious problems in public health, or in business and law, and many other fields – that ability carries the potential to affect in positive ways the well-being of people and societies everywhere, and to do so more rapidly and less expensively than is now conceivable.

I am inclined to believe that, at least for most undergraduates and first-degree graduate or professional school students, a residential education that is founded on the ability of human beings to educate one another, through constant association – in a multitude of activities, in class and out of class – will continue to be the most powerful, stimulating, and profound available. The new information technologies can reinforce and extend – powerfully – what can be achieved in such campus-based education and research. For instance, over one thousand of our undergraduate courses already have sophisticated Web sites, with many kinds of information on them that is often unavailable in other forms. E-mail questions pass back and forth at all hours. On-line class discussion groups take place before and after face-to-face classes – and so on.

The uses of the new technologies are already affecting – profoundly – how we teach on campus, how we do research, and how we learn.

At the same time, it is hard to imagine a truly excellent education in all the liberal arts and sciences that would be fundamentally carried out “on-line.” How much real science, experimental science, could one expect to do “virtually”? Can one really do – at least in a research university – major historical work without an

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extraordinary library that has rare printed materials, as well as millions of manuscript pages (and other items) that are vital to the scholar and advanced student but are not likely to be digitized at any point in the foreseeable future?

And how do we help to inculcate important communal as well as individual values – including the benefits of a diverse student body and faculty – if we do not have students and faculty present on campus, in an actual living and working residential community where people must learn to come to terms with one another's differences as well as their similarities? How do we sustain and build an educational community where one can, in microcosm, try to achieve a greater measure of tolerance and understanding among many different kinds of people – something that the world at large will have to achieve if we are finally to manage our human affairs in ways that are peaceable, respectful, and decent?

There is, in short, simply too much of education that involves human growth and development, human interaction, and the stimulus of human debate, discussion, questioning, probing, and collaboration; there is too much that depends on the development of human relations that are real and that cannot be compensated for electronically. Given that fact, I believe that campus-based residential education is here to stay, because of its unrivaled excellence and also because it can do certain vital things that on-line or distance learning simply cannot do.

I am certain that the new technologies will have profound, long-term effects in higher education: they will lead to a greater differentiation of institutional types; they will be especially powerful in mid-career distance learning and in reaching whole populations who have essentially no access to education right now; and they will reinforce and extend the capacity and quality of the very best in undergraduate residential education, rather than replacing the on-campus experience.

For all the other ways in which these technologies will alter

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our lives, I leave to our other conference speakers. I thank you all for coming – and thank you for contributing so much to our collective effort to understand this quite astonishing technological phenomenon that now lives among us and with us.

