

The Fruits of Science and Serendipity

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.