# Text of William Hewlett's commencement address

*(Editor's note: The following is the text of the commencement speech delivered by William R. Hewlett SM '36 to MIT's 120th graduating class. The speech is entitled "Random Thoughts on Creativity."*

It's a very great pleasure to be with you this morning, particularly because it's been exactly 50 years since I walked across this stage and was given a piece of paper that said I was a master of science. In those 50 years, I have been intimately associated with the creative process that is so important to our modern, high-technology culture. I felt it might be appropriate, therefore, to share with you some random thoughts on creativity and its importance in today's society.

When I was preparing this address, I happened to ask Chuck House, who heads our engineering productivity program, what he thought about creativity. With a twinkle in his eye, Chuck said, "Creativity is what screws up my engineering program." Unfortunately, there is much truth in that statement.

Thomas Edison is alleged to have remarked about his laboratory, "There ain't no rules around here. We're trying to accomplish something."

I cite these two comments because they say a great deal about the creative process. It works best when it is not too structured, but it must, in the long run, be tamed, harnessed and hitched to the wagon of man's needs.

But first let me set a background for this country's renewed interest in innovation and creativity. By 1983, it was increasingly evident that we were losing the competitive edge that for so long had characterized the American Economy. To better understand this problem, President Reagan created a high level commission of distinguished business leaders and educators to ". . .review means of increasing the long-term competitiveness of United States industry at home and abroad, with particular emphasis on high technology. . ."

After an in-depth study, the commission concluded that we are not meeting the competitive challenge well enough. It stated, "Our ability to compete in world markets is eroding. Growth in US productivity lags far behind that of our foreign competitors. Real hourly compensation of our work force is no longer improving. US leadership in world trade is declining. Finally, pre-tax rates of return on assets invested in manufacturing discourage investments in this vital core of our economy."

One of the commission's primary recommendations was to "Create, apply and protect technology. Innovation spurs new industries and revives mature ones. Technological advances lead to improved productivity, an essential ingredient for our standard of living."

In essence, this recommendation was two-fold — to create technology and improve productivity.

How do I define creativity? Nobel Prize winner Albert Szent-Gyorgyi provided a good working definition when he said, "Discovery consists of looking at the same thing as everyone else and thinking something different." I think that is a good enough summary to cover much of what I want to comment on.

The trouble is that creativity is really a poly-faceted discipline.

Trying to describe it in detail reminds me of the story of the three blind men who attempted to describe an elephant solely by their sense of feel. One explored the trunk. One discovered the tusks. The third explored the animal's enormous feet. But none really had a good picture of what the whole animal looked like. I would like to describe my "elephant" — creativity — as I have had a chance to observe it over these years.

First, let me make one general comment about creative people. Education is not a *sine qua non* for being creative.

A case in point is that of a most successful engineer who worked for Hewlett-Packard company for many years. Despite the fact that he had completed only one year of college, he was one of the most creative people I've known. You could present Larry with the most difficult problems and he'd come up with ingenious solutions. He had the ability to isolate the essence of the problem and attack it with vigor. It was such a pleasure to talk with him about his work — he just bubbled over with enthusiasm. Many of his ideas are still incorporated in a number of important products we manufacture.

It is very difficult to spot a creative individual just by looking at a resume. Psychologists can't even agree on how to measure this characteristic, let alone predict who will display it. Establishing an environment that fosters creativity and observing who flourishes is probably the best way of finding this elusive characteristic.

I'd like to distinguish between two kinds of creativity. One is spontaneous, in which an individual sees a complete and elegant solution to an interesting problem.

The other I call "creativity on demand," in which specific objectives are established and must be met, but with a great deal of flexibility in how the results are to be achieved.

Both types of successful innovators share many common traits. Creative people have an abiding curiosity and an insatiable desire to learn how and why things work. They take nothing for granted. They are interested in things around them and tend to stow away bits and pieces of information in their minds for future use. And, they have a great ability to mobilize their thinking and experiences for use in solving a new problem.

Problems, however, are rarely solved on the spur of the moment. They must be organized and dissected, then key issues isolated and defined. A period of gestation then sets in, during which these issues are mulled over. You put them in your mind and consciously or unconsciously work at them at odd hours of the day or night — even at work. It is somewhat analagous to trying to place a name on the face of someone you've met before. Often the solution to a problem comes to you in much the same way you eventually recall the name.

There is a sub-class of creative individuals that not only has the ability to see things around them, but also to note that which differs from the norm.

A good example is Sir Arthur Fleming, who discovered penicillin. His story is familiar to many of you.

He first noted that when a mold had landed on a culture dish with colonies of Staphylococci, the colonies adjacent to the mold were killed. Many other scientists may have had this same problem but it was simply passed by. In fact, Fleming himself remembered such a previous occurence, but this time became more interested and concluded that the mold must have secreted something that was toxic to the bacteria and, if so, that "something" might be beneficial in the treatment of human infection. Thus, the drug penicillin was born.

I have observed the same creative phenomenon and the same questioning mind a number of times. A few years ago, a young British engineer who was working for us was investigating the characteristics of a new semiconductor device. It performed basically as expected in all the tests, but Frank noted that there seemed to be an excess of "noise" in his measurements.

He completed his project, but was still curious. He decided to look into the source of this excess noise. With the aid of a newly developed measurement technique, he discovered that the "noise" was in fact a very high order harmonic train — in a sense, an electrical analog of a water hammer. This proved to be a very important discovery for certain nanosecond measurements. In fact, it made practical the very technology that was used to identify it.

Intellectual curiosity is a great source of creativity. An example of this is demonstrated by Nobel Prize winner Luis Alvarez, a long-time member of the Hewlett-Packard Board of Directors. While visiting Egypt, Luis became interested in the fact that no major burial chamber had been found in the pyramid of Khephren and began to muse about how one might determine if such a chamber did exist. Luis was familiar with cosmic rays and knew they might be suitable for X-raying the pyramid.

Careful investigation led him to conclude that if he had been asked to design a proper radiation source for this purpose, it would have been the Mu Meson, an important component of cosmic rays emitted by the sun. It exactly fitted the need.

An added bonus was the fact that under the pyramid was a chamber that extended the full length of the base, in which he could locate his "film;" that is, a series of detectors that could measure the stregth of the Mu Meson, as well as their direction of arrival.

With these thoughts in mind, he went to the chancellor of U.C. Berkeley who, on the basis of Luis's analyses, provided a small amount of money to carry out the experiment. I mention this because it is a good example of how a little effort can encourage a creative person. This study was not a normal function of a physics department, nor was financing it that easy. It was just a fascinating subject that the Chancellor thought might add to man's knowledge of the past.

Luis also received the enthusiastic support of the Egyptian government and the experiment, in due course, was carried out. No chamber was discovered, yet the experiment was successful because Luis was able to prove that there was no such chamber.

Another example is that of an HP scientist who was a specialist in designing quartz crystals used to generate extremely accurate time standards. The accuracy of such reference crystals is very sensitive to changes in temperature and mechanical force. Much of the existing technologies used to stabilize these crystals has to do with minimizing the effects of these two variables.

Don took the opposite view. He thought, why not use the intrinsic sensitivity to temperature as a way to provide a digital measure of temperature? Normally the frequency change was not a linear function of temperature, but Don devised a technique to linearize this relationship to about a tenth of a degree over a range from -40 to 200 degrees celsius, and with a resolution of about ten thousandths of a degree.

A major advantage of this technique was that the sensing element could be located as far as 10,000 feet from this measuring instrument, with no loss in accuracy.

In similar fashion, he produced a quartz transducer that operated at pressures up to ten thousand pounds per square inch with an accuracy of about a twentieth of a PSI and a resolution of a thousandth of a PSI.

This device has been used extensively in oceanographic studies and for measuring differential pressures in oil fields to determine the best pumping strategy.

Basically, I've been talking about creativity applied to research-type situations. Let me now turn to the development phase, the "create on demand" type of creativity. Here, creativity's role is slightly different, as mentioned earlier. There is now a clearly defined objective and the job is to find a way to meet that goal.

This is the type of creativity about which much has been written, primarily because there are techniques to stimulate and enhance it. One book on the subject I greatly enjoyed was "Conceptual Blockbusting" by James L. Adams. His title suggests that we all suffer from mental blocks that stand in the way of solving the problem at hand. These might be emotional blocks such as fear of failure, frustration or too much or too little motivation. They may be perceptual blocks such as using incorrect information or the wrong method, or not using all your senses. Quite often, they are culture blocks which sometimes can be the hardest to overcome.

I think this is an area in which younger people have a tremendous advantage, since, as you well know, they have an endearing habit of always questioning past wisdom and authority.

They say to themselves that there must be a better way. Ninety-nine times out of a hundred, they discover that the existing, traditional way is the best. But it is that one percent that counts. That is how progress is made.

A wonderful example of the desire to break out of the rigid tradition of the past would be that of the French impressionist painters during the latter part of the last century. The most important works of these painters had been excluded from the salons, held in paris nearly every year under the auspices of Les Academie Des Beaux-Arts. The salon juries refused their works because they did not follow the tradition of the Academy schools.

Finally, in 1874, the impressionists, many of them in their twenties and thirties, banded together to share the costs of exhibiting their own controversial works. A series of eight of these impressionist exhibits were held, and by 1886, the impressionist school was well established and recognized.

But to return now to the mundane world of R&D. . .

Projects do not always progress at a steady, uniform rate. Sometimes progress is stymied by a very difficult problem. The problem might be overcome by a clear, technical breakthrough, but more often than not, it is bypassed with a compromise solution I like to call a "hot patch." If there are too many of these "hot patches," you'll probably wind up with a very cumbersome solution to the problem.

My company often employs retired engineers or scientists on a part-time consulting basis. One such was Harald Friis of Bell Labs. I'm sure some of the electrical engineers in this audience are familiar with his book on antenna design.

Harald and his wife would come to California during the winter months and spend time in Palo Alto. Harald enjoyed visiting with our engineers in the laboratories. Frankly, he didn't know beans about modern transistor circuitry, but he knew how to think about the development process and he loved to work with engineers who felt that they had reached a dead end on a project.

He could get them to step back and view their work as a whole. He would ask, "What are you really trying to do? Are you on the right track, but feel you have too many hot patches?" or, "are you really on the wrong track and need to make a fresh start?" This can be the toughest judgement call a development engineer may have to make. Harald was just wonderful in helping our engineers reach this critical decision. He had a way of making a person see things in perspective and the engineers just loved him.

We always try to encourage this kind of interaction in the labs between generations because experienced engineers can be very helpful in the developmental process. In this exchange of ideas, I have often seen younger researchers learn new ways to harness and use their creative instincts.

In practice, spontaneous creativity and the normal development process are often intertwined and may, in fact, seem to conflict. Witness Chuck House's comments, referred to earlier.

There is a time and place for creativity, but in the developmental process, timing sometimes outweighs technical innovations. It all comes back to the question of how often you can change course and still make forward progress. It is simply a matter of judgement.

I remember when we were trying to bring out our first scientific desktop calculator. Integrated circuits were just being introduced and we had to decide whether to delay the entry of the product so that we might use IC's or go ahead and introduce it with a primative, but proven, read-only-memory device. We chose the latter. Timing was the dominant factor and not the "niceness" of the solution.

I've talked enough about the creative process in the R&D phase. Now, let's look at how creativity can help increase productivity and improve quality. This challenge clearly defined by the findings of the President's commission that I mentioned earlier. Modern technology must be used to improve productivity. We need the same creative effort in the production process that we now lavish on the development phase. We must start by having productivity and quality as objective in the research and development process. Productivity must be designed into products — not added at a later date. Quality cannot be "inspected in."

There is already a great deal of technology readily available that can be used to improve quality and manufacturability of a product. In many cases, however, US industries are not taking advantage of this knowledge, although much of it originated in the US we need new ideas and new leadership in this quest. Here, the universities have a very real responsibility. I don't mean that they should go back to teaching forging, foundry, machine shop and drafting, subjects that I had to take as an engineering student.

But our universities do need to provide a theoretical base for quality and efficiency in the manufacturing process. I was delighted to learn that this trend is already under way at this institution. But, after all, what else would you expect?

I hope I've made it clear that creativity will play a vital and critical role in our increasingly high tech society. Our company's president, John Young, puts it this way: "Creativity is the only American competitive advantage left." Industry is going to have to make some drastic changes in how it views the importance of the research and development program and the necessity of increasing productivity. Changes are never easy to make. There is comfort and safety in tradition, but change must come, no matter how painful or expensive it may be.

From your standpoint, this situation is anything but bleak. Personal advancement in a static company or a static industry can be slow and difficult. Change, however, opens cracks in the most monolithic structures. It presents a period of great opportunity, for this is the time when the best and the most creative minds will be sought out and placed in positions of key responsibility.

In the high-tech field, top leadership is always looking for good minds, high energy levels and a willingness to accept responsibility. In fact, our company is so dependent on creativity that we are still emphasizing the recruitment of engineering graduates, even though a hiring freeze is in effect for the rest of the company.

It may well turn out that the present period will be looked back on as one of unprecedented opportunity for the scientifically minded. I hope so. I wish you success, happiness and great bursts of creativity in all of your endeavors.

# Text of President Gray's address

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saved, I was tempted to extend my remarks, but on this day I — like you — take my marching orders from the Commencement Committee. And so I will be brief and, if I may, a bit more serious in these final remarks to you.

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While your horizons may seem limitless at the moment, the world you enter is, in many ways, much smaller than the world of your ancestors. In recent decades, time and space have become compressed — the result, in large measure, of scientific advances and technological innovation. I think particularly of the influence of electronics and physics on international security and communication. Today we are able to speak, hear, see, and reach across vast distances, even into space. We push time around in our travels. And the consequences of each act reach further and faster than ever before.

Contrast this with the state of the world at the time of this country's founding — just two centuries ago. In the spring of 1775, there was a battle involving fewer than two hundred men on Lexington Common in Massachusetts. Shortly after that, there was another battle in nearby Concord. Out of those battles began a war for independence that changed forever the nature of this continent, changed forever the nature of the relationship between the individual and the state, and changed forever the relationships among nations.

But is was more than two months before the House of Commons in London learned that anything had happened.

Now consider our circumstances today. In the spring of 1986, something occurs in Chernobyl, in Soweto, or in Libya and, if we don't see it happening live on television, we surely see it replayed and analyzed on that evening's news. This instantaneous quality of communication — about events, about ideas — is a product of technologically-driven change. At the same time, it is an engine of change — as people and governments act and react on a time scale that would have been impossible two hundred, even fifty years ago.

I was struck by a recent essay in *The New Yorker*. The author, commenting on the waves of fear generated by political clashes halfway around the globe, said:

"We know that a universal geography, discovered by modern physics, cancels out the human, earthly geography that has always given us our feeling of safety. In the scale of the new geography, in which distance is measured in light-years, and explosive power is measured in millions of tons of TNT, blue oceans lose their immensity, and the earth itself shrinks to the size of a pea. In the scale of that geography, which is the essential geography of our time, the boat that burns in the water. . .is no farther away from us than the television screen in our living room which shows us the scene."

This compression of time and space will require of you — more than any previous generation — an ability to take the long view in your personal and professional decisions: a perspective which embraces contrasting values and cultures, which unites an understanding of the contemporary scene with a sense of history, and which keeps faith with human potential. When space and time were virtually unlimited, there was, on the one hand, more time for thoughtful consideration of alternative courses of action, and on the other, less urgency for people to evaluate their acts in terms of distant countries or later generations. Now this perspective — this long view — must be constantly before us, must be part of us, for we know that what we do today will affect not only our contemporaries near and far, but tomorrow's children as well.

The right decisions will not always be obvious, will not always be easy. But the choices you make in your life will be sounder if you can bring them the sense that knowing *why* is as important as knowing *how*.

I hope that your years at MIT have given you some of this wisdom. I do not pretend that an MIT education — any college education — can give you more than you bring to it yourself. You are a great company of ambitious, intellectually curious, witty, even charming, high achievers — and you learn as much from each other as you do from your faculty. If we have been able to help you continue to learn and build on your God-given talents, and to expand the universe of your intellect and feelings, then we have done our job.

Perhaps the best way for me to explain my hopes for you is to recall one of our graduates who was a shining example of the extraordinary quality we have come to expect of those who have been part of MIT. I speak of Ronald E. McNair — one of the Challenger astronauts, who received his doctorate in physics from MIT just nine years ago. Ron's life was one of stellar achievement, bright promise, and clear vision. Speaking of his view of the earth from space — and he, if anyone, had a long view — he said:

"Truly there is no more beautiful sight than to see the earth from space beyond. This planet is an exquisite oasis. Warmth emanates from the earth when you look at her from space. . . . My wish is that we would allow this planet to be the beautiful oasis that she is, and allow ourselves to live more in the peace that she generates."

Ron gave much of himself to MIT and to the people of MIT, and he was a symbol to a whole generation of young people around the nation of the best qualities that I can hope for you. In February, the MIT family came together to remember and to honor him. I am pleased today to report another form of recognition which we are privileged to give. This morning, the governing board of the Institute voted to name the building that houses MIT's Center for Space Research after Ronald E. McNair.

The faculty, students, and staff in this Center are dedicated to exploring space and understanding the cosmos, and nothing could be more fitting than to have Ron's name — and his spirit — associated with that mission and this campus. The McNair Building will stand as a permanent reminder to future generations at MIT of the grace and significance of extraordinary achievement tempered by an uncommon wisdom and an abiding love of humankind.

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I could wish no better model for you. As you undertake this next stage in your lives, I wish for you a life that is rich in opportunities to stretch your talents, your interests, your imagination, and your vision of this small planet as a beautiful oasis . . . generating peace.

And as you depart from this special place, I wish you good luck and Godspeed.