ON SEEING . . . AND THINKING . . . .

Phi Beta Kappa Initiation Address, May 15, 1987
State University of New York at Buffalo
Elaine M. Hull

I am delighted to be able to share this important occasion with you, and to reflect for a few moments on your college experiences and their impact on the rest of your life. This is no small task! It is hard to know where to begin. Perhaps the best place to begin is with you yourselves. In order to be here today, you must have some impressive intellectual and personal characteristics. That applies to all the parents who are here as well. If I may rephrase John Donne slightly, "No person is an island"; it is fitting that parents, friends and teachers should share in this moment of triumph and leave-taking and beginning.

In trying to characterize the qualities that you exhibit, several came to mind: creativity, intellectual precision, willingness to work, and intensity. I think that there is a thread connecting all of these qualities, and I'd like to explore both the qualities and the connections.

Let's start with creativity. Albert Einstein once observed that creativity consisted in "seeing what others have seen, but thinking what no one else has thought." This applied most immediately to his conception of the Special Theory of Relativity. It is said that his first conception of this theory arose from a visual image of a man jumping off a roof carrying a ball. He observed that the motion of the ball could be specified with respect to two different points of reference: the roof, away from which it was moving at a predictable speed, and the man, with regard to whom it was perfectly still. We have all jumped down from chairs, tables, trees, or roofs, perhaps sometimes carrying a ball, or a hammer, or a cat retrieved from the garage roof. However, doing so has never made me postulate anything very remarkable, much less the Special Theory of Relativity. Einstein's insight was remarkable.

There are several ideas here worth pondering. First is the part about seeing what others have seen. The visual nature of the insight is important. Einstein saw a man jumping from a roof carrying a ball. He has observed most of his insights were based on this sort of visual "associative play." "Conventional words or other signs have to be sought for, laboriously, only in a secondary stage, when the associative play is sufficiently established and can be reproduced at will." It's essentially a perceptual reorganization—like the reversing staircase illusion. You can see the staircase from above as descending: and with a flip of the mind, you are beneath the staircase, watching its steps rise above you. That perceptual reorganization is part of good science and good art. O. Henry was noted for his perceptual reorganizations created in the last lines of his short stories, and much art work turns on a recasting of the ordinary into an extraordinary perspective. The process can be characterized as play because it is frequently achieved with apparent effortlessness, and the insight is not only satisfying, but fun. The spirit soars, and a little voice inside is heard to chuckle or even laugh out loud.

The second part has to do both with the ability to make such a perceptual leap, and with the ability to spell out its implications logically and clearly. This is where the intellectual precision and willingness to work comes in. Seeing what others have seen includes looking carefully and thoughtfully at the world, observing its rich detail—watching the movement of a bird's wings, or the unfolding of a tulip, or the way in which people in different cultures relate to one another.

However, it also has to do with compiling a great deal of information to form the foundation of a perceptual shift. I'd like to start with a rather simple example of the way this works. In our home we have a rubber tree. For years it was a spindly, straight, and rather uninteresting plant. It was also a favorite scratching post for our cat. One day we noticed a new sprout emerging from the main trunk, and were pleased that the plant was taking on a more interesting shape. Months went by, and the new branch became full and sturdy, and I forgot about it. One day at dinner, our son, who was taking junior high biology, noticed that of course the sprout emerged at just that place, just below the worst cat scratches, because the scratches had interrupted the xylem and phloem tubes that carried inhibitory auxins from the growing tip of the main trunk.

The area of the sprout was protected from those inhibitory influences. Of course! Why hadn't I thought of that" I hadn't thought of that because my formal encounter with xylem and phloem and auxins had occurred many years before, and was not at hand to direct my perceptions. That's one thing that a liberal education can do—provide a wealth of systematic information about a wealth of topics. I still don't

know how a tree *without* cat scratches manages to form branches: maybe some of you can inform me later. However, I am much more aware of the pattern of branches than I was before.

I have another example, this time from my laboratory. We study the pharmacology of sexual behavior of male rats. Before you rush to offer a Golden Fleece Award for our research on "rat porn", let me point out that similar pharmacological principles seem to apply to humans, and there is the likelihood of a clinical application to human dysfunctions. One of our major hypotheses is that the neurotransmitter dopamine, in a very small area at the base of the brain, is very important for male sexual behavior. Men treated with drugs that enhance dopamine function frequently report enhanced libido and potency, and male rats given the same drugs copulate with increased vigor. Conversely, drugs that block dopamine, have the side effect of impairing these functions. Side effects occur because dopamine is used at many sites in the brain, for several different functions. (The body is very clever at using a given messenger to carry many types of message.) When drugs are given systematically, they reach all of those sites and affect numerous functions.

Back to our hypothesis: If we could destroy only the dopamine terminals in that one tiny area of the rat brain (about 1 mm in diameter), we should observe impairment in sexual behavior. One of my graduate students wished to take this as the first of a series of experiments for his dissertation. He carried out the procedure impeccably, tested the animals a few days later, and observed that every one of the animals copulated with at least as much vigor as did control animals that had no lesion—if anything, they were perhaps a bit <u>better</u> than the controls. Before proceeding any further, we had to know whether our hypothesis was really wrong—whether dopamine in that area of the rat's brain had very little to do with sexual behavior—or whether the brain had found some way to compensate for the effects of the lesion.

An "aside" is appropriate here. The business of science can be advanced by negative findings, just as with positive ones. If the question is skillfully asked, and Nature's answer is carefully noted and interpreted, then an answer of "No, that is not the case," is an interesting finding. However, by this time we had accumulated considerable evidence consistent with our original hypothesis. If that were wrong, we had a lot of explaining to do to reconcile our previous positive results with the present negative one.

Back to the experiments. The graduate student was able to show that, indeed, the brain had compensated for the effects of the lesion. The remaining, undamaged, terminals very cleverly increased their output of dopamine to compensate exactly for the lost terminals. When this increased output was blocked with another drug, the expected deficit occurred. This showed that the recovery of function depended at least in part on the increased output. In addition, the neurons that <u>received</u> dopamine became supersensitive, so that less transmitter, or less injected drug, was necessary to produce a given effect. It finally made sense: The reason that the animals with lesions actually seemed to copulate more effectively than control animals, is that the brain had doubly compensated for the lesions. As much dopamine as ever was being released, and it was being taken up by supersensitive receptors. It is interesting that similar compensation is thought to occur in Parkinson's disease, which is due to degeneration of a different dopamine pathway. In Parkinson's disease at least 80% of all the neurons in that pathway degenerate before even subtle symptoms are observed. It seems incredible, but the brain can compensate for a loss of 80% of the neurons in some structures, if that loss is gradual. The brain is, indeed, a remarkable, and in many ways very resilient organ.

This is another example of a perceptual shift. A <u>dis</u>confirmation of a hypothesis was turned into a confirmation. Furthermore, the final result was not <u>simply</u> a confirmation of the hypothesis that a certain group of neurons are important for a behavior. We also learned more about the brain's ability to recover from damage. That, too, may have clinical implications. However, it required a log of knowledge and a lot of skill to effect that transformation.

I'm sure this sort of thing has happened to each of you. You encounter a problem that appears to be insoluble, or at least unsettling. You work at it mentally, viewing the various pieces from different perspectives, "playing" with them, fitting them together in different ways. Finally, a new order emerges—sometimes in an apparent "flash", but more frequently as an emerging process. The value of problems and difficulties is enormous. I is frequently when something <u>doesn't</u> work that we are forced to try something new. At the risk of sounding like Peter Sellers in the 1979 Film, BEING THERE, I'll observe than when a plant is root-bound, it is time to free the roots and put the plant into a bigger pot.

I think that one of the great services this University has provided for you, for the past four years, is to give you a <u>lot</u> of problems! There have probably been times when three exams and two term papers were due on the same day. There have been volumes of reading, volumes of writing, and an indefinitely large

number of math problems. You may have asked yourself why you had to memorize the ancient kinds og England or the molecular structure of all the amino acids.

I propose that there are three sources of value in all that work. First, it has given you the detailed background to look carefully at the world, and see what others have seen. That applies to the arts and humanities as well as to the natural and social sciences. You are equipped to look at the whole world, not just a narrow slice of it. Furthermore, if you have to learn a great deal of information, that information must be organized in some way. You have undoubtedly had a lot of experience organizing information. You have "learned how to learn," if I may use a term from psychology.

Second, it has given you some conceptual challenges-—at least every now and then—to help you think what no one else has thought. I suspect that you have made several perceptual shifts along the way. That, too, is a skill that can be learned, and can be improved with practice.

Third, and finally, I'm sure that your experiences here have taught you something about yourself. We can apply the same concepts of seeing and thinking to our knowledge of our internal world, as we can to knowledge of the external world. Erik Erikson has observed that our lives typically progress through stages, with something very much akin to perceptual shifts that allow movement from one stage to the next. Frequently, the college years are a time in which a sense of personal identity is achieved, leading the way to a new stage of commitment to a profession and to another person. There is such a barrage of experiences—work to be done, personal relationships to establish, attempts to balance a need for privacy with a need for sharing. Just as seeing what others have seen in the outside world requires extensive garnering of material, so does seeing what is inside require extensive experiences, trial and error, decisions as to which elements fit and which don't fit. A liberal education may help with this, even thought the process is an intensely personal experience. Just as comprehensive and detailed seeing may lead to perceptual shifts in the external world, so it also may lead to shifts in the inner sense of self.

Furthermore, the commitments made now are sure to evolve further as new experiences and new insights are incorporated. Ideally, the personal and professional commitments evolve along with the sense of self. But, sooner or later, a new perceptual shift will probably occur. The trick is to recognize it, to see all of the elements, to poke, prod, and reorganize them into a satisfying whole. If your liberal education here has facilitated that process, if it has provided you with enough details about enough different subjects, and given you enough problems, and stimulated you both to see fully and to think fully, and I might add, to experience fully, then it has been a success. Congratulations!