

The 476th Convocation

Address: "There's Treasure Everywhere"

By Thomas A. Witten

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My son Mark is about the same age as you graduates. When he was a kid, Mark was passionate about the *Calvin and Hobbes* comic strip. Calvin is a scrappy little boy and Hobbes is his stuffed tiger. One of Mark's *Calvin and Hobbes* collections features a picture of Calvin digging madly in the dirt, discovering a worm, and shouting, "There's treasure everywhere!" Another passion of Mark's was the movie called *The Matrix*. You have probably seen it. In this movie, we are told that the reality we see is an unreal projection that we can learn to look beyond. The hero, Neo, learns to bend a spoon by just seeing it differently. I must confess to catching some of Mark's fascination for these delusional heroes of his, and I would bet many of you were intrigued as well. I think we are fascinated because we see a kernel of truth in Calvin's and Neo's delusions. And I think this kernel of truth is connected to why we are here today.

We are here to celebrate the intellectual attainments of graduates, attested by your hard-won academic degrees. These degrees have worth because we value knowledge and the pursuit of knowledge. Professors like me are in the business of developing knowledge. Students like you spend time here because you see value in knowledge and in the efforts of professors to get knowledge. Our common adherence to the cause of knowledge is pithily expressed in the University's Latin motto, which I like very much. You can see it in tiny print on the logo in your program. Literally, it says: "Let knowledge increase so that life may be enriched." In its deadpan optimism, it evokes an inevitable, organic process, like some giant redwood tree growing tall over the centuries—giving shelter to birds, nourishment to the soil, and oxygen to the biosphere. For us in this chapel, the ideal of steadily growing knowledge is right up there with motherhood and apple pie. You graduates and I have been hitting the books for much of our adult lives in the service of this ideal.

This motto was coined in 1912, when the University and the nation were younger and the growth of knowledge and progress seemed as inevitable as the motto says. Nowadays though, the reality,

the desirability, and even the feasibility of steadily growing knowledge is more and more called into question. The feasibility of indefinitely growing knowledge is enough to give us pause in our postmodern world where there is so much knowledge already. Knowledge—especially scientific knowledge—has advanced greatly since 1912. How long can this go on? This feasibility of indefinitely growing knowledge is what I want to talk about in the next few minutes. How much knowledge is left to discover and where is it to be found?

Scientists like me were brought up to imagine science as a body of knowledge that has frontiers. In my field of physics those frontiers lie in pretty rugged and inaccessible territory, and it requires a major effort for my colleagues to reach them. They reach to a frontier of time extending into a past where the universe was only a minute old. They reach to a frontier of temperature that is a hundred billion times colder than this room in one direction and a hundred thousand times hotter in the other. My colleagues in other fields could cite as many impressive frontiers in their domains of study.

These rugged scientific frontiers give credence to a notion implicit in the concept of a frontier: the frontier separates a region where more or less everything is known from a region where more or less nothing is known. To think of knowledge in this way is a metaphor that seems to have come from the seventeenth century, when the New World was rapidly being discovered. Francis Bacon in 1620 made the analogy between the state of geographic knowledge and the state of knowledge generally. Bacon wrote, “Surely it would be disgraceful if, while the regions of the material globe—that is, of the earth, of the sea, and of the stars—have been in our times laid widely open and revealed, the intellectual globe should remain shut up within the narrow limit of old discoveries.” He wanted to push out those frontiers of knowledge.

Since Bacon’s time, those frontiers have been pushed out quite a ways. But with this advance has come an implicit attitude about science that is misleading. Let’s suppose that the metaphor is valid and science really is like geography. Then it follows that discoveries must become increasingly scarce and inaccessible as the known region expands. Geographically, the age of discovery ended long ago. Must it not be the same with science and other knowledge? Even if the world of knowledge is not bounded like the globe, mustn’t its frontiers recede further and

further from reach as more is discovered?

No, science is not like that. Certainly, there are wonderful things to discover at the outer frontiers like the early universe that I mentioned earlier. But the familiar world far from such frontiers is also bristling with things to discover. I believe that even in the familiar world practically everything is waiting to be discovered. This belief shapes my research and that of many of my colleagues. We find new discoveries in areas that the frontiers of knowledge swept over a century or more ago. We are like the little comic strip boy Calvin playing in the dirt, discovering earthworms and iron filings.

Let me try to convince you by giving a few examples. These were fundamental discoveries that could have been made hundreds of years before in domains long believed to be thoroughly known. The first example takes place on an English pond in the late eighteenth century. A dowdy gentleman named Benjamin Franklin gently pours a spoonful of oil on the surface of the pond and watches it spread. The oil spot spreads wider and wider and grows thinner and thinner. And then it stops spreading. Franklin's observation indicates that the oil is made of discrete units that we now call molecules. The spreading has to stop when the thickness has decreased to a single layer of these molecules. By comparing the amount of oil in his spoon with the size of the oil spot, one can get a rough idea of how big the molecules are. Philosophers since the ancient Greeks had speculated about whether matter was composed of discrete units. This absurdly simple experiment made them apparent.

The second example is something you can do right now while you are sitting there. Put your two index fingers together and look at your left fingertip with your left eye shut. Now move your right finger away. Though you are still looking at the left fingertip, you can easily see both of them. But when you have moved your finger about six inches away, something funny happens. The top of your right finger disappears. When you move it even further away, the fingertip reappears. Clearly there is a blind spot in your vision that was there all along. This fact is before our eyes every day, yet we can easily live our whole lives without realizing it. Who knew?

The third example is a discovery made by a University of Chicago colleague only a few years

ago. He noticed something puzzling about the ring-shaped water stains on his dishes and kitchen counter. The stains are residual deposits of material originally dissolved in the water. We have all seen them a thousand times and not noticed anything puzzling about them. But on reflection, it is puzzling: the dissolved material starts out mostly in the middle where the drop is thickest, but it ends up very strongly concentrated around the rim. What makes it flee so strongly from its starting position? The answer is that the evaporation of a drop forces the water to flow outward, carrying the material with it. The laws that make this happen are as simple and inevitable as the principle of the siphon. Like the siphon, they are also very useful. But no one had realized them until a few years ago.

I hope these examples convince you that knowledge is not to be gained merely at the outer frontiers but everywhere we look. You may ask, “Why weren’t these things discovered before, since they were right under our noses?” The answer seems clear: the main obstacle to discovering something lies not in getting access to the thing discovered, but in recognizing what is before us. Our reality is completely focused in the familiar territory of what we know. Like Neo in *The Matrix*, we seem to need all our wit and a lot of faith to glimpse anything beyond this familiar reality. Though I took my examples from the physical phenomena I know best, the conclusion seems to apply to any realm of knowledge. We all know many examples of thinkers and artists who made us see what had been unknown and invisible, from Mozart to Monet to Marx. The conclusion that knowledge is everywhere has an upside and a downside. On the downside, it shows how blind we are in our groping pursuit of knowledge. On the upside, it suggests that there is a lot left to discover. If such remarkable things went undiscovered for so long, who can say what amazing discoveries still await?

It seems that we need to modify our geographic metaphor about the frontiers of knowledge. We should not think of the realm of known things as a smooth, bounded region like a continent. Here is another image that might be more appropriate. Think of all possible knowledge as a straight line on a piece of paper. Now erase the middle third of the line, leaving two remaining thirds. Then erase the middle third of these two pieces, creating four smaller pieces. Next, erase the middle third of these four pieces. Keep on erasing *forever*. You will not erase everything, but you will erase almost everything. What remains of the line after this process is called a Cantor

Set. This Cantor Set is a possible metaphor for our actual knowledge. Its frontier is everywhere. Everything known is right next to an infinity that is unknown. The trick is to be able to see it.

All of us sought out the University of Chicago as a place to invest years of our lives partly because here the accessibility of new knowledge is demonstrated every day. Every day here we see people reaching out and gathering new knowledge, opening their eyes and seeing it. In this atmosphere, we come to believe that we can do it, too. This spoon-bending faith that allows us to create knowledge may be the greatest thing we give our students. After spending your years here, you may believe the world is running out of energy, territory, clean resources, or time. But we are not running out of wonderful things to discover. To quote Calvin, “There’s treasure—everywhere.”

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