Dr. Craig B. Thompson

450th Convocation Address: "Better Living through Biology?,"

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"Better Living through Biology?"
by Dr. Craig B. Thompson

It is a great privilege to address this audience on such an important occasion. For the graduates, this is a time of excitement and celebration. You can be justifiably proud of what you have accomplished and can look forward to a new beginning. The audience, too, has much to be proud of. Your friends and loved ones are being honored for the successful achievement of a longsought-after goal, a goal that would not have been accomplished without your support.

As a faculty member, however, I look on this day with mixed emotions. Each of you, the graduates, has contributed more than you can appreciate to this community of scholars through your enthusiasm, energy, and eagerness to learn. Your presence will be missed by those of us who stay on at the University. For a professor, convocation also brings on a feeling of anxiety. Have we, the faculty, been successful in helping you to obtain the necessary skills to be successful in your future endeavors? As you graduates have learned, the University takes its academic mission seriously. During your time here, every attempt has been made to turn each new experience into an opportunity for learning. I suspect that this is why the University has a policy that a faculty member always gives the convocation address. It gives us one last chance to add to your education.

In beginning this final lecture, it is useful to consider what you have learned here. As a result of your studies, you know a massive amount of factual information. In the upcoming weeks, you are sure to dazzle your family, friends, and future employers with the knowledge you now have at your command. You have also learned how to acquire and assimilate new information. It is the development of the skill to learn new concepts that has been at the heart of your education here. How well you are able to apply that skill to your future endeavors will determine whether your experience here has been worthwhile. Many of the facts that you have learned will soon be outdated by the rapid advances being made in information and technology. In fact, it is the very pace at which technology advances that places a premium on the ability to learn.

Let me provide you with an example. My father gave me a slide rule when I graduated from college. At that time, a slide rule was the most sophisticated mathematical tool owned by most scientists. It was essential

for performing scientific calculations. Most of today's graduates would neither recognize a slide rule nor know how to use it. Today, the use of a slide rule has been all but eliminated. Scientific calculations are now performed on increasingly sophisticated computers.

In college I attended a lecture given by the college president, a noted mathematician. In this lecture he warned us of the coming of the computing age. To prepare us, our school was the first in the country to provide all students with the opportunity to be trained in the latest computer technology. I learned to program in the now almost extinct language of Basic, and I learned how to store my computer files on paper ticker tapes. My classmates and I left school confident that we had all the skills needed to deal with any computer we might encounter in the future. At the time we were unaware of a computer pioneer named Gordon Moore who had just described what is now known as Moore's Law. In the late 1960s, Moore had noted that in the preceding twenty years the power and sophistication of computers had doubled every eighteen months. Moore predicted that this exponential increase in computing power would continue for many years into the foreseeable future. Based on Moore's observations, some computer scientists went so far as to predict that, someday, there might be computers in private homes.

Well, it turns out that Moore has been right. The computational powers of computers have grown over ten million-fold in the last thirty years. The computer revolution that Moore predicted has taken place and there is still no end in sight. Every one of today's graduates is proficient in the use of computers. Computers are ubiquitous in our lives. Parents of students in the college now complain of not receiving e-mail from their children, just the way my mother complained about not receiving a letter. Even those in the audience who do not yet have a home computer have had their lives inalterably affected by computer technology. For example, a family car made this year can contain as many as five computer microprocessors, each with enough computing power to rival the best personal computers made just a few years ago.

None of the computing skills that I learned in college prepared me in any practical way for the changes that computers have introduced into both my private and professional life. My professors did not accurately perceive the way the computing revolution would reshape everyday life. However, the broad-based education they provided helped me to develop the skills needed to learn and adapt to an ever-changing environment. The faculty who have been your teachers here at the University of Chicago have stressed the development of these same skills.

Today we are on the verge of the twenty-first century and a new revolution is taking shape. The next century will see unparalleled changes in the fields of biology and medicine that will alter our lives in more fundamental ways than even the computer revolution. At the beginning of the present century, most scientists thought that the underlying basis for life was a fundamental force termed “vitalism.” They believed that vitalism would not be explainable through simple physical laws. However, research over the last ninety years has demonstrated that biology, although extraordinarily complex, is built on basic physical and chemical principles, just as complex computer programs are created using a simple binary code of zeros and ones. This suggests that many aspects of biology are more predictable and definable than previously believed.

Today, we know that all of the information necessary to reproduce an individual is contained within our DNA. Each of us is made up of a complex and unique set of DNA comprised of six billion base pairs. When biologists first learned these facts, it seemed like a hopelessly complex task to unravel the information contained within such a massive data set. However, technological advances will soon allow this amount of information to be imprinted on a compact disc. Approximately ten years ago, scientists began a national project to sequence the entire human genome. Initially, the hope was that a complete sequence of the human genome would be completed by 2020. However biotechnology is rapidly improving. We are now doubling the rate at which we acquire genetic information every two years, the biological equivalent of Moore’s Law. Currently, it is expected that the first complete sequence of the human genome will be finished in 2002.

If our biological data base continues to expand exponentially by doubling every two years, it can be predicted that, by 2050, every individual will be able to own a compact disc containing their entire, individually unique, genetic code. To me, as a scientist, the implications resulting from this remain unfathomable. Up until now, the rapid acquisition of genetic information has been primarily the concern of scientists. However, as genetic studies of complex diseases such as cancer, heart disease, high blood pressure, and diabetes are undertaken, the genetic variations that predispose to these illnesses will be uncovered. This will allow us to use our individual DNA data bases to predict the risk of developing these diseases. Therefore how DNA information is utilized will be of concern to everyone in this room. Independent of your future career plans, each of you graduates will be vital participants in the biological revolution. The education you have received here has provided you with the skills to deal with this new age of biology. However to master the coming changes, you will have to stay intellectually curious and actively involved.

This will take time and effort on your part, but it is important because the new information provided by the biological revolution will affect all aspects of your lives.

Doubtless, there are many in the audience who are skeptical about whether this biological revolution will really come to pass. These predictions have been made in the popular press throughout the last fifty years, beginning with the discovery of DNA. One of the most common questions I am asked is, “When are we going to realize the advances biology has promised?” In one respect, these promises have already been fulfilled. In this century, improvements in public health and medicine have led to a rapid increase in the expected life span. For most of the time that human beings have existed, the average individual lived eighteen years. At the turn of this century, after 100,000 years as a species, humans had a forty-nineyear median life span. Today, the graduates in this room have an expected life span of eighty-five years.

In 1972, this country launched a war on cancer. Although this war has not been universally successful, over half of children who develop cancer are now cured of their disease, an outcome that was unthinkable in 1972. The major genetic causes of breast and ovarian cancer have been found and genetic screening can identify individuals at increased risk of developing these disorders. These advances have led to earlier diagnosis and treatment of these diseases.

The biological revolution will improve our lives only if we develop methods to productively utilize the information it provides. Although exactly how the biological revolution will take shape remains difficult to predict, it is important that we begin to consider its implications for society. As medical treatments advance through a better understanding of biology, individuals will live longer. What are the social implications of a changing age distribution? How will we deal with the ability to predict our risk of developing specific illnesses? What effect will this information have on personal health, employment, or insurability? Should parents be allowed to choose the traits they pass on to their children? These are thorny issues which society as a whole will have to grapple with and the answers will have broad economic, legal, and moral implications.

In the next few years, scientists will undoubtedly uncover previously unsuspected aspects of biology. One such recent discovery seems particularly appropriate to consider today. As a student, I was disappointed to learn that careful studies by anatomists had suggested that human brains contain their maximum number of cells when we are in our mid-twenties. With each subsequent decade of life, the brain contains progressively fewer cells. As I interpreted it then, this meant that our intellectual capability would be greatest around the

time of university graduation. Unfortunately, this also suggested that our adult life is one long intellectual deterioration. To understand this process, my laboratory has been studying why cells die. Through genetic studies, we and others have found that the major reason cells die is through a form of cellular suicide which has been termed apoptosis, after the classical Greek word used to describe the dropping of dying leaves from a tree. Apoptotic cell death is an essential process, one required for the elimination of cells that have outlived their usefulness to the body. Interestingly, all cells constantly express the genes that can carry out their own suicide. To suppress the function of these death genes, cells must constantly receive signals from their neighbors. Cells that fail to receive the appropriate survival signals commit suicide, interpreting from their lack of stimulation that they are no longer of use to the body. For example, this mechanism allows the body to rid itself of the excess white blood cells following the successful eradication of a virus. Unfortunately, this system for controlling cell survival can also have negative consequences. Following a spinal cord injury, an individual's medical problems are compounded because the leg muscles atrophy as a result of the loss of signals from the damaged nerves.

This system for controlling cell survival apparently applies to all cells in the body. A major mechanism to prevent a cell from committing suicide is continuous use. Athletes may have known this for many years. Athletic training results in increased muscle mass, but these gains are lost with the cessation of training. This has resulted in the athletic slogan, "use it or lose it." It now appears that this slogan can be applied to tissues other than muscle. It has recently been demonstrated that adult animals provided with a stimulatory environment can continue to develop an increased number of brain cells as a result of the suppression of cell death. Furthermore recent studies have suggested that maintaining intellectually challenging pursuits is associated with a decreased incidence of neurological diseases commonly associated with aging or mental deterioration. Therefore, staying intellectually curious and actively engaged in life's challenges will help you to maintain your own vitality. In closing, my fondest hope for this audience is that your brains will continue to grow for many years to come.

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