Keith Moffat

444th Convocation Address: "Only Connect: The Beast and the Monk,"

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"Only Connect: The Beast and the Monk"
by Keith Moffat

It is a great honor to be asked to address you today, on one of the most important days of your life. You may know that the convocation address at the University of Chicago is always given by a faculty member. Like many of my predecessors, I've wondered what the basis is for this tradition and whether, given a free choice, you might not opt for Bill Gates, Colin Powell, or even Dennis Rodman. Could any such celebrity, a more conventional choice of speaker, meet the high critical standards for learning, analysis - and amusement - set by you, the graduates of the University of Chicago? A faculty speaker is undeniably cost effective, an aspect that has continuing appeal to University administrators. We are available, inexpensive, and not at all reluctant to express our views forcefully in public. Some of us are convinced that our ideas are superior to those of every other candidate speaker and that, if only we had a betterment, we too would be pulling down thirty million dollars next year. Perhaps the role of the faculty speaker to act as muse, to commune on your behalf not with Eleanor Roosevelt (the reported source of inspiration for Hillary Clinton) but with Charles Darwin, John Maynard Keynes, or Niccolò Machiavelli. This role has definite appeal - but the faculty here prefer to speak for themselves.

Three core values hold sway at the University of Chicago: the pursuit of scholarly excellence; the sense of intellectual community; and the encouragement of a connected, interdisciplinary perspective. It is to the last of these values that I will speak today. The three values are, however, clearly interdependent. An interdisciplinary approach is worthless if not founded on excellence in its core disciplines, and its success may be measured by the extent to which it enhances a broader intellectual community.

In his 1910 novel Howards End, the English novelist Edward Morgan Forster introduced the intellectual, free-thinking Schlegel sisters, who could well have been modeled, in another context, on graduates of the University of Chicago. Forster has Margaret Schlegel set forth his slogan:

Only connect! That was the whole of her sermon. Only connect the prose and the passion, and both will be exalted, and human love will be at its height. Live in fragments no longer. Only connect, and the beast and the monk, robbed of the isolation that is life to either, will die.

The notion of connection is the one that I want to explore. It can be interpreted at many levels, from the sociological to the molecular, in ways that Forster never dreamed of. How do we - and you - confront intellectual prejudices, one of the thrusts of Forster's phrase? What motivates us to pursue intellectual connections, either within a single discipline or between disciplines, or in the workplace? How do new disciplines arise at the interfaces between the old? It may seem self-evident that major research universities should foster interdisciplinary activities but this is not always the case. The University of Chicago is noted for its graduate committees whose splendid titles express their interdisciplinary reach: the Committee on Social Thought, the Committee on the Conceptual Foundations of Science, and the Committee on Evolutionary Biology, to name but three. As undergraduates you have also been required to take courses outside your specific areas of interest and thus to confront quite different approaches to knowledge.

But there are countervailing pressures, in your workplace as in the universities. Making intellectual connections demands confidence, but not arrogance. We are all at first ignorant of areas other than our own, yet to advance we must not be afraid to be in error, or to appear foolish in the eyes of more established, single-minded practitioners. These practitioners may be experienced but they are not necessarily right or even headed in the appropriate direction. Thirty years ago, the biologist Sydney Brenner sought to develop the new disciplines, first of molecular biology and then of developmental biology. In reviewing the current state of knowledge, he stated: "At any moment, 90% of the scientific literature is either wrong or irrelevant. The only problem is, I can't figure out which is the relevant 10%!"

Brenner and his colleagues also encountered predictable hostility from the more established disciplines of chemistry, biology, and biochemistry they sought to connect. The classical biochemists' view of molecular biology, at that time the new kid on the intellectual block, was that it was "naught but the unlicensed practice of biochemistry." They were wrong. The interdisciplinary science of molecular biology gave birth to the entire biotechnology industry, to the genome sequencing projects, and to powerful new approaches to structure-based drug design in the pharmaceutical industry. It did so through the intellectual and experimental coupling of a structural, chemically based approach with a genetic, biologically based approach. This coupling is exemplified at a more personal level by Francis Crick, who with Jim Watson discovered in 1953 the famous double helix, the structure of DNA. Sometime later Crick stated:

I was forced to call myself a molecular biologist because when enquiring clergymen asked me what I did, I got tired of explaining that I was a mixture of crystallographer, biophysicist, biochemist, and geneticist, an explanation which in any case they found too hard to grasp.

This comment from Crick harks back to Forster and reveals the attitude of at least one biologist, the beast, towards the monk. Yesterday's new approach is today's old fogy, another classical discipline, taken for granted and used as a springboard for new endeavors.

One approach to problems in biology (and, I stress, not the only approach) is to seek to simplify them, to reduce them to their essential components and then to apply the techniques and experimental approaches of the physical sciences. This reductionist approach has a long history. Sixty years ago it was motivated at least in part by the romantic notion that the laws of physics and chemistry as then understood might not be adequate to explain all biological phenomena. There might be as-yet-undiscovered fundamental laws of nature that distinguish living systems from inanimate. No such laws have been discovered, and it seems less and less likely that they exist. The failure to discover such laws does not invalidate the reductionist approach. It is worth emphasizing that the connection, the flow of concepts between the biological and physical sciences, is by no means one way. The recent development of combinatorial chemistry is based on the biological processes of replication of the nucleic acids, DNA and RNA. As a second example, a hard class of mathematical problems, such as identifying the optimum route among many cities for a traveling salesman, can now be attacked and solved in the test tube. The problem is ingeniously encoded in biologically derived structures, DNA sequences. After several biochemical manipulations, each corresponding closely to a computational step, the solution is identified as one particular DNA molecule, one particular chemical structure. This recent experiment extends our fundamental notions of mathematical computation. Although the intellectual connections between biology and chemistry might now seem self-evident, those between biology and the foundations of mathematical computation were a great deal less so. We can now ask: does the brain compute, in any mathematical sense?

Let me illustrate further the nature of interdisciplinary connections with two examples, both of which bear on fundamental human concerns.

The first concerns an estimate of the carrying capacity of our planet. In his recent book How Many People Can the Earth Support? Joel Cohen from Rockefeller University reviews estimates made over the last three centuries of the total population that the Earth could conceivably support, under certain assumptions. Even the recent and presumably better-informed estimates span a remarkably wide range. One 1967 estimate by an agronomist assumed that the biological process of photosynthesis was the sole constraint and derived an estimate of 1,000 billion people. An estimate three years later by a geneticist assumed that production of food, forest products, and certain nonrenewable resources was limiting and derived an estimate of only 1

billion people. This estimate is 1,000 times lower than the first and indeed, lower than the actual 1970 population of around 3.6 billion people. How should these wildly divergent estimates be reconciled? Cohen argues that estimates based on a narrow, disciplinary perspective and simple constraints are likely to be in error. A connected, multidisciplinary approach is called for, since populations depend on a complex interplay of biological and societal values. To you and to your generation will fall the challenge of deciding whether a more refined estimate is plausible and, if so, what its implications are for the future of the human race on Earth.

A second example of a rather different flavor is coming to play an increasing part in all our lives. The worldwide genome sequencing projects are producing an explosion of knowledge on the genetic constitution of organisms, from bacteria to plants to humans. We are confronted regularly with reports of the isolation of new genes such as a “nurturing” gene or a gene that confers resistance to infection by the AIDS virus. These reports suggest that complex and basic biological processes are founded on the expression of a single, or at most a few, genes and underpin an increasing, and it seems to me increasingly dangerous, sense of genetic determinism. The knowledge encoded in a gene is at the outset of a purely chemical nature, the sequence of the nucleotides that are the chemical blueprint for the entire organism. Is this chemical knowledge, this information, useful in and of itself? What are its limitations? To what must it be connected to become truly useful and not harmful? The sequence is inherently one-dimensional, the simple order of the nucleotides; yet biology depends ultimately on three-dimensional processes. To derive three-dimensional structural information from one-dimensional sequence information, and hence to connect the sequence with biochemistry and physiology, is a challenging research problem indeed, at the far frontier of the achievable. Suppose however that this scientific problem were now solved. What should we do with this genetic and structural information? We could study modes of inheritance of this information, the province of the classical discipline of genetics; or we could seek to modify the nucleotide sequence and remove defects in it, the province of the newer disciplines of genetic engineering, of molecular biology, and of cell biology. Most importantly, we ask not what could be done but what should be done with this information, the province of the much longer established disciplines of ethics, of psychology, of moral philosophy, of theology, and realistically also of politics, of economics, and of law.

All these disciplines are represented here by you, today, and these disciplines will have to be brought to bear on the far-reaching societal issues posed by genetic knowledge and by the rapidly increasing population of the Earth. We, the faculty, have tried to instill and nurture in you the powerful drive of plain old intellectual curiosity. You have minds open to new ideas, that recognize the strengths and weaknesses of

alternative logical or experimental approaches, and the skills to connect them with more conventional approaches. You see new uses for unexpected data and the relevance of unusual viewpoints. Your minds are full of the facts we have taught you, opinions we have exposed you to, and conclusions you have drawn from these facts and opinions. It is sobering to realize today that many of these facts already are, or soon will be, out of date. What will endure are the general strategies for learning, for sifting and evaluating new data, for connecting seemingly disparate new ideas, and for forming new opinions. It is not an accident that the degrees you are about to receive bear correspondingly general titles such as bachelor of arts, master of science, or doctor of philosophy, rather than specific, disciplinary titles.

I urge you to confront intellectual prejudices, retain the edge of intellectual discomfort, question received ideas, and always seek to connect.

The wishes of the faculty for you, for your families and friends, are captured in this old Gaelic blessing:

May the sun shine gently on your face;

May the rain fall soft upon your fields;

May the wind be at your back;

May the road rise to meet you;

May the Lord hold you in the hollow

of his hand;

Until we meet again.

Good luck, and thank you.

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