ON SCIENCE AND THE HUMANITIES

What I've been so presumptuous, some would say reckless, to suggest, in an age when irony and skepticism are the ruling intellectual fashion, is essentially as follows: Although it's widely assumed that there are many ways to account for the human condition, in fact there are only two ways to account for the human condition. The first comes from the natural sciences, whose practitioners set out more than four centuries ago and with considerable success to understand how the material world works; and, all will agree, they've preempted that particular enterprise. The second way to account for the human condition is all the other ways.

Since the eighteenth century the great branches of learning have been classified into the natural sciences, the social sciences, and humanities. Today we have the choice between, on the one hand, trying to make the great branches of learning consilient—that is, coherent and interconnected by cause-and-effect explanation—or, on the other hand, *not* trying to make them consilient. Surely universal consilience is worth a serious try. After all, the brain, mind, and culture are composed of material entities and processes; they don't exist in an astral plane that floats above and outside the tangible world.

The most useful term to capture the unity of knowledge is surely *consilience*. It means the interlocking of cause-and-effect explanations across different disciplines, as for example between physics and chemistry, chemistry and biology, and, more controversially, biology and the social sciences. The word consilience was introduced in 1840 by William Whewell, the founder of the modern philosophy of science. It's more serviceable than the words coherence or interconnectedness, because its rarity of usage since 1840 has preserved its original meaning, whereas coherence and interconnectedness have acquired many meanings scattered among the different disciplines.

Consilience, defined then as cause-and-effect explanation across the disciplines, has plenty of credibility. It's the mother's milk of the natural sciences. Its material understanding of how the world works and its technological spin-off are the foundation of modern civilization. The time has come, I believe, to consider more seriously its relevance to the social sciences and humanities. I will grant immediately that belief in the possibility of consilience beyond the natural sciences and across to the other great branches of learning isn't the same as science, at least not yet. It's a metaphysical world view, and a minority one at that, shared by only a few scientists and philosophers. Its best support is little more than an extrapolation of the consistent past success of the natural sciences. Its strongest appeal is in the prospect of intellectual adventure and, given even modest success, the value of understanding the human condition with a higher degree of certainty.

I believe also that it's a matter of practical urgency to focus on the unity of knowledge. Let me illustrate that claim with an example. Think of two intersecting lines that form a cross, and picture the four quadrants thus created. Label one quadrant environmental policy, the next ethics, the next biology, and the final one social science. Each of these subjects has its own experts, its own language, rules of evidence, and criteria of validation. Now if we focus on more specific topics within each of the quadrants, such as forestry management, environmental ethics, ecology, and economics, we see how general theory translates into the analysis of practical problems. And we understand that in each case we somehow have to learn how to travel, as clockwise here, from one subject to the next. In a single discussion, maybe in a sentence or two in the discussion, it's necessary to travel the entire circuit. Now move through concentric circles toward the intersection of the disciplines. As we approach the intersection, where most real-world problems exist, the circuit becomes more difficult and the process more disorienting and contentious.

The nub of the problem vexing a great deal of human thought is the general belief that a fault line exists between the natural sciences on one side and the humanities and humanistic social sciences on the other, in other words, very roughly, between the scientific and literary cultures as defined by C. P. Snow in his famous 1959 Rede Lecture. The solution to the problem, I believe, is the recognition that this boundary is not a fault line. It is not a permanent epistemological division, and it is not a Hadrian's Wall, as many would have it, needed to protect high culture from the reductionist barbarians of science. What we are beginning at last to understand is that this line does not exist as a line at all. It is instead a broad domain of poorly understood material phenomena awaiting cooperative exploration from both sides.

During the past 20 years three borderland disciplines have grown dramatically in the natural sciences, or more precisely in the biological sciences, which bridge this intermediate domain. They are, respectively, cognitive neuroscience, which is mapping the activity of the brain with increasing resolution in time and space; human genetics, including the genetics of behavior; and evolutionary biology, including sociobiology (or evolutionary psychology, as it is often called), which is tracing the biological origins of human nature. From the social sciences side the bridging disciplines include cognitive psychology and biological anthropology. To an increasing degree cognitive psychology and biological anthropology are becoming consilient with the three biology-born disciplines. In fact, they are anastomosing with them through cause-and-effect explanations. And the connections are strengthening very rapidly, as exemplified by rates of DNA sequencing and gene mapping in the human genome. The world effort is now on target to complete DNA sequencing by no later than 2005.

Why is this conjunction among the great branches of learning important? Because it offers the prospect of characterizing human nature with greater objectivity and precision, an exactitude that is the key to human self-understanding. The intuitive grasp of human nature has been the substance of the creative arts. It's been the underpinning of the social sciences, and a beckoning mystery to the natural sciences. To grasp human nature objectively, and explore it to its depths scientifically, and grasp its ramifications, would be to approach if not attain the grail of scholarship, and to fulfill the dreams of the Enlightenment.

Now, rather than let the matter hang in the air thus rhetorically, I want to suggest a preliminary definition of human nature, and then illustrate it with examples. Human nature isn't the genes, which prescribe it. It isn't the cultural universals, such as the incest taboos and rites of passage, that are the products of human nature. Rather, human nature is the epigenetic rules, the inherited regularities of mental development. These rules are the genetic biases in the way our senses perceive the world, the symbolic coding by which we represent the world, the options we open to ourselves, and the responses we find easiest and most rewarding to make. In ways that are beginning to come into focus at the physiological and even a few cases the genetic level, the epigenetic rules alter the way we see and linguistically classify color. They cause us to evaluate the aesthetics of artistic design according to elementary abstract shapes and the degree of complexity. They lead us differentially to acquire fears and phobias concerning dangers in the environment (as from snakes and heights), to communicate with certain facial expressions and forms of body language, to bond with infants, to bond conjugally, and so on across a wide range of categories in behavior and thought. Most are evidently very ancient, dating back millions of years in mammalian ancestry. Others, like the stages of linguistic development, are uniquely human and probably only hundreds of thousands of years old.

As an example of an epigenetic rule, consider the instinct to avoid incest. Its key element is the Westermarck effect, named after Edward Westermarck, the Finnish anthropologist who discovered it a century ago. When two people live in close domestic proximity during the first 30 months in the life of either one, both are desensitized to later close sexual attraction and bonding. The Westermarck effect has been well documented in anthropological studies, although the genetic prescription and neurobiological mechanics underlying it remain to be studied. What makes the human evidence the more convincing is that all of the non-human primates whose sexual behavior has been closely studied also display the Westermarck effect. It therefore appears probable that the trait prevailed in the human ancestral line millions of years before the origin of *Homo sapiens*, our present-day species. The existence of the Westermarck effect runs directly counter to the more widely known Freudian theory of incest avoidance. Freud argued that members of the same family lust for one another, making it necessary for societies to create incest taboos in order to avoid the social damage that would follow if within-family sex were allowed. But the opposite is evidently true. That is, incest taboos arise naturally as products of response mediated by a relatively simple inherited epigenetic rule. The epigenetic rule is the Westermarck effect. The adaptive advantage of the Westermarck effect is, of course, that it reduces inbreeding depression and the production of dead or defective children. That relentless pressure is almost surely how it arose through evolution by natural selection.

In another, wholly different realm, consider the basis of aesthetic judgment. Neurobiological monitoring, in particular measurements of the damping of the alpha wave, during presentations of abstract designs, have shown that the brain is most aroused by patterns in which there is a 20 percent redundancy of elements, or put very roughly, the amount of complexity found in a simple maze, or two turns of a logarithmic spiral, or an asymmetric cross. It may be a coincidence—that about the same property is shared by a great deal of the art in friezes, grillwork, colophons, logographs, and flag designs. It crops up again in the glyphs of ancient Egypt and Mesoamerica as well as the pictographs of modern Asian languages.

To take the same approach but in another direction, I would like to mention biophilia, the innate affiliation people seek into other organisms and especially with the natural world. Studies have shown that, given complete freedom to choose the setting of their homes or offices, people gravitate toward an environment which combines three features, intuitively understood by landscape architects and real estate entrepreneurs. These features are as follows: people want to be on a height looking down, they prefer open savanna-like terrain with scattered trees and copses, and they want to be near a body of water, such as a river or lake, even if all these elements are purely aesthetic and not functional. They will pay enormous prices for this view.

They look for two other, crosscutting elements: they want both a retreat in which to live and a prospect of fruitful terrain in which to forage, and in the prospect they like distant, scattered large animals and trees with low, nearly horizontal branches.

In short, if you will allow me now to take a deep breath and then plunge where you may not wish to follow, people want to be in the environments in which our species evolved over millions of years, that is, hidden in a copse or against a rock wall, looking out over savanna and transitional woodland, at acacias and similar dominant trees of the African environment. And why not? All mobile animal species have a powerful, often highly sophisticated inborn guide for habitat selection. Why not human beings?

And then again, in the biologically important realm of erotic aesthetics, the basis of sexual attraction, there is the matter of preferred female facial beauty open to objective analysis. The ideal subjectively preferred in tests is not the exact average, as once thought.

It is not the average of faces from the general population, which can be readily blended by computer. Rather, it is the average of the subset considered most attractive and then blended by computer. The ideal has higher cheekbones than the average, a smaller chin, shorter upper lip, and wider eyes, all relative to the size of the face. The evolutionary biologist might surmise that these traits are the signs of juvenescence still on the faces of the young women, hence relative youth and reproductive potential. If all this seems irrational, ask any middle-aged professor whose second wife is a graduate student.

How much do we know about the innate basis of such aesthetics? Not a lot, and certainly very little about the genetics and neurobiology in particular of the epigenetic rules– not because they've been investigated and then found lacking, not because they are too technically daunting, but simply because they haven't been studied; only recently have researchers begun to ask the right questions within the borderland disciplines.

In the creation of human nature—that is, the epigenetic rules of mental development—genetic evolution and cultural evolution have proceeded in a closely interwoven manner, and we are only beginning to obtain a glimmer of the nature of this process. We know that cultural evolution is shaped substantially by biology, and that biological evolution of the brain, especially the neocortex, has occurred in a social context. But the principles and the details are the great challenge in the emerging borderland disciplines to which I referred. In my opinion, the exact process of gene-culture convolution is the central problem of the social sciences and much of the humanities, and it is one of the great remaining problems of the natural sciences. Solving it is the obvious means by which the branches of learning can be foundationally united.

In summary, biologists, social scientists, and humanities scholars, by meeting within the borderland disciplines, have begun to discover increasing numbers of epigenetic rules such as the ones I've illustrated and speculated on here. Many more rules and their biological processes, I'm confident, will come to light as scholars shift their focus to search for these phenomena explicitly.

I'm very aware that the conception of a biological foundation of complex social and cultural structures runs against the grain for a lot of scholars. They object that too few such inherited regularities have yet been found to make the case solid, and in any case higher mental processes and cultural evolution are too complex, shifting, and subtle to be encompassed this way. Reduction, they say, rips human thought from its context, it is vivisectional, and it bleeds away the artist's true intended meaning. It melts the Inca gold.

But the same was said by the vitalists about the nature of life when the first enzymes and other complex organic molecules were discovered. The same was declared about the physical basis of heredity even as early evidence pointed straight to the relatively simple DNA molecule as the carrier of the genetic code. And most recently, doubts about the accessibility of the physical basis of mind are fading before the successes of sophisticated imaging techniques. In the history of the natural sciences a common sequence has predictably unfolded as follows. An entry point to a complex system is found by analytic probing. At first one and then more such paradigmatic reductions are accomplished. Examples are multiplied as the whole system opens up and the foundational architecture is laid bare. Finally, when the mystery is at least partly solved, the cause-and-effect explanations seem in retrospect to have been obvious, even inevitable.

The value of the consilience program—or renewal of the Enlightenment agenda if you prefer that expression—is that at long last we appear to have acquired the means either to establish the truth of the fundamental unity of knowledge, or to discard the idea. I think we're going to establish it.