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The Rise of Complexity

Twenty-first-century America is a mind-boggling place. We've got more than 310 million people, 80 percent of whom are congregated in densely populated urban areas. In the business sector, more than twenty-seven million different firms compete and cooperate to supply a bewildering variety of goods and services—the typical supermarket alone stocks some thirty thousand different items. Another 1.5 million registered nonprofits, along with countless informal groups, collaborate to serve an immense range of perceived community needs. And providing the nation's legal and regulatory framework, as well as a host of other public services, are the vast bureaucracies of the federal government, fifty state governments, and more than eighty-seven thousand local governmental units. This incredibly intricate division of labor, meanwhile, is deeply integrated into a larger global economy that encompasses billions of people.

All of this highly organized, highly specialized activity requires the accumulation and communication of vast amounts of knowledge and know-how. In just the past year, nearly 248,000 new patents were granted in this country, while almost 290,000 new book titles and editions were published. According to a 2003 estimate (which doubtless is already completely obsolete), the total amount of new

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information stored on paper, film, and magnetic and optical media in the United States comes to two trillion megabytes annually—or the equivalent of nearly fifteen thousand new book collections as big as the Library of Congress.⁴ What about flows of information? Every day, Americans send six hundred million pieces of mail, make billions of phone calls, send billions more text messages, and transmit untold tens of billions of e-mails. And they spend an incredible eight hours of every day watching television, listening to the radio, reading, and surfing the Internet.

Living this way doesn't come naturally. From the first appearance of anatomically modern *Homo sapiens* more than one hundred thousand years ago until the advent of agriculture some ten thousand years ago, human beings lived as hunter-gatherers in roving bands that averaged about 150 members. The division of labor within these groups was extremely rudimentary, as virtually all able-bodied people worked in food production. Exchanges between groups were infrequent and often violent. The extent of human knowledge was limited to what could be retained in memory. Technology evolved glacially, changing noticeably only over the course of thousands of years.

The static world of the small, face-to-face group—that is our native home. That is the social environment in which we evolved and to which our brains are adapted. That is the setting for more than 90 percent of the human story so far.

⁴ Peter Lyman and Hal R. Varian, *How Much Information 2003*, http://chnm.gmu.edu/digitalhistory/links/pdf/preserving/8_5a.pdf.

So how on earth did we end up where we are now? Let's go back to the two dimensions of social complexity I highlighted above: the extent of the division of labor, and the amount of knowledge distributed throughout the system. It turns out that these two characteristics are interrelated. More to the point, they are mutually reinforcing. Stripped down to its bare essentials, the story of the rise of complexity is the story of a positive feedback loop in which the growth of the division of labor feeds the growth of knowledge, which in turn feeds the further growth of the division of labor—and off we go.

Here's the basic logic. The more we know collectively, the more we have to specialize in order to make effective use of that knowledge. The growth of knowledge thus creates an incentive for specialization. Specialization, meanwhile, expands our overall knowledge base. First, we learn by doing, so a wider variety of occupations leads to wider varieties of expertise. In addition, more specialists overall mean, among other things, more people who specialize in discovery and innovation.

But for most of human existence, the conditions that allow this logic to operate were absent. Namely, we just didn't know enough. Only with the advent of agriculture ten millennia ago was the critical threshold crossed. Because of the superior productivity of cultivation and animal husbandry, a food surplus emerged for the first time—which meant that some people could be liberated from food production and devote their full attention to other tasks. Specialization on a significant scale was now possible, and

with it came the first cities—agglomerations of people who depend on others for food—and huge additional breakthroughs in knowledge. The most important of those was the invention of writing, which freed the accumulation of knowledge from the limits of memory and the transmission of knowledge from the need for personal contact. Human-kind entered the realm of history.

Until quite recently, however, the social institutions for developing and applying useful knowledge remained extremely inefficient. Consequently, the positive feedback loop between knowledge and specialization ran slowly and suffered frequent and lengthy breakdowns. And the division of labor stayed quite limited. Outside a few relatively small cities (only rarely did the largest exceed one hundred thousand people), more than 90 percent of humanity continued to eke out a bare subsistence in small, isolated groups. Now the groups were villages of sedentary peasants rather than tribes of mobile hunter-gatherers, but the distinction made little difference. Indeed, according to the economic historian Gregory Clark, the typical peasant worked harder and experienced an even lower standard of living than did his hunter-gatherer ancestors.⁵

The critical turning point came in the past few centuries with the emergence of two new and immensely potent systems of social institutions: the modern market economy and modern science. Both relied on decentralized processes of experimentation and feedback—what came to be known

⁵ Gregory Clark, *A Farewell to Alms: A Brief Economic History of the World* (Princeton, N.J.: Princeton University Press, 2007), pp. 1–2.

as the scientific method for the one; entrepreneurial investment, competitive enterprise, and the profit-and-loss system for the other. Both utilized new methods of quantitative reasoning (calculus, for example, and double-entry book-keeping) that enabled unprecedented degrees of analytical sophistication and rigor. Both broke free of traditional cultural constraints to pursue innovation and discovery wherever they might lead.

For some time, these two sets of institutions developed more or less independently. Indeed, many of the early advances in industrial technology were the handiwork of inspired tinkerers and entrepreneurs, not men of science. But by the middle of the nineteenth century, the two paths converged. The increasing dependence of economic production in western Europe and North America on technological innovation eventually led to the systematic application of scientific methods to technological problems—and thus to the integration of science and commerce. The result was a second quantum leap in human productivity—an advance that the Nobel Prize–winning economic historian Douglass North calls the “second economic revolution.”⁶

It is this revolution, more commonly known as industrialization, that has carried us to the dizzying heights of economic abundance and social complexity we now occupy. In the industrial era, the growth of knowledge has exploded. Over the past century or so, annual technological progress, or productivity growth, has averaged 1 percent or higher

⁶ Douglass C. North, *Structure and Change in Economic History* (New York: W. W. Norton, 1981), pp. 158–186.

in healthy advanced economies. By contrast, throughout the agrarian age, technological progress never surpassed 0.05 percent a year for any sustained period.⁷ The division of labor, likewise, has undergone a radical transformation. Today, because of the rise in productivity, fewer than 2 percent of Americans work as farmers—down from nearly two-thirds in 1850. The positive feedback loop between knowledge and specialization now spins so fast that conditions change dramatically from decade to decade.

Born and raised in this vertiginous world, we take it for granted and assume it is normal. It is emphatically not normal. We are a scant few generations removed from the biggest discontinuity in human existence in ten thousand years. More changes in the human condition have occurred in this brief period than in all the more than three hundred generations of the agrarian era—which, in turn, was a period of convulsive dynamism in comparison to the more than three thousand generations of hunting and gathering that preceded it. We are all unwitting participants in the biggest revolution of them all.

⁷ Clark, *A Farewell to Alms*, p. 140.