Fifty years ago, our technologies, our organizations and our lives were less complicated than today. Things were simpler. Most of us prize this plainness, this simplicity. Yet we are fascinated by complexity. Lately I’ve been wondering why the simple becomes complex. Is there a general principle causing things to get more complicated as time passes? Is complexity useful?

One good place to look for answers to these questions is the history of technology. The original turbojet engine, designed by Frank Whittle in 1936, was beautifully simple. The idea was to propel aircraft by a jet of high-speed air. To do this the engine took in air, pumped up its pressure by a compressor, and ignited fuel in it. It passed the exploding mixture through a turbine to drive the compressor, and released it through an exhaust nozzle at high speed to provide thrust. The original prototype worked well with just one moving part, the compressor-turbine combination.

Yet over the years, jet engines steadily become more complicated. Why? Commercial and military interests exert constant pressure to overcome limits imposed by extreme stresses and temperatures, and to handle exceptional situations. Sometimes these improvements are achieved by using better materials; more often by adding a subsystem. And so, over time, jet designers achieve higher pressures by using not one, but an assembly of many compressors. They cool the combustion chamber by blowing air around it in a by-pass system. They increase efficiency by a guide-vane control system that admits more air at high altitudes and velocities. They control unexpected pressure surges (the tendency of the compressed air to blow backwards) by a bleed-valve subsystem. They add afterburner assemblies, fire-detection systems, de-icing assemblies. Soon they will cool the red-hot turbine blades by a system that circulates fluid inside them.

But all these require further subsystems, to monitor and control them and enhance their performance when they run into limitations. These subsystems in turn require sub-sub-systems to enhance their performance. All this indeed improves performance—today’s jet engine is 30 to 50 times more powerful than Whittle’s. But it ends up encrusting the original simple system with subsystem upon subsystem and subassembly upon subassembly in a vastly complicated array of interconnected modules and parts. Modern engines have upwards of 7,000 parts.

There’s nothing wrong with this increase in complexity. We can admire it. On the outside, jet engines are sleek and lean; on the inside, complex and sophisticated. In nature, higher organisms are this way too. On the outside, a cheetah is powerful and fast; on the inside, even more complicated than a jet engine. A cheetah too has temperature-regulating systems, sensing systems, control functions, maintenance functions, all embodied in a complex assembly of organs, cells, and organelles, modulated not by machinery and electrics but by interconnected networks of chemical and neurological pathways. The steady pressure of competition causes evolution to “discover” new functions occasionally that push out performance limits. There’s something wonderful about this—about how, over eons, a cheetah forms from its simple multicellular ancestors.

But sometimes the results of growing complexity are not so streamlined. A modern research university, for example, needs to secure private and federal grants, acquire and protect patents, satisfy government regulations, and account and plan for these. What might have occupied a few people in a back office 60 years ago now requires a development department, legal department, sponsored-projects office, dean-of-research office, grants and contracts accounting department, budget control office, naval research
office, technology licensing office. In part, such bureaucratic functions are necessary because the research-grant world itself is more complicated (and so complexity engenders further complexity). But often, once established they linger past their usefulness because the career interests they create overpower any external competitive forces that might pare them away. In 1896, my own university, Stanford, had only 12 administrators. It is still leaner than most; yet now it has more administrators than the British had running India in the 1830s.

It’s that way with our lives too. As we get better off, we gain more ways to squeeze more performance from our limited time. We acquire a car, profession, house, computers, fitness programs, pets, pools, a second car. Fine. But all these bring with them maintenance, repairs, appointments, obligations—a thousand sub-activities to keep them going. In this case again, the overall result is increased complexity of debatable effectiveness.

So in answer to the original question, there is indeed a general law or principle: Complexity tends to increase as functions and modifications are added to a system to break through limitations, handle exceptional circumstances, or adapt to a world itself more complex. This applies, if you think about it, not just to technologies and biological organisms, but also to legal systems, tax codes, scientific theories, even successive releases of software programs. Where forces exist to weed out useless functions, increasing complexity delivers a smooth, efficient machine. Where they do not, it merely encumbers.

But interestingly, even when a system gets lumbered down with complications, there is hope. Sooner or later a new simplifying conception is discovered that cuts at the root idea behind the old system and replaces it. Copernicus’s dazzlingly simple astronomical system, based on a heliocentric universe, replaced the hopelessly complicated Ptolemaic system. Whittle’s jet-engine, ironically, replaced the incurably complicated piston aero-engine of the 1930s, before it also became complex. And so growing complexity is often followed by renewed simplicity in a slow back-and forth dance; with complication usually gaining a net edge over time.

The writer Peter Matthiessen once said “the secret of well-being is simplicity.” True. Yet the secret of evolution is the continual emergence of complexity. Simplicity brings a spareness, a grit; it cuts the fat. Yet complexity makes organisms like us possible in the first place. Complexity is indeed a marvel when it evolves naturally and delivers powerful performance. But when we seek it as an end or allow it to go unchecked, it merely hampers. It is then that we need to discover the new modes—the bold strokes—that bring fresh simplicity to our organizations, our technology, our government, our lives.

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