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The Genius of the Tinkerer

The secret to innovation is combining odds and ends, writes Steven Johnson.

By STEVEN JOHNSON

In the year following the 2004 tsunami, the Indonesian city of Meulaboh received eight neonatal incubators from international relief organizations. Several years later, when an MIT fellow named Timothy Prestero visited the local hospital, all eight were out of order, the victim of power surges and tropical humidity, along with the hospital staff's inability to read the English repair manual.

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Nerdbots are assembled from found objects. Like ideas, they're random pieces connected to create something new.

Mr. Prestero and the organization he cofounded, Design That Matters, had been working for several years on a more reliable, and less expensive, incubator for the developing world. In 2008, they introduced a prototype called the NeoNurture. It looked like a streamlined modern incubator, but its guts were automotive. Sealed-beam headlights supplied the crucial warmth; dashboard fans provided filtered air circulation; door chimes sounded alarms. You could power the device with an adapted cigarette lighter or a standard-issue motorcycle battery. Building the NeoNurture out of car parts was doubly efficient, because it tapped both the local supply of parts and the local knowledge of automobile repair. You didn't have to be a trained medical technician to fix the NeoNurture; you just needed to know how to replace a broken headlight.

The NeoNurture incubator is a fitting metaphor for the way that good ideas usually come into the world. They are, inevitably, constrained by the parts and skills that surround them. We have a natural tendency to romanticize breakthrough innovations, imagining momentous ideas transcending their surroundings, a gifted mind somehow seeing over the detritus of old ideas and ossified tradition.

But ideas are works of bricolage. They are, almost inevitably, networks of other ideas. We take the ideas we've inherited or stumbled across, and we jigger them together into some new shape. We like to think of our ideas as a $40,000 incubator, shipped direct from the factory, but in reality they've been cobbled together with spare parts that happened to be sitting in the garage.

The Genius of the Tinkerer

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Graver

As a tribute to human ingenuity, the evolutionary biologist Stephen Jay Gould maintained an odd collection of sandals made from recycled automobile tires, purchased during his travels through the developing world. But he also saw them as a metaphor for the patterns of innovation in the biological world. Nature's innovations, too, rely on spare parts.

Evolution advances by taking available resources and cobbling them together to create new uses. The evolutionary theorist Francois Jacob captured this in his concept of evolution as a "tinkerer," not an engineer; our bodies are also works of bricolage, old parts strung together to form something radically new. "The tires-to-sandals principle works at all scales and times," Mr. Gould wrote, "permitting odd and unpredictable initiatives at any moment—to make nature as inventive as the cleverest person who ever pondered the potential of a junkyard in Nairobi."

You can see this process at work in the primordial innovation of life itself. Before life emerged on Earth, the planet was dominated by a handful of basic molecules: ammonia, methane, water, carbon dioxide, a smattering of amino acids and other simple organic compounds. Each of these molecules was capable of a finite series of transformations and exchanges with other molecules in the primordial soup: methane and oxygen recombining to form formaldehyde and water, for instance.

Think of all those initial molecules, and then imagine all the potential new combinations that they could form spontaneously, simply by colliding with each other (or perhaps prodded along by the extra energy of a propitious lightning strike). If you could play God and trigger all those combinations, you would end up with most of the building blocks of life: the proteins that form the boundaries of cells; sugar molecules crucial to the nucleic acids of our DNA. But you would not be able to trigger chemical reactions that would build a mosquito, or a sunflower, or a human brain. Formaldehyde is a first-order combination: You can create it directly from the molecules in the primordial soup. Creating a sunflower, however, relies on a whole series of subsequent innovations: chloroplasts to capture the sun's energy, vascular tissues to circulate resources through the plant, DNA molecules to pass on instructions to the next generation.

INSPIRATION POINT

Big new ideas more often result from recycling and combining old ideas than from eureka moments. Consider the origins of some familiar innovations.

Double-entry accounting

One of the essential instruments of modern capitalism appears to have been developed collectively in Renaissance Italy. Now the cornerstone of bookkeeping, double-entry's innovation of recording every financial event in two ledgers (one for debit, one for credit) allowed merchants to accurately track the health of their businesses. It was first codified by the Franciscan friar Luca Pacioli in 1494, but it had been used for at least two centuries by Italian bankers and merchants.

Gutenberg press

The printing press is a classic combinatorial innovation. Each of its key elements—the movable type, the ink, the paper and the press

The scientist Stuart Kauffman has a suggestive name for the set of all those first-order combinations: "the adjacent possible." The phrase captures both the limits and the creative potential of change and innovation. In the case of prebiotic chemistry, the adjacent possible defines all those molecular reactions that were directly achievable in the primordial soup. Sunflowers and mosquitoes and brains exist outside that circle of possibility. The adjacent possible is a kind of shadow future, hovering on the edges of the present state of things, a map of all the ways in which the present can reinvent itself.

The strange and beautiful truth about the adjacent possible is that its boundaries grow as you explore them. Each new combination opens up the possibility of other new combinations. Think of it as a house that magically expands with each door you open. You begin in a room with four doors, each leading to a new room that you haven't visited yet. Once you open one of those doors and stroll into that room, three new doors appear, each leading to a brand-new room that you couldn't have reached from your original starting point. Keep opening itself—had been developed separately well before Johannes Gutenberg printed his first Bible in the 15th century. Movable type, for instance, had been independently conceived by a Chinese blacksmith named Pi Sheng four centuries earlier. The press itself was adapted from a screw press that was being used in Germany for the mass production of wine.

Air conditioning

AC counts as a rare instance of innovation through sheer individual insight. After summer heat waves in 1900 and 1901, the owners of a printing company asked the heating-systems specialist Buffalo Forge Co. for a way to make the air in its press rooms less humid. The project fell to a 25-year-old electrical engineer named Willis Carrier, who built a system that cooled the air to a temperature that would produce 55% humidity. His idea ultimately rearranged the social and political map of America.

new doors and eventually you'll have built a palace.

Basic fatty acids will naturally self-organize into spheres lined with a dual layer of molecules, very similar to the membranes that define the boundaries of modern cells. Once the fatty acids combine to form those bounded spheres, a new wing of the adjacent possible opens up, because those molecules implicitly create a fundamental division between the inside and outside of the sphere. This division is the very essence of a cell. Once you have an "inside," you can put things there: food, organelles, genetic code.

The march of cultural innovation follows the same combinatorial pattern: Johannes Gutenberg, for instance, took the older technology of the screw press, designed originally for making wine, and reconfigured it with metal type to invent the printing press.

More recently, a graduate student named Brent Constantz, working on a Ph.D. that explored the techniques that coral polyps use to build amazingly durable reefs, realized that those same techniques could be harnessed to heal human bones. Several IPOs later, the cements that Mr. Constantz created are employed in most orthopedic operating rooms throughout the U.S. and Europe.

Mr. Constantz's cements point to something particularly inspiring in Mr. Kauffman's notion of the adjacent possible: the continuum between natural and man-made systems. Four billion years ago, if you were a carbon atom, there were a few hundred molecular configurations you could stumble into. Today that same carbon atom can help build a sperm whale or a giant redwood or an H1N1 virus, along with every single object on the planet made of plastic.

The premise that innovation prospers when ideas can serendipitously connect and recombine with other ideas may seem logical enough, but the strange fact is that a great deal of the past two centuries of legal and folk wisdom about innovation has pursued the exact opposite argument, building walls between ideas. Ironically, those walls have been erected with the explicit aim of encouraging innovation. They go by many names: intellectual property, trade secrets, proprietary technology, top-secret R&D labs. But they share a founding assumption: that in the long run, innovation will increase if you put restrictions on the spread of new ideas, because those restrictions will allow the creators to collect large financial rewards from their inventions. And those rewards will then attract other innovators to follow in their path.

Getty Images

Circa 1450, Johannes Gutenberg (1400 - 1468) inventor of printing examines a page from his first printing press. (Photo by Rischgitz/Getty Images)

The problem with these closed environments is that they make it more difficult to explore the adjacent possible, because they reduce the overall network of minds that can potentially engage with a problem, and they reduce the unplanned collisions between ideas originating in different fields. This is why a growing number of large organizations—businesses, nonprofits, schools, government agencies—have begun experimenting with more open models of idea exchange.

Organizations like IBM and Procter & Gamble, who have a long history of profiting from patented, closed-door innovations, have embraced open innovation platforms over the past decade, sharing their leading-edge research with universities, partners, suppliers and customers. Modeled on the success of services like Twitter and Flickr, new Web startups now routinely make their software accessible to programmers who are not on their payroll, allowing these outsiders to expand on and remix the core product in surprising new ways.

Earlier this year, Nike announced a new Web-based marketplace it calls the GreenXchange, where it has publicly released more than 400 of its patents that involve environmentally friendly materials or technologies. The marketplace is a kind of hybrid of commercial self-interest and civic good. This makes it possible for outside firms to improve on those innovations, creating new value that Nike might ultimately be able to put to use itself in its own products.

In a sense, Nike is widening the network of minds who are actively thinking about how to make its ideas more useful, without adding any more employees. But some of its innovations might well turn out to be advantageous to industries or markets in which it has no competitive involvement whatsoever. By keeping its eco-friendly ideas behind a veil of secrecy, Nike was holding back ideas that might, in another context, contribute to a sustainable future—without any real commercial justification.

A hypothetical scenario invoked by the company at the launch of the GreenXchange would have warmed the heart of Stephen Jay Gould: perhaps an environmentally-sound rubber originally invented for use in running shoes could be adapted by a mountain bike company to create more sustainable tires. Apparently, Gould's tires-to-sandals principle works both ways. Sometimes you make footwear by putting tires to new use, and sometimes you make tires by putting footwear to new use.

There is a famous moment in the story of the near-catastrophic Apollo 13 mission—wonderfully captured in the Ron Howard film—in which the mission control engineers realize they need to create an improvised carbon dioxide filter, or the astronauts will poison the lunar module atmosphere with their own exhalations before they return to Earth. The astronauts have plenty of carbon "scrubbers" onboard, but these filters were designed for the original, damaged spacecraft and don't fit the ventilation system of the lunar module they are using as a lifeboat to return home. Mission control quickly assembles a "tiger team" of engineers to hack their way through the problem.

In the movie, Deke Slayton, head of flight crew operations, tosses a jumbled pile of gear on a conference table: hoses, canisters, stowage bags, duct tape and other assorted gadgets. He holds up the carbon scrubbers. "We gotta find a way to make this fit into a hole for this," he says, and then points to the spare parts on the table, "using nothing but that."

The space gear on the table defines the adjacent possible for the problem of building a working carbon scrubber on a lunar module. (The device they eventually concocted, dubbed the "mailbox," performed beautifully.) The canisters and nozzles are like the ammonia and methane molecules of the early Earth, or those Toyota parts heating an incubator: They are the building blocks that create—and limit—the space of possibility for a specific problem. The trick to having good ideas is not to sit around in glorious isolation and try to think big thoughts. The trick is to get more parts on the table.

—Steven Johnson is the author of seven books, including "The Invention of Air." This essay is adapted from "Where Good Ideas Come From: The Natural History of Innovation" by Steven Johnson, to be published by Riverhead Hardcover on Oct. 5. Copyright © by Steven Johnson.

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