ANNALS OF INNOVATION

IN THE AIR

By Malcolm Gladwell

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Nathan Myhrvold met Jack Horner on the set of the "Jurassic Park" sequel in 1996. Horner is an eminent paleontologist, and was a consultant on the movie. Myhrvold was there because he really likes dinosaurs. Between takes, the two men got to talking, and Horner asked Myhrvold if he was interested in funding dinosaur expeditions.

Myhrvold is of Nordic extraction, and he looks every bit the bearded, fair-haired Viking—not so much the tall, ferocious kind who raped and pillaged as the impish, roly-poly kind who stayed home by the fjords trying to turn lead into gold. He is gregarious, enthusiastic, and nerdy on an epic scale. He graduated from high school at fourteen. He started Microsoft's research division, leaving, in 1999, with hundreds of millions. He is obsessed with aperiodic tile patterns. (Imagine a floor tiled in a pattern that never repeats.) When Myhrvold built his own house, on the shores of Lake Washington, outside Seattle—a vast, silvery hypermodernist structure described by his wife as the place in the sci-fi movie where the aliens live—he embedded some sixty aperiodic patterns in the walls, floors, and ceilings. His front garden is planted entirely with vegetation from the Mesozoic era. ("If the 'Jurassic Park' thing happens," he says, "this is where the dinosaurs will come to eat.") One of the scholarly achievements he is proudest of is a paper he co-wrote proving that it was theoretically possible for sauropods—his favorite kind of dinosaur—to have snapped their tails back and forth faster than the speed of sound. How could he say no to the great Jack Horner?

"What you do on a dinosaur expedition is you hike and look at the ground," Myhrvold explains. "You find bones sticking out of the dirt and, once you see something, you dig." In Montana, which is prime dinosaur country, people had been hiking around and looking for bones for at least a hundred years. But Horner wanted to keep trying. So he and Myhrvold put together a number of teams, totalling as many as fifty people. They crossed the Fort Peck reservoir in boats, and began to explore the Montana badlands in earnest. They went out for weeks at a time, several times a year. They flew equipment in on helicopters. They mapped the full dinosaur ecology—bringing in specialists from other disciplines. And they found dinosaur bones by the truckload.

Once, a team member came across a bone sticking out from the bottom of a recently eroded cliff. It took Horner's field crew three summers to dig it out, and when they broke the bone open a black, gooey substance trickled out—a discovery that led Myhrvold and his friend Lowell Wood on a twenty-minute digression at dinner one night about how, given enough goo and a sufficient number of chicken embryos, they could "make another one."

There was also Myhrvold's own find: a line of vertebrae, as big as apples, just lying on the ground in front of him. "It was seven years ago. It was a bunch of bones from a fairly rare dinosaur called a thescelosaurus. I said, 'Oh, my God!' I was walking with Jack and my son. Then Jack said, 'Look, there's a bone in the side of the hill.' And we look at it, and it's a piece of a jawbone with a tooth the size of a banana. It was a T. rex skull. There was nothing else it could possibly be."

People weren't finding dinosaur bones, and they assumed that it was because they were rare. But—and almost everything that Myhrvold has been up to during the past half decade follows from this fact—it was our fault. We didn't look hard enough.

Myhrvold gave the skeleton to the Smithsonian. It's called the N. rex. "Our expeditions have found more T. rex than anyone else in the world," Myhrvold said. "From 1909 to 1999, the world found eighteen T. rex specimens. From 1999 until now, we've found nine more." Myhrvold has the kind of laugh that scatters pigeons. "We have *dominant T. rex market share*."

In 1874, Alexander Graham Bell spent the summer with his parents in Brantford, Ontario. He was twenty-seven years old, and employed as a speech therapist in Boston. But his real interest was solving the puzzle of what he then called the "harmonic telegraph." In Boston, he had tinkered obsessively with tuning forks and electromagnetic coils, often staying up all night when he was in the grip of an idea. When he went to Brantford, he brought with him an actual human ear, taken from a cadaver and preserved, to which he attached a pen, so that he could record the vibration of the ear's bones when he spoke into it.

One day, Bell went for a walk on a bluff overlooking the Grand River, near his parents' house. In a recent biography of Bell, "Reluctant Genius," Charlotte Gray writes:

> A large tree had blown down here, creating a natural and completely private belvedere, which [he] had dubbed his "dreaming place." Slouched on a wicker chair, his hands in his pockets, he stared unseeing at the swiftly flowing river below him. Far from the bustle of Boston and the pressure of competition from other eager inventors, he mulled over everything he had discovered about sound.

In that moment, Bell knew the answer to the puzzle of the harmonic telegraph. Electric currents could convey sound along a wire if they undulated in accordance with the sound waves. Back in Boston, he hired a research assistant, Thomas Watson. He turned his attic into a laboratory, and redoubled his efforts. Then, on March 10, 1876, he set up one end of his crude prototype in his bedroom, and had Watson take the other end to the room next door. Bell, always prone to clumsiness, spilled acid on his clothes. "Mr. Watson, come here," he cried out. Watson came running—but only because he had heard Bell on the receiver, plain as day. The telephone was born.

In 1999, when Nathan Myhrvold left Microsoft and struck out on his own, he set himself an unusual goal. He wanted to see whether the kind of insight that leads to invention could be engineered. He formed a company called Intellectual Ventures. He raised hundreds of millions of dollars. He hired the smartest people he knew. It was not a venture-capital firm. Venture capitalists fund insights—that is, they let the magical process that generates new ideas take its course, and then they jump in. Myhrvold wanted to *make* insights—to come up with ideas, patent them, and then license them to interested companies. He thought that if he brought lots of very clever people together he could reconstruct that moment by the Grand River.

One rainy day last November, Myhrvold held an "invention session," as he calls such meetings, on the technology of self-assembly. What if it was possible to break a complex piece of machinery into a thousand pieces and then, at some predetermined moment, have the machine put itself back together again? That had to be useful. But for what?

The meeting, like many of Myhrvold's sessions, was held in a conference room in the Intellectual Ventures laboratory, a big warehouse in an industrial park across Lake Washington from Seattle: plasma TV screens on the walls, a long table furnished with bottles of Diet Pepsi and big bowls of cashews.

Chairing the meeting was Casey Tegreene, an electrical engineer with a law degree, who is the chief patent counsel for I.V. He stood at one end of the table. Myhrvold was at the opposite end. Next to him was Edward Jung, whom Myhrvold met at Microsoft. Jung is lean and sleek, with closely cropped fine black hair. Once, he spent twenty-two days walking across Texas with nothing but a bedroll, a flashlight, and a rifle, from Big Bend, in the west, to Houston, where he was going to deliver a paper at a biology conference. On the other side of the table from Jung was Lowell Wood, an imposing man with graying red hair and an enormous head. Three or four pens were crammed into his shirt pocket. The screen saver on his laptop was a picture of Stonehenge.

"You know how musicians will say, 'My teacher was So-and-So, and his teacher was So-and-So,' right back to Beethoven?" Myhrvold says. "So Lowell was the great protégé of Edward Teller. He was at Lawrence Livermore. He was the technical director of Star Wars." Myhrvold and Wood have known each other since Myhrvold was a teen-ager and Wood interviewed him for a graduate fellowship called the Hertz. "If you want to know what Nathan was like at that age," Wood said, "look at that ball of fire now and scale that up by eight or ten decibels." Wood bent the rules for Myhrvold; the Hertz was supposed to be for research in real-world problems. Myhrvold's field at that point, quantum cosmology, involved the application of quantum mechanics to the period just after the big bang, which means, as Myhrvold likes to say, that he had no interest in the universe a microsecond after its creation.

The chairman of the chemistry department at Stanford, Richard Zare, had flown in for the day, as had Eric Leuthardt, a young neurosurgeon from Washington University, in St. Louis, who is a regular at I.V. sessions. At the back was a sombre, bearded man named Rod Hyde, who had been Wood's protégé at Lawrence Livermore.

Tegreene began. "There really aren't any rules," he told everyone. "We may start out talking about refined plastics and end up talking about shoes, and that's O.K."

He started in on the "prep." In the previous weeks, he and his staff had reviewed the relevant scientific literature and recent patent filings in order to come up with a short briefing on what was and wasn't known about self-assembly. A short BBC documentary was shown, on the early work of the scientist Lionel Penrose. Richard Zare passed around a set of what looked like ceramic dice. Leuthardt drew elaborate diagrams of the spine on the blackboard. Self-assembly was very useful in eye-of-the-needle problems—in cases where you had to get something very large through a very small hole—and Leuthardt wondered if it might be helpful in minimally invasive surgery.

Cartoon by Rob Esmay

The conversation went in fits and starts. “I’m asking a simple question and getting a long-winded answer,” Jung said at one point, quietly. Wood played the role of devil’s advocate. During a break, Myhrvold announced that he had just bought a CAT scanner, on an Internet auction site.

“I put in a minimum bid of twenty-nine hundred dollars,” he said. There was much murmuring and nodding around the room. Myhrvold’s friends, like Myhrvold, seemed to be of the opinion that there is no downside to having a CAT scanner, especially if you can get it for twenty-nine hundred dollars.

Before long, self-assembly was put aside and the talk swung to how to improve X-rays, and then to the puzzling phenomenon of soldiers in Iraq who survive a bomb blast only to die a few days later of a stroke. Wood thought it was a shock wave, penetrating the soldiers’ helmets and surging through their brains, tearing blood vessels away from tissue. “Lowell is the living example of something better than the Internet,” Jung said after the meeting was over. “On the Internet, you can search for whatever you want, but you have to know the right terms. With Lowell, you just give him a concept, and this stuff pops out.”

Leuthardt, the neurosurgeon, thought that Wood’s argument was unconvincing. The two went back and forth, arguing about how you could make a helmet that would better protect soldiers.

“We should be careful how much mental energy we spend on this,” Leuthardt said, after a few minutes.

Wood started talking about the particular properties of bullets with tungsten cores.

“Shouldn’t someone tell the Pentagon?” a voice said, only half jokingly, from the back of the room.

How useful is it to have a group of really smart people brainstorm for a day? When Myhrvold started out, his expectations were modest. Although he wanted insights like Alexander Graham Bell’s, Bell was clearly one in a million, a genius who went on to have ideas in an extraordinary number of areas—sound recording, flight, lasers, tetrahedral construction, and hydrofoil boats, to name a few. The telephone was his obsession. He approached it from a unique perspective, that of a speech therapist. He had put in years of preparation before that moment by the Grand River, and it was impossible to know what unconscious associations triggered his great insight. Invention has its own algorithm: genius, obsession, serendipity, and epiphany in some unknowable combination. How can you put that in a bottle?

But then, in August of 2003, I.V. held its first invention session, and it was a revelation. “Afterward, Nathan kept saying, ‘There are *so* many inventions,’ ” Wood recalled. “He thought if we came up with a half-dozen good ideas it would be great, and we came up with somewhere between fifty and a hundred. I said to him, ‘But you had eight people in that room who are seasoned inventors. Weren’t you expecting a multiplier effect?’

And he said, 'Yeah, but it was more than multiplicity.' Not even Nathan had any idea of what it was going to be like."

The original expectation was that I.V. would file a hundred patents a year. Currently, it's filing five hundred a year. It has a backlog of three thousand ideas. Wood said that he once attended a two-day invention session presided over by Jung, and after the first day the group went out to dinner. "So Edward took his people out, plus me," Wood said. "And the eight of us sat down at a table and the attorney said, 'Do you mind if I record the evening?' And we all said no, of course not. We sat there. It was a long dinner. I thought we were lightly chewing the rag. But the next day the attorney comes up with eight single-spaced pages flagging thirty-six different inventions from dinner. *Dinner*."

And the kinds of ideas the group came up with weren't trivial. Intellectual Ventures just had a patent issued on automatic, battery-powered glasses, with a tiny video camera that reads the image off the retina and adjusts the fluid-filled lenses accordingly, up to ten times a second. It just licensed off a cluster of its patents, for eighty million dollars. It has invented new kinds of techniques for making microchips and improving jet engines; it has proposed a way to custom-tailor the mesh "sleeve" that neurosurgeons can use to repair aneurysms.

Bill Gates, whose company, Microsoft, is one of the major investors in Intellectual Ventures, says, "I can give you fifty examples of ideas they've had where, if you take just one of them, you'd have a startup company right there." Gates has participated in a number of invention sessions, and, with other members of the Gates Foundation, meets every few months with Myhrvold to brainstorm about things like malaria or H.I.V. "Nathan sent over a hundred scientific papers beforehand," Gates said of the last such meeting. "The amount of reading was huge. But it was fantastic. There's this idea they have where you can track moving things by counting wing beats. So you could build a mosquito fence and clear an entire area. They had some ideas about super-thermoses, so you wouldn't need refrigerators for certain things. They also came up with this idea to stop hurricanes. Basically, the waves in the ocean have energy, and you use that to lower the temperature differential. I'm not saying it necessarily is going to work. But it's just an example of something where you go, Wow."

One of the sessions that Gates participated in was on the possibility of resuscitating nuclear energy. "Teller had this idea way back when that you could make a very safe, passive nuclear reactor," Myhrvold explained. "No moving parts. Proliferation-resistant. Dead simple. Every serious nuclear accident involves operator error, so you want to eliminate the operator altogether. Lowell and Rod and others wrote a paper on it once. So we did several sessions on it."

The plant, as they conceived it, would produce something like one to three gigawatts of power, which is enough to serve a medium-sized city. The reactor core would be no more than several metres wide and about ten metres long. It would be enclosed in a sealed, armored box. The box would work for thirty years, without need for refuelling. Wood's idea was that the box would run on thorium, which is a very common, mildly radioactive metal. (The world has roughly a hundred-thousand-year supply, he figures.) Myhrvold's idea was that it should run on spent fuel from existing power plants. "Waste has negative cost," Myhrvold said. "This is how we make this idea politically and regulatorily attractive. Lowell and I had a monthlong no-holds-barred nuclear-physics battle. He didn't believe waste would work. It turns out it does." Myhrvold grinned. "He concedes it now."

It was a long-shot idea, easily fifteen years from reality, if it became a reality at all. It was just a tantalizing idea at this point, but who wasn't interested in seeing where it would lead? "We have thirty guys working on it," he went on. "I have more people doing cutting-edge nuclear work than General Electric. We're looking for someone to partner with us, because this is a huge undertaking. We took out an ad in *Nuclear News,* which is the big trade journal. It looks like something from *The Onion:* 'Intellectual Ventures interested in nuclear-core designer and fission specialist.' And, no, the F.B.I. hasn't come knocking." He lowered his voice to a stage whisper. "Lowell is known to them."

It was the dinosaur-bone story all over again. You sent a proper search team into territory where people had been looking for a hundred years, and, lo and behold, there's a T. rex tooth the size of a banana. Ideas weren't precious. They were everywhere, which suggested that maybe the extraordinary process that we thought was necessary for invention—genius, obsession, serendipity, epiphany—wasn't necessary at all.

In June of 1876, a few months after he shouted out, "Mr. Watson, come here," Alexander Graham Bell took his device to the World's Fair in Philadelphia. There, before an audience that included the emperor of Brazil, he gave his most famous public performance. The emperor accompanied Bell's assistant, Willie Hubbard, to an upper gallery, where the receiver had been placed, leaving Bell with his transmitter. Below them, and out of sight, Bell began to talk. "A storm of emotions crossed the Brazilian emperor's face—uncertainty, amazement, elation," Charlotte Gray writes. "Lifting his head from the receiver . . . he gave Willie a huge grin and said, 'This thing speaks!' " Gray continues:

> Soon a steady stream of portly, middle-aged men were clambering into the gallery, stripping off their jackets, and bending their ears to the receiver. "For an hour or more," Willie remembered, "all took turns in talking and listening, testing the line in every possible way, evidently looking for some trickery, or thinking that the sound was carried through the air. . . . It seemed to be nearly all too wonderful for belief."

Bell was not the only one to give a presentation on the telephone at the Philadelphia Exhibition, however. Someone else spoke first. His name was Elisha Gray. Gray never had an epiphany overlooking the Grand River. Few have claimed that Gray was a genius. He does not seem to have been obsessive, or to have routinely stayed up all night while in the grip of an idea—although we don't really know, because, unlike Bell, he has never been the subject of a full-length biography. Gray was simply a very adept inventor. He was the author of a number of discoveries relating to the telegraph industry, including a self-adjusting relay that solved the problem of circuits sticking open or shut, and a telegraph printer—a precursor of what was later called the Teletype machine. He worked closely with Western Union. He had a very capable partner named Enos Barton, with whom he formed a company that later became the Western Electric Company and its offshoot Graybar (of Graybar Building fame). And Gray was working on the telephone at the same time that Bell was. In fact, the two filed notice with the Patent Office in Washington, D.C., on the same day—February 14, 1876. Bell went on to make telephones with the company that later became A. T. & T. Gray went on to make telephones in partnership with Western Union and Thomas Edison, and—until Gray's team was forced to settle a lawsuit with Bell's company—the general consensus was that Gray and Edison's telephone was better than Bell's telephone.

"You should see the size of the shark the Chinese are using."

Cartoon by Glen Le Lievre

In order to get one of the greatest inventions of the modern age, in other words, we thought we needed the solitary genius. But if Alexander Graham Bell had fallen into the Grand River and drowned that day back in Brantford, the world would still have had the telephone, the only difference being that the telephone company would have been nicknamed Ma Gray, not Ma Bell.

This phenomenon of simultaneous discovery—what science historians call "multiples"—turns out to be extremely common. One of the first comprehensive lists of multiples was put together by William Ogburn and Dorothy Thomas, in 1922, and they found a hundred and forty-eight major scientific discoveries that fit the multiple pattern. Newton and Leibniz both discovered calculus. Charles Darwin and Alfred Russel Wallace both discovered evolution. Three mathematicians "invented" decimal fractions. Oxygen was discovered by Joseph Priestley, in Wiltshire, in 1774, and by Carl Wilhelm Scheele, in Uppsala, a year earlier. Color photography was invented at the same time by Charles Cros and by Louis Ducos du Hauron, in France. Logarithms were invented by John Napier and Henry Briggs in Britain, and by Joost Bürgi in Switzerland.

"There were four independent discoveries of sunspots, all in 1611; namely, by Galileo in Italy, Scheiner in Germany, Fabricius in Holland and Harriott in England," Ogburn and Thomas note, and they continue:

The law of the conservation of energy, so significant in science and philosophy, was formulated four times independently in 1847, by Joule, Thomson, Colding and Helmholz. They had been anticipated by Robert Mayer in 1842. There seem to have been at least six different inventors of the thermometer and no less than nine claimants of the invention of the telescope. Typewriting machines were invented simultaneously in England and in America by several individuals in these countries. The steamboat is claimed as the "exclusive" discovery of Fulton, Jouffroy, Rumsey, Stevens and Symmington.

For Ogburn and Thomas, the sheer number of multiples could mean only one thing: scientific discoveries must, in some sense, be inevitable. They must be in the air, products of the intellectual climate of a specific time and place. It should not surprise us, then, that calculus was invented by two people at the same moment in history. Pascal and Descartes had already laid the foundations. The Englishman John Wallis had pushed the state of knowledge still further. Newton's teacher was Isaac Barrow, who had studied in Italy, and knew the critical work of Torricelli and Cavalieri. Leibniz knew Pascal's and Descartes's work from his time in Paris. He was close to a German named Henry Oldenburg, who, now living in London, had taken it upon himself to catalogue the latest findings of the English mathematicians. Leibniz and Newton may never have actually sat down together and shared their work in detail. But they occupied a common intellectual milieu. "All the basic work was done—someone just needed to take the next step and put it together," Jason Bardi writes in "The Calculus Wars," a history of the idea's development. "If Newton and Leibniz had not discovered it, someone else would have." Calculus was in the air.

Of course, that is not the way Newton saw it. He had done his calculus work in the mid-sixteen-sixties, but never published it. And after Leibniz came out with his calculus, in the sixteen-eighties, people in Newton's circle accused Leibniz of stealing his work, setting off one of the great scientific scandals of the seventeenth century. That is the inevitable human response. We're reluctant to believe that great discoveries are in the air. We want to believe that great discoveries are in our heads—and to each party in the multiple the presence of the other party is invariably cause for suspicion.

Thus the biographer Robert Bruce, in "Bell: Alexander Graham Bell and the Conquest of Solitude," casts a skeptical eye on Elisha Gray. Was it entirely coincidence, he asks, that the two filed on exactly the same day? "If Gray had prevailed in the end," he goes on,

> Bell and his partners, along with fanciers of the underdog, would have suspected chicanery. After all, Gray did not put his concept on paper nor even mention it to anyone until he had spent nearly a month in Washington making frequent visits to the Patent Office, and until Bell's notarized specifications had for several days been the admiration of at least some of "the people in the Patent Office." . . . It is easier to believe that a conception already forming in Gray's mind was precipitated by rumors of what Bell was about to patent, than to believe that chance alone brought Gray to inspiration and action at that precise moment.

In “The Telephone Gambit,” Seth Shulman makes the opposite case. Just before Bell had his famous conversation with Watson, Shulman points out, he visited the Patent Office in Washington. And the transmitter design that Bell immediately sketched in his notebook upon his return to Boston was identical to the sketch of the transmitter that Gray had submitted to the Patent Office. This could not be coincidence, Shulman concludes, and thereupon constructs an ingenious (and, it should be said, highly entertaining) revisionist account of Bell’s invention, complete with allegations of corruption and romantic turmoil. Bell’s telephone, he writes, is “one of the most consequential thefts in history.”

But surely Gray and Bell occupied their scientific moment in the same way that Leibniz and Newton did. They arrived at electric speech by more or less the same pathway. They were trying to find a way to send more than one message at a time along a telegraph wire—which was then one of the central technological problems of the day. They had read the same essential sources—particularly the work of Philipp Reis, the German physicist who had come startlingly close to building a working telephone back in the early eighteen-sixties. The arguments of Bruce and Shulman suppose that great ideas are precious. It is too much for them to imagine that a discovery as remarkable as the telephone could arise in two places at once. But five people came up with the steamboat, and nine people came up with the telescope, and, if Gray had fallen into the Grand River along with Bell, some Joe Smith somewhere would likely have come up with the telephone instead and Ma Smith would have run the show. Good ideas are out there for anyone with the wit and the will to find them, which is how a group of people can sit down to dinner, put their minds to it, and end up with eight single-spaced pages of ideas.

Last March, Myhrvold decided to do an invention session with Eric Leuthardt and several other physicians in St. Louis. Rod Hyde came, along with a scientist from M.I.T. named Ed Boyden. Wood was there as well.

"Lowell came in looking like the Cheshire Cat," Myhrvold recalled. "He said, 'I have a question for everyone. You have a tumor, and the tumor becomes metastatic, and it sheds metastatic cancer cells. How long do those circulate in the bloodstream before they land?' And we all said, 'We don't know. Ten times?' 'No,' he said. 'As many as *a million times*.' Isn't that amazing? If you had no time, you'd be screwed. But it turns out that these cells are in your blood for as long as a year before they land somewhere. What that says is that you've got a chance to intercept them."

How did Wood come to this conclusion? He had run across a stray fact in a recent issue of *The New England Journal of Medicine*. "It was an article that talked about, at one point, the number of cancer cells per millilitre of blood," he said. "And I looked at that figure and said, 'Something's wrong here. That can't possibly be true.' The number was incredibly high. Too high. It has to be one cell in a hundred litres, not what they were saying—one cell in a millilitre. Yet they spoke of it so confidently. I clicked through to the references. It was a commonplace. There really were that many cancer cells."

Wood did some arithmetic. He knew that human beings have only about five litres of blood. He knew that the heart pumps close to a hundred millilitres of blood per beat, which means that all of our blood circulates through our bloodstream in a matter of minutes. *The New England Journal* article was about metastatic breast cancer, and it seemed to Wood that when women die of metastatic breast cancer they don't die with thousands of tumors. The vast majority of circulating cancer cells don't do anything.

"It turns out that some small per cent of tumor cells are actually the deadly ones," he went on. "Tumor stem cells are what really initiate metastases. And isn't it astonishing that they have to turn over at least ten thousand times before they can find a happy home? You naïvely think it's once or twice or three times. Maybe five times at most. It isn't. In other words, metastatic cancer—the brand of cancer that kills us—is an amazingly hard thing to initiate. Which strongly suggests that if you tip things just a little bit you essentially turn off the process."

That was the idea that Wood presented to the room in St. Louis. From there, the discussion raced ahead. Myhrvold and his inventors had already done a lot of thinking about using tiny optical filters capable of identifying and zapping microscopic particles. They also knew that finding cancer cells in blood is not hard. They're often the wrong size or the wrong shape. So what if you slid a tiny filter into a blood vessel of a cancer patient? "You don't have to intercept very much of the blood for it to work," Wood went on. "Maybe one ten-thousandth of it. The filter could be put in a little tiny vein in the back of the hand, because that's all you need. Or maybe I intercept all of the blood, but then it doesn't have to be a particularly efficient filter."

Wood was a physicist, not a doctor, but that wasn't necessarily a liability, at this stage. "People in biology and medicine don't do arithmetic," he said. He wasn't being critical of biologists and physicians: this was, after all, a man who read medical journals for fun. He meant that the traditions of medicine encouraged qualitative observation and interpretation. But what physicists do—out of sheer force of habit and training—is measure things and compare measurements, and do the math to put measurements in context. At that moment, while reading *The New England Journal*, Wood had the advantages of someone looking at a familiar fact with a fresh perspective.

"These medicines all taste pretty good—let's approve them."

Cartoon by Farley Katz

That was also why Myhrvold had wanted to take his crew to St. Louis to meet with the surgeons. He likes to say that the only time a physicist and a brain surgeon meet is when the physicist is about to be cut open—and to his mind that made no sense. Surgeons had all kinds of problems that they didn't realize had solutions, and physicists had all kinds of solutions to things that they didn't realize were problems. At one point, Myhrvold asked the surgeons what, in a perfect world, would make their lives easier, and they said that they wanted an X-ray that went only skin deep. They wanted to know, before they made their first incision, what was just below the surface. When the Intellectual Ventures crew heard that, their response was amazement. "*That's* your dream? A subcutaneous X-ray? We can do that."

Insight could be orchestrated: that was the lesson. If someone who knew how to make a filter had a conversation with someone who knew a lot about cancer and with someone who read the medical literature like a physicist, then maybe you could come up with a cancer treatment. It helped as well that Casey Tegreene had a law degree, Lowell Wood had spent his career dreaming up weapons for the government, Nathan Myhrvold was a ball of fire, Edward Jung had walked across Texas. They had different backgrounds and temperaments and perspectives, and if you gave them something to think about that they did not ordinarily think about—like hurricanes, or jet engines, or metastatic cancer—you were guaranteed a fresh set of eyes.

There were drawbacks to this approach, of course. The outsider, not knowing what the insider knew, would make a lot of mistakes and chase down a lot of rabbit holes. Myhrvold admits that many of the ideas that come out of the invention sessions come to naught. After a session, the

Ph.D.s on the I.V. staff examine each proposal closely and decide which ones are worth pursuing. They talk to outside experts; they reread the literature. Myhrvold isn't even willing to guess what his company's most promising inventions are. "That's a fool's game," he says. If ideas are cheap, there is no point in making predictions, or worrying about failures, or obsessing, like Newton and Leibniz, or Bell and Gray, over who was first. After I.V. came up with its cancer-filter idea, it discovered that there was a company, based in Rochester, that was already developing a cancer filter. Filters were a multiple. But so what? If I.V.'s design wasn't the best, Myhrvold had two thousand nine hundred and ninety-nine other ideas to pursue.

In his living room, Myhrvold has a life-size T. rex skeleton, surrounded by all manner of other dinosaur artifacts. One of those is a cast of a nest of oviraptor eggs, each the size of an eggplant. You'd think a bird that big would have one egg, or maybe two. That's the general rule: the larger the animal, the lower the fecundity. But it didn't. For Myhrvold, it was one of the many ways in which dinosaurs could teach us about ourselves. "You know how many eggs were in that nest?" Myhrvold asked. "Thirty-two."

In the nineteen-sixties, the sociologist Robert K. Merton wrote a famous essay on scientific discovery in which he raised the question of what the existence of multiples tells us about genius. No one is a partner to more multiples, he pointed out, than a genius, and he came to the conclusion that our romantic notion of the genius must be wrong. A scientific genius is not a person who does what no one else can do; he or she is someone who does what it takes many others to do. The genius is not a unique source of insight; he is merely an efficient source of insight. "Consider the case of Kelvin, by way of illustration," Merton writes, summarizing work he had done with his Columbia colleague Elinor Barber:

> After examining some 400 of his 661 scientific communications and addresses . . . Dr. Elinor Barber and I find him testifying to at least 32 multiple discoveries in which he eventually found that his independent discoveries had also been made by others. These 32 multiples involved an aggregate of 30 other scientists, some, like Stokes, Green, Helmholtz, Cavendish, Clausius, Poincaré, Rayleigh, themselves men of undeniable genius, others, like Hankel, Pfaff, Homer Lane, Varley and Lamé, being men of talent, no doubt, but still not of the highest order. . . . For the hypothesis that each of these discoveries was destined to find expression, even if the genius of Kelvin had not obtained, there is the best of traditional proof: each was in fact made by others. Yet Kelvin's stature as a genius remains undiminished. For it required a considerable number of others to duplicate these 32 discoveries which Kelvin himself made.

This is, surely, what an invention session is: it is Hankel, Pfaff, Homer Lane, Varley, and Lamé in a room together, and if you have them on your staff you can get a big chunk of Kelvin's discoveries, without ever needing to have Kelvin—which is fortunate, because, although there are plenty of Homer Lanes, Varleys, and Pfaffs in the world, there are very few Kelvins.

Merton's observation about scientific geniuses is clearly not true of artistic geniuses, however. You can't pool the talents of a dozen Salieris and get

Mozart's Requiem. You can't put together a committee of really talented art students and get Matisse's "La Danse." A work of artistic genius is singular, and all the arguments over calculus, the accusations back and forth between the Bell and the Gray camps, and our persistent inability to come to terms with the existence of multiples are the result of our misplaced desire to impose the paradigm of artistic invention on a world where it doesn't belong. Shakespeare owned Hamlet because he created him, as none other before or since could. Alexander Graham Bell owned the telephone only because his patent application landed on the examiner's desk a few hours before Gray's. The first kind of creation was sui generis; the second could be re-created in a warehouse outside Seattle.

This is a confusing distinction, because we use the same words to describe both kinds of inventors, and the brilliant scientist is every bit as dazzling in person as the brilliant playwright. The unavoidable first response to Myhrvold and his crew is to think of them as a kind of dream team, but, of course, the fact that they invent as prodigiously and effortlessly as they do is evidence that they are not a dream team at all. You could put together an Intellectual Ventures in Los Angeles, if you wanted to, and Chicago, and New York and Baltimore, and anywhere you could find enough imagination, a fresh set of eyes, and a room full of Varleys and Pfaffs.

The statistician Stephen Stigler once wrote an elegant essay about the futility of the practice of eponymy in science—that is, the practice of naming a scientific discovery after its inventor. That's another idea inappropriately borrowed from the cultural realm. As Stigler pointed out, "It can be found that Laplace employed Fourier Transforms in print before Fourier published on the topic, that Lagrange presented Laplace Transforms before Laplace began his scientific career, that Poisson published the Cauchy distribution in 1824, twenty-nine years before Cauchy touched on it in an incidental manner, and that Bienaymé stated and proved the Chebychev Inequality a decade before and in greater generality than Chebychev's first work on the topic." For that matter, the Pythagorean theorem was known before Pythagoras; Gaussian distributions were not discovered by Gauss. The examples were so legion that Stigler declared the existence of Stigler's Law: "No scientific discovery is named after its original discoverer." There are just too many people with an equal shot at those ideas floating out there in the ether. We think we're pinning medals on heroes. In fact, we're pinning tails on donkeys.

Stigler's Law was true, Stigler gleefully pointed out, even of Stigler's Law itself. The idea that credit does not align with discovery, he reveals at the very end of his essay, was in fact first put forth by Merton. "We may expect," Stigler concluded, "that in years to come, Robert K. Merton, and his colleagues and students, will provide us with answers to these and other questions regarding eponymy, completing what, but for the Law, would be called the Merton Theory of the reward system of science."

In April, Lowell Wood was on the East Coast for a meeting of the Hertz Foundation fellows in Woods Hole. Afterward, he came to New

York to make a pilgrimage to the American Museum of Natural History. He had just half a day, so he began right away in the Dinosaur Halls. He spent what he later described as a "ridiculously prolonged" period of time at the first station in the Ornithischian Hall—the ankylosaurus shrine. He knew it by heart. His next stop was the dimetrodon, the progenitor of Mammalia. This was a family tradition. When Wood first took his daughter to the museum, she dubbed the fossil "Great Grand-Uncle Dimetrodon," and they always paid their respects to it. Next, he visited a glyptodont; this creature was the only truly armored mammal, a fact of great significance to a former weaponeer.

He then wandered into the Vertebrate Origins gallery and, for the hundredth time, wondered about the strange openings that Archosauria had in front of their eyes and behind their nostrils. They had to be for breathing, didn't they? He tried to come up with an alternate hypothesis, and couldn't—but then he couldn't come up with a way to confirm his own hunch, either. It was a puzzle. Perhaps someday he would figure it out. Perhaps someone else would. Or perhaps someone would find another skeleton that shed light on the mystery. Nathan Myhrvold and Jack Horner had branched out from Montana, and at the end of the summer were going to Mongolia, to hunt in the Gobi desert. There were a lot more bones where these came from. ♦

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Malcolm Gladwell is a staff writer at The New Yorker and the host of the podcast "Revisionist History."

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