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The most formative moment in Bran Ferren's life was the one that set him on a long career in breakthrough innovation. At age 9, he accompanied his parents on a visit to the Pantheon in Rome. Looking up at the temple's enormous domed ceiling, he was transported not just by its artistry, but by the engineering prowess required to build it. Here was an enormous concrete structure unsupported by columns (the largest such dome in the world), with walls composed of five circular layered

rings that grew thinner and lighter as they rose toward the ceiling. At the top was an oculus that cast a shaft of light so strong that it appeared to have substance, while cooling the room and creating a feeling of direct connection to the heavens.

Ferren realized then and there that his schoolteachers were wrong: They talked as if art and science were separate things. But this experience at a structure built around 125 A.D. showed the two were intimately linked. He also began to re-

alize how difficult innovations like this could be, and how important they were to civilization.

"To build the Pantheon took some miracles," he explained to the audience in a 2014 TED talk that has attracted more than a million views. "By *miracles*, I mean things that are technically barely possible, [are] very high risk, and might not be actually accomplishable at this moment in time, certainly not by you." Creating the Pantheon required more than skilled use of concrete. It required knowledge of structural engineering, visual design, light, and religious behavior (because the Pantheon was a place of worship), and, most important, a vision of how to put it all together. Any significant innovation, Ferren went on to say, required at least five miracles — and given the limits of human imagination and life span, an innovator could count on having only "one to one-and-a-half" such insights himself or herself. To fulfill the rest, a creator must depend on the innovations that came before. Among the breakthroughs that Ferren says evolved this way: electricity, refrigeration, and the "connected car" technology emerging now. The Internet doesn't count, he says, be-

cause it wasn't a single planned invention; it featured dozens of separate evolutionary technologies that coalesced in the 1990s.

From his childhood in New York, Ferren's life and work took place at the nexus of art and engineering. His parents, John and Rae Ferren, were influential abstract expressionist artists, and two of his uncles were prominent engineers, in aircraft and audio recordings, respectively. Ferren dropped out of MIT at age 17, in 1970, and went on to become a designer and engineer for theater, for touring rock acts (including Paul McCartney and Pink Floyd), and for dozens of movies. His visual effects are prominent, for example, in *Altered States* and *Little Shop of Horrors*. In 1993, when the Walt Disney Company acquired his company, Associates & Ferren, he became a lead Imagineer there, and then went on to become president of R&D for Disney, leading its 4,000-person Imagineering group. (Its first leader had been the company's founder.)

In 2000, Ferren and fellow Disney R&D executive Danny Hillis left to found a design and invention firm called Applied Minds. Hillis was also a renowned entrepreneur; among other accomplishments, he had founded Thinking Machines, the first company to make parallel architecture supercomputers. Based in Los Angeles, Applied Minds soon gained an enviable track record of successful projects. In 2014, Applied Minds spun out another atelier-style company, called Applied Inventions, which is based in Boston and works on startup and commercial inventions. Applied Minds continues to focus on projects for government and large-scale businesses. Now run by Ferren, it is

dedicated to assembling creative minds in a wide variety of disciplines, including gaming software, biotechnology, materials science, specialized exploration vehicles, and satellite and space technology. The researchers at Applied Minds collaborate continually across disciplines to produce game-changing innovations.

Both Applied Minds and Applied Inventions innovate for clients on demand. But when a particular idea has legs and no existing organization has the capacity to grow it into its full potential, the resulting business gets spun off as a stand-alone entity. One notable spin-off was Metaweb, which makes a system for parsing concepts more precisely and thus enabling more effective searches; it was bought by Google in 2010. Another was Applied Proteomics, a biotech company that develops blood-analysis diagnostics for early detection of cancer. Applied Minds and Applied Inventions now hold about 1,000 U.S. patents between them; Ferren's own name has appeared on more than 500 during his career. One patent, issued in 2005, was for multi-touch gestures for touchscreens; this later influenced a court to decide (in a lawsuit Apple brought against Samsung) that Apple did not own the "pinch" command, used to zoom in or out on smartphones.

The significance of Ferren's ideas about innovation is not limited to design and technology. His enterprises have attracted, empowered, and nurtured dozens of remarkable artists, inventors, and engineers. They produce breakthrough innovations in record time, with an extraordinarily consistent track record and in a variety of industrial and consumer areas. He has, in other

words, created a company that routinely creates miracles.

Ferren spoke with *strategy+business* at the Applied Minds rapid prototyping facility in Burbank, Calif. The conversation cut to the heart of a key aspiration for many business leaders: fostering greatness, in the form of new products, services, and technologies, within the context of an established company or institution.

S+B: In your TED talk, you say that all truly revolutionary innovations need at least five miracles to come together — but any individual can generate at most one-and-a-half miracles in a lifetime. That seems like quite a challenge.

FERREN: I'm talking about innovations that change the course of history. These are extremely rare. Many powerful innovations, like the graphite pencil, were important but didn't change history. People would have used different tools for writing if graphite didn't exist.

But if you want a profoundly important new development that changes the way people live and think, that's really hard. It requires several different innovations coming together. That's what happened with the dome of the Pantheon. Another classic example is the airplane. The Wright brothers took their invention to the U.S. Army and said, "This would be a great military device." The Army thought it had no practical military value. In addition to all the technological inventions that made the airplane usable, like the controls in the cockpit, it needed an Air Force, an organization that had utilizing the invention of human flight as its core mission.

A more contemporary example is the iPhone — a communications-

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(FT Press, 2009).

centric computer, designed in the form of a smartphone. There wasn't a lot of new invention involved in it. Instead, it brought together inventions that already existed, that had evolved independently of one another. I was not an insider, but we all know what was involved. It required a high-resolution display, bright enough to read, and lithium batteries that could provide enough power in a small enough size. It needed thermal and chemically tempered glass, which Corning had developed. It needed a multi-touch touchscreen, which meant the appropriate capacitive conductive screen technology. It needed wireless digital networks — cellular telephony, Bluetooth, and Wi-Fi — but also the ability to surf the Internet.

The iPhone and the Newton [Apple's failed handheld device, released during the mid-1990s] essentially started with the same idea: a personal digital assistant. But the difference between them was profound, because the Newton existed without the Internet as we know it, and without voice and digital communications, and it was too big and heavy. A personal digital assistant that wasn't networked was basically useless.

S+B: What about the Internet? Wouldn't that count as a miracle-style innovation?

FERREN: The Internet was like the discovery of fire in its importance. Fire was critical to the growth and prosperity of civilization, but it wasn't sufficient in itself. Nor was it invented to solve a specific problem. The first people to harness fire didn't do it in a laboratory; they didn't put together a frictional component and a hydrocarbon in an oxidizing environment, trying to raise the fuel temperature above the kindling point. Probably they found burning fires caused by lightning strikes, and began to use them, eventually learning how to create their own. The innovations around fire, arguably, came from trying to harness it: making fires, putting them out, and using them to cook, warm people, and eventually drive engines.

The Internet, when it started in the early 1970s, was a vision for connecting big computers together in a robust and survivable manner. Its creators had enormous vision; they designed it to be truly scalable and enabling. However, there was no grand plan for turning this into a world-shaping platform that would directly affect our daily lives in the

way it has. Remember, the personal computer, mobile telephone, and flat-panel display did not exist then. The Internet evolved through a continuous flow of significant advances and other inventions, including the invention of personal computers, wireless networks, the browser (which was rudimentary at the start), and the World Wide Web architecture, which has been the Achilles' heel of most Web designers ever since. Then the search engine appeared, and technological adaptations keep the system evolving as the Web's archaic framework morphs to keep up with the world. No one I knew in 1995, if asked to pick the best Internet sub-architecture for linking the planet together, would have picked the World Wide Web. But it's the one that took off.

This is very different from the way the airplane or smartphone came about.

The Art of Leading a Company

S+B: Most companies, of course, want to produce that more deliberate kind of innovation — one they can profit from.

FERREN: Yes, but they don't understand what that means. If you had

shown them the iPhone 10 years ago and said, “This will be the future of how civilization works,” they would have said, “No, it won’t.” In fact, some companies looked at this space and elected not to pursue it.

This is because their innovation process doesn’t give their leadership a context for thinking about profound innovation. In a conventional company, an innovation process is often a substitution for creativity and thoughtfulness. Companies have come to us and asked for something like “disruptive innovation.” It is fashionable and they’ve read about it; they don’t know why they need it, but they hope it will help. However, they are seldom prepared to embrace what’s necessary to actually do this.

S+B: Like “thinking outside the box.”

FERREN: Yes. They tell their engineers to think outside the box, and the engineers dutifully respond by immediately designing a new box. They take the boxes they’ve already got, the products and processes already with them, and they usually make those boxes brighter, shinier, lighter, and more efficient. The result is usually more of the same with incremental improvement at best. The business leaders are obsessed with getting the right answer, but they’re not willing to put the energy into making sure they’re asking the right questions.

A good innovation process establishes context. It sets up a dia-

logue among the most capable people you can attract. So, should you have a revelation, you can recognize it and say, “That’s it!”

S+B: Wouldn’t that be obvious?

FERREN: Actually, it isn’t. I remember meeting Richard and Robert Sherman, the composers of “It’s a

roll. This experience with live audiences was invaluable in the visual effects work I later did for films. When the audience was taken away from the creative feedback process, as it is in film production, I still had the instincts I had learned on stage. I had a sense of timing and effect. I knew what it took to touch or

“Business leaders are obsessed with getting the right answer, but they’re not willing to put the energy into asking the right questions.”

Small World,” which they wrote for the attraction at Disneyland. It’s said to be one of the most widely played songs in the world; it’s one of those songs that contaminates your brain when you hear it, so you can’t get it out of your head. They tell the story that when they first submitted it for Walt Disney’s approval, it was one of about 20 options. They played all of them for him, one after another, with one brother on the piano and the other one singing. He didn’t love any of the other candidates, but when they finally got to that song, he commented, “That’ll do.”

People like Walt operate by instinct. Their instinct comes, at least in part, from the in-depth training that they get from immersion in creative work. For example, early in my career, I did visual effects in theater and live rock-and-

frighten someone, or to make them laugh, or to get across a sense of why one thing caused another. I could get the audience to jump, applaud, or scream.

If you have skills like those in some relevant form of creativity — preferably one that combines art and science — and if you hone those skills, then you have a reasonable sense of what you can accomplish in other types of invention. There are no standardized metrics you can apply to this kind of innovation judgment, only your well-trained instinct. Suppose, for instance, that you are a director working on a comedy film. There is a joke in the script. You film it and it works well before test audiences. But then you make another change [to a scene appearing] four minutes earlier [in the film], and the joke doesn’t work any-

more. Why? You will probably never know. There are books written on comedy theory and a whole bunch of things like that, but it's very hard to pin down. You need to develop instinct, based upon experience.

Creating and leading a great company is just as much an art as making a film is. It is not science. And when you don't understand the difference, you can end up hiring engineers to do the job of an artist.

S+B: It sounds like you're using *art* to mean the ingrained understanding that comes from practicing your craft over time.

FERREN: No, craft is different from art. Art is the ability to conceptualize and have the vision for something that hasn't existed before —

single demonstration said everything that needed to be said about that computer. Great theater.

But the heart of [the art of leading a company] is the ability to identify an idea, conceptualize it, bring a team of people together, execute it in a way that's effective, and course-correct as you go. According to Steve, the iPhone was originally a tablet project. Partway through the R&D process, he said, "Hmm, we can make a phone out of this." After the launch, many people rewrote history and said that the purpose of the iPhone was to reinvent the future of telephony.

Suppose you had been at Research in Motion (RIM) — the creator of the BlackBerry — at that time, thinking about inventing the

when I run out of power, I can't put in a new battery. Make it really thin, because I really care about thinness. And please give me apps (whatever they are), and I really need an online store where I can go buy those apps."

How many BlackBerry users would have responded with any portion of that list? Probably close to none. And if they had anticipated the concept of apps, then someone else would have rightfully pointed out, "The phone business is controlled by the carriers. They will never let you put third-party software on it, let alone make money from it." Or "It's a mature business, with no growth left in it. It's dominated by Motorola and Nokia. There's no point in investing that much." Or "This has all been pitched or tried before, and we know it doesn't work."

That's another reason you need an artist. It takes someone who intuitively understands the context of the future to override perfectly sensible objections like those.

"You need an artist. It takes someone who intuitively understands the future to override perfectly sensible objections."

and bring it to life. Or it's the ability to have a notion, and then by an iterative process of experimentation, derive the same outcome. Someone, perhaps the Roman emperor Hadrian, was the artist behind the Pantheon. In business innovation, as in film, this is a commercial endeavor: You care about reaching and affecting an audience.

Showmanship is one part of it. For example, when Steve Jobs revealed the MacBook Air [at his MacWorld keynote in 2008], he took it out of a manila envelope onstage. When he stood up with the envelope, nobody knew a computer was going to slide out of it. That

future of telephony, with no holds barred. Suppose you conducted market research with your most expert BlackBerry users and asked them, "What do you crave in a phone?" You would tell them to assume no boundaries or constraints, to just ask for something so great it would change their world.

What devoted BlackBerry user would have said, "Get rid of all the keys. Give me a screen three times as big, and it needs to be multimedia capable. I really need a music and video player, and multi-touch would be nice. I'd like one-third the battery life, and make sure that battery isn't interchangeable, so

Where Picassos May Flourish

S+B: Can a company become the kind of place that teaches its people how to be creative in this way?

FERREN: No. I believe that it's a fallacy to think you can teach anybody to be profoundly creative. That's like trying to find the next Pablo Picasso by hiring perfectly skilled MBAs, political scientists, art majors, and art historians, and saying, "Guys, keep at it. You're not Picasso yet, but we believe you'll get there with enough persistence and encouragement. We'll just send you to creativity school, provide free cinnamon almond lattes, and keep training you." It doesn't work that way. [You

get that] only if you happen to find the next Picasso in one of your cubicles, or can attract him or her from elsewhere — and can find a way to appreciate, harness, and develop that talent.

Most people don't get what it means to be creative at this level, let alone succeed at making the creative idea happen. I see this when I talk about the history of innovations. Many people don't know who invented electricity, the radio, or the computer — or, more important, what went into each of these inventions and their paths to eventual success. Understanding the importance of history and the value of multidimensional thinking — and how to break free of history, tradition, and conventional wisdom — can be too much of a leap for some people. It's like being color-blind and trying to understand the difference between red and green.

The first step is to accept that there's a different way of thinking about things, and that it exists beyond the boundaries you're accustomed to. As an organizational planner or leader, you may have to recognize the importance of this other way of thinking, even though you're not skilled at it yourself. Then you have to attract someone whom you can communicate with easily, but who has that additional dimension of thinking that you don't have, to help make your thought process better. Then you need a plan to execute your new idea, without killing what makes it great. [See “What

Self-Made Billionaires Do Best,” by John Sviokla and Mitch Cohen, *s+b*, Spring 2015.]

At most companies that care, you can set up creative, innovative environments and teach everyone to function better within them. You can hire a Picasso. Or, better yet, you can hire several Picassos: Several extraordinary people with complementary talents, who each have strengths that the others don't have. Having picked them, you can empower them. You can put them with 15 other people as good as they are, but in different ways. You then get a type of generative activity and creativity that you don't get otherwise. Even then you still have to take that creativity, massage it, and create an output that's valuable for a customer. Which is hard for most companies to do.

Meanwhile, odds are that the rest of your organization, especially middle management, will strive to eliminate them. So you need to give them top cover.

S+B: Is that what you do here [at Applied Minds]?

FERREN: Yes. We try to set a context where high levels of creativity can flourish. That means creating an environment that is attractive to the next Picasso, or the next Nikola Tesla, or the next atomic physicist. We can't train them in their fields; they have to come to us with talent, passion, and great skills. But we can train them to work within our multidisciplinary envi-

ronment, with people of very different perspectives and backgrounds, so they don't all kill each other in the middle of each project. We try to develop people's ability to work with others outside their specialty, and to be able to synthesize their insights together, for the benefit of our customers.

S+B: How do you accomplish this?

FERREN: I have very simple rules of business. First, work with people you like. Life is too short to work with jerks. Also, people you don't like tend to misunderstand what you do.

Second, do things that are good for the world. I like to ask myself, “My daughter is 6 years old. How do I make the world a better place than the way I found it, with each project we do?”

Third, make more money than you spend. This rule is the opposite of what people often do in venture funding, where the point is to move quickly toward a liquidity event. In our businesses, we start with understanding the needs and desires of our customers. When we get an idea, we turn the idea into something valuable — in our case, valuable for our clients' business — and then ideally we both share in that success.

We earn our keep by creating things that, odds are, these companies wouldn't have been able to create on their own, and then we find a way to merge it into their process in such a way that it can be ef-

fective for them. And that hopefully doesn't trigger their organization's immune response.

Innovation and Bravery

S+B: Many companies tend to succeed these days through their distinctive capabilities: things they can do that no one else can. If you're correct, then these capabilities depend on attracting and holding people like Picasso, Tesla, Disney, and Jobs. How can a typical large company do this?

FERREN: Often, it can't. Our approach at Applied Minds is essentially a bet with the CEOs of large companies that we can attract, motivate, and focus this type of talent better than they can. In fact, depending upon the topic area, if they tried to do it themselves, it could prove a distraction and actually diffuse their business strategy rather than help it.

Applied Minds functions more like an atelier or a movie studio model than like a typical requirements-driven engineering or design innovation group within a company. Our project managers are like directors — they're brought in to drive an endeavor from start to finish, recruiting and managing other people to play their parts. It's hard to make that work in large companies that believe in consensus management.

Only a few creative companies, like Apple or Disney, work this way. They are led by talented people who

function like movie directors, driving the creative development process and personally deciding what will work. Like Steve Jobs at Apple. This model is very talent-driven. You don't set up teams that operate through consensus. You pick and empower an individual "talent star," or they pick themselves and create the company, and you're making the bet on his or her success.

S+B: Do you see any great innovators who are generating miracles this way?

FERREN: In the auto industry, they sponsor exotic and fabulously expensive technologies that go into Formula 1 cars. These state-of-the-art innovations come from sharp, highly skilled, passionate people, with big budgets for experimentation and engineering. Some of that technology trickles down into a much larger parent organization where the focus is otherwise on sales and manufacturing efficiency, not ultimate performance.

The other end of the spectrum is Elon Musk, who is working to build what he believes to be the future of transportation. I know a lot of Tesla owners, and they absolutely love their cars. He's said to be losing money on each one, but building truly great innovative electric cars, while working on strategies and new business models to make them profitable. He has clearly created a passionate user community by capturing people's imagination in ways that the big automakers have yet to

do. This is thought leadership.

Can Elon leverage his vision and track record into long-term economic success? Maybe. A lot of electric car companies have failed or had minimal impact. In general, the big automotive business moves very slowly. Before the Tesla, the DNA of an automobile hadn't changed in 100 years. It's dominantly an internal combustion engine, four wheels, a steering wheel, an accelerator, and a brake.

I think self-driving cars will be a fundamental game changer. They will change the way people think about transportation, how we design cities, and the economics of mobility. Yet I don't know one car company whose leaders now think it's the future of their entire industry. They think it will happen, but not before they retire. If you keep thinking that way, one day you wake up and you see that the disruptive future is in fact happening to you right now. Then you suffer the fate of Motorola, Nokia, Polaroid, or Kodak.

Bravery is often necessary for success in creativity, and bravery, like business acumen, often involves what others would consider risky behavior. So if you are risk-averse, by definition you generally won't do the things that are necessary to accomplish these sorts of breakthroughs, because you may have to bet the farm every time you do those things.

Most corporate leaders understand that this is a problem. But

does it hold them back so much that it's worth changing their normal way of doing things? They're dealing with such a complex enterprise, with so many things at once, that to make them feel compelled enough to take a big bet on innovation, there has to be enough upside to be worth the cost — the cost in money, time, and stress. Not to mention risking their job and reputation. This is a bridge too far for most traditional CEOs, or good process managers.

can keep you from accomplishing your goal — but no one in sight seems to be able to say yes, and make it happen.

S+B: What kind of learning do you suggest for managers who aspire to be true artist leaders in their companies, to balance their technical knowledge with intuition?

FERREN: First of all, come to appreciate the contributions of artists of all forms, not just following our traditional definitions of art. The best

which you weren't pre-gifted with the intuition and skills to do well.

Flying a helicopter is a good example. It doesn't matter how smart or artistically creative you are or how good your sense of balance is. There's nothing natural or intuitive about it; you have to rewire your nervous system to be able to do it. Once you learn, it becomes intuitive and things like hovering just happen without thinking about it. It becomes Zen-like.

Zen archery was one of the first articulated skills that I read about that trains you to rewire your nervous system that way. Controlling your breathing, your heart rate, shooting between heartbeats and breaths — all of that is required. For the best of those who practice it, Zen archery becomes an art form that goes beyond what you'd think a human being is capable of.

Witness that the noteworthy book on this subject is called *Zen in the Art of Archery*. Similarly, Sun Tzu's classic on war strategy is called *The Art of War*. It's not "the science of archery," or "the technology of war," or "the discipline of innovation strategy." At the summit of performance, each of them is an art. +

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“Self-driving cars will be a fundamental game-changer. Yet I don't know one car company whose leaders think it's their future.”

Moreover, in most large companies, with a handful of notable exceptions, nobody has the ability to say yes and let big plays happen. The CEO will say, “Such-and-such is my highest priority.” The organization says, “It's the 135th ‘most important’ priority you've handed us this year, and we'll take it for further consideration. Besides, we can probably wait you out, and your successor won't remember what you said.” Meanwhile, if you show up at the building with a great idea, but the security guard doesn't like the way you look, you're not getting into the building. So everyone, including the security guard,

programmers I've met are artists and treat programming as much more of an art form than a science.

Then, go live a life worth living. Experience with passion what this amazing world has to offer, and learn to appreciate the brilliance of the creativity of others. Learn to do something really hard that takes you out of your comfort zone. This could be writing a screenplay for a film, acting in a play or video, building a rocket, giving a public speech on something you're passionate about to inspire others, or learning how to paint. For those who already have a strong creative drive, it can be learning how to do something for

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