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CHAPTER 1

THE CAPACITY
FOR CHANGE

Say the word *Pixar* and what comes to mind? Kids of all ages think of *Toy Story*, *A Bug's Life*, *Monsters Inc*, *Finding Nemo*, *The Incredibles*, *Cars*, and *Ratatouille*. All of these films create magical worlds in which toys, bugs, monsters, fish, superheroes, and cars come to life, and a rat can become a gourmet chef. Even after my son was too old to want to go to the theater with me, I eagerly awaited the release of each new Pixar film—not only to watch what great story would unfold, but also to see how the company's brilliant animators pushed technology to make their onscreen characters even more engaging. At Pixar, the technology inspires the art and the art challenges the technology. It's a two-way street.

I remember my first visit to Pixar headquarters in Emeryville, California, when Disney was in the process of acquiring the company. The lobby opens into a giant atrium surrounded by conference rooms, gaming spaces, and a cafeteria, inviting employees to play, meet, eat, and create. Scooters and skateboards are used to zip around the building, encouraging people to get out of their offices and move around. The openness of the building immediately conveys the openness of the environment.

Walking through the door of the animation department is like entering a Pixar movie—or a bustling small town. The

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workspace is decorated thematically for each new film. On the day I visited, there were rats everywhere (cute ones, of course) because the project in production was *Ratatouille*. Each animator creates his or her own unique workspace. One had built a little cottage out of a gardening shed; another, who prefers to work standing up, designed an office with no walls and no chairs. It was clear how much thought had been put into creating a physical environment that inspires individualism, creativity, and fun.

Behind Pixar's incredible creative and financial success is leadership that has a deep understanding of the importance and process of innovation. Launched with \$10 million by Ed Catmull and John Lasseter in 1986, the company was sold to Disney for over \$7 billion in 2006. Catmull is now the president of Disney and Pixar Animation Studios. Lasseter, who is the chief creative officer, is often referred to as the next Walt Disney.

The genesis of the company was an example of innovation at work. What is now Pixar began in 1979 when George Lucas, of *Star Wars* fame, set up a group to explore new techniques for digital printing and audio and video editing. He hired Catmull, a leading researcher in computer graphics, who has always had a passion for filmmaking. After several years, they agreed to set up the group as an independent company. Following months of discussions with venture capitalists (VCs) and corporate partners that led nowhere, they finally negotiated a deal with Apple founder Steve Jobs, who was attracted by the talent of the team. Their passion was to make full-length computer-generated animated films. But recognizing that neither the technology nor the market was ready, they sold advanced imaging systems to medical-imaging firms, government agencies, and other movie studios, including Disney. Never giving up on their long-term vision, a small group led by Lasseter developed animated short films that helped drive the technol-

ogists and incubated what would eventually become Pixar's main business.

From 1986 to 1991, Pixar went through several variations of its business strategy. "We were grasping for a workable model. We sold the hardware business and started to sell software. Then we started making TV commercials," Catmull recalls. "Throughout, we struggled. Steve stuck with us as we were losing money. Then Disney gave us the opportunity to do a feature film."

If the team had been less passionate and tenacious, there would be no *Toy Story* or *Cars*. If the company had been backed by typical venture capitalists instead of a visionary entrepreneur like Jobs, it would never have survived its various transitions. Although he is not usually thought of as a patient personality, Jobs provided patient capital for the company. He trusted the smart people on the team, recognizing that their attempts to create various business models were not fatal failures, but steps toward success. When Disney approached Pixar in 1991 to work together on a set of 3D computer-animated feature films, the company and its technology were ready.

How has the company managed to always stay out ahead of the competition, each film amazing audiences more than the one before? Part of the answer is that the technology organization is always working on three time horizons simultaneously. Pixar developers who are dedicated to the next film in the lineup work side by side with the directors, writers, and animators to apply and extend the current technology. Other developers work on the next generation of animation tools so that the characters and environments in future films are even more real—enabling water to flow, shiny cars to reflect light, and fur to look soft to the touch. Pixar also has a small applied research group that focuses on longer-term development. This group collaborates with the research community at large on new

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algorithms that continually push the state of the art of graphics and animation.

Pixar's internal culture encourages creativity through questioning, openness, and a healthy attitude toward failure. Self-assessment is ongoing—not only when there's a problem, but also when things seem to be working well. Everyone is encouraged to comment on one another's work. "We have a group of filmmakers who don't take critiques personally. Here, it would be a serious error not to say what you thought," says Catmull. This level of honesty requires a working environment in which people trust management and feel safe.

Employees are encouraged to make their ideas available for feedback early. "People not only have to be willing to take risks, but others have to be willing to let them take the risk," Catmull observes. "Our first job is to get to the failure as soon as possible." Then they figure out why they failed and fix the things they couldn't foresee. Instead of viewing failures as negative, they recognize the initial missteps as necessary to getting the feedback needed to develop an important software tool or a brilliant film.

Pixar produces great entertainment by employing the best talent in research, development, and application of technology. The company has a shared vision and an unwavering commitment to the core values and process of innovation.

THE BASIC INGREDIENTS

Sustainable innovation does not happen in a vacuum. It is not just a flash of brilliance from a lone scientist, nor is it simply the result of a group going offsite to brainstorm and play team-building games. People often overestimate the *aha!* factor in the invention process. That process starts with creating the right kind of environment. "The rare thing is not coming up with ideas. It is creating that soup where lots of people are coming

up with ideas, and having a system that translates them into something effective,” says Danny Hillis, a former Disney Imagineer and cofounder of Applied Minds, an R&D consulting firm that calls itself the “little Big Idea company.” The soup starts with some common ingredients, a set of human attitudes and beliefs that are so critical that I call them the five core values of innovation: *questioning, risk taking, openness, patience, and trust.*

If pushed to an extreme, any one of these values can actually stifle innovation. Trust without questioning is blind. Too much patience can create an environment in which nothing happens. Risk taking must be tempered by questioning so that it does not become reckless. Questioning without trust can become merely judgmental. When all five values are in balance, they work together to create the capacity for change that enables innovation to thrive.

Questioning

Innovators naturally ask why or how something works, or if something can be done in a new way. This curiosity is encouraged by giving them room to explore. “My folks would be at home working on technology whether I paid them or not,” says Miley Ainsworth, IT director for FedEx Labs. “They have a natural hunger for new stuff. Technology happens to be their job, but it’s also their hobby.” Author and consultant John Seely Brown, former chief scientist at Xerox, calls himself “Chief of Confusion, helping people ask the right questions.” This restless curiosity inspires innovators to uncover promise and potential that others have overlooked.

In the early days of the ARPANET—the predecessor of the Internet—the focus of development was on creating networks that would allow computers in disparate geographical locations

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to communicate. But Bob Metcalfe, then at Xerox, became curious about the data being exchanged between computers in the same building, which had been nicknamed “incestuous traffic.” Out of this curiosity came the development of Ethernet, the foundation of local area networks that enable individuals to share information with their coworkers, friends, and family.

David Culler, a computer science professor at UC Berkeley, describes this kind of inquisitiveness as “stubbing my toe on the same spot often enough that I say, ‘What is this?’ Then I look down and find that what I’m tripping on is just the tip of a very big rock below the surface.” Innovation can also be driven by curiosity about things that *don’t* exist. “Once, when my three-year-old son was learning to read road signs,” says Culler, “he asked me, ‘Dad, why aren’t there any “go” signs?’ Kids see these things. What else are we not seeing?”

The only way to get beyond mere incremental improvements is to question the status quo. When Tesla Motors introduced its flashy red electric sports car in 2006, it made a big splash. People lined up to place orders for a car that hadn’t even been built yet. The Tesla was not the first electric car to hit the market, but its reception was different because the company’s cofounder, Martin Eberhard, was willing to take a new approach. All of the prior efforts to market electric cars had prioritized affordability to reach the broadest possible market. “They made horrible little cars that nobody wanted to drive,” says Eberhard. Instead, Tesla decided to launch with a high-end model that was outright cool to create desirability for the product concept; later it would figure out how to make a more affordable version. Whether the company is successful over the long term or not, Eberhard’s willingness to buck the trend has created positive, disruptive changes in the electric-car industry.

Entrepreneur Randy Scott launched a start-up called Incyte to sequence and catalog genes with the goal of discovering new

drugs. But the genetic data themselves turned out to be Incyte's most valuable asset. "We created one of the first information-based business models in biotech to generate gene-sequence information and sell it to big pharmaceutical companies," says Scott. He feared that Incyte would end up in a mad race with dozens of other companies jumping into the emerging biotech market. But because of its unique business model, Incyte had few competitors. "Everyone was caught up in the idea that the only way to make money in biotech was to develop a new drug. The idea of selling the information was just too different," Scott recalls. Eventually, the company grew to over \$200 million a year in sales because its founders were willing to adopt a new way of doing business.

Scott's next venture grew out of a more personal kind of questioning—asking why there were so few effective medical interventions available to a good friend who was diagnosed with breast cancer. His friend's treatment plan included chemotherapy, which had a remote chance of putting her cancer into remission, but would surely make her gravely ill. "I asked myself why we weren't using all the information we could get out of the genome to classify tumors better," says Scott. Leveraging the growing global bank of genetic data, he launched a company called Genomic Health to provide more personalized medicine, identifying treatments targeted to the genetic makeup of an individual patient and his or her specific disease. In the end, it was too late for Scott to help his friend, but not to bring the benefits of genomically targeted medicine to millions of others.

The way that leaders ask questions affects motivation and behavior, setting the tone for the whole organization. Questions can be inquisitive or judgmental. They can convey interest or impatience. Asking, "Why did you . . .?" conveys judgment, not trust. Similar information can be gleaned by asking, "Can you

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explain . . . ?” The types of questions that are critical to managing an ongoing project—“When will this be done? What are the milestones to measure progress or success?”—can also suppress new ideas. Research projects often consist of a set of open-ended questions or hypotheses that are being investigated without a clear outcome or end date. That doesn’t mean that you shouldn’t ask *what* the researchers are working on and *how* they plan to move forward. Leaders also need to be open to being questioned by others and themselves.

As we mature, we’re more prone to take situations as givens and forget to question the status quo or ourselves. With more to lose, we may be less willing to take risks. The same thing can happen as companies, industries, and fields of science mature and innovation becomes more incremental. But just as midlife can be viewed as a time of positive change, mature companies, industries, and scientists should continue to question their assumptions and pursue bold, broad-ranging innovation. Change may be more difficult at that stage, but curiosity and assessment should not stop with age or growth.

Risk

Accepting failure is not easy, and it is often costly in terms of dollars and reputation. It’s hard for people to give up when they passionately believe in a vision. But tolerance and patience are necessary if you want people to take creative and promising risks. FedEx CIO Rob Carter credits part of his company’s success to having a healthy attitude toward failure. “Failure is painful, and we struggle with it,” he admits. “But we have a great culture around bold risk taking.”

Failure is an inherent part of innovation. “When you start a project, you don’t know enough about the competition or the customer needs. You haven’t developed the best ideas or the best

technology,” says Curtis Carlson, CEO of SRI International, an independent nonprofit R&D organization. “So it’s the nature of the game that in the beginning, most of what you’re going to do is going to be a failure.”

People need to trust that they will not be labeled as career flops if they have done their jobs well and understand why their ideas or projects did not succeed. Failures should not be personalized unless they result from poor execution or lack of effort. Aim for accountability without finger-pointing and blame.

FedEx acquired a transportation company called Flying Tigers in 1989 as part of the company’s international expansion strategy. “We were very aggressive in Europe in the late 1980s and early 1990s, and got ahead of ourselves,” admits CEO Fred Smith. “We had to restructure those businesses, but we treated everyone fairly. You have to recognize that some things won’t work out. Then you’ve got to regroup and not shoot the people who made a valiant effort.” Instead, FedEx built out its Express Freighter network and narrowed its focus in Europe, which has become the company’s most profitable international market. By buying Flying Tigers, the company also acquired landing rights in Asia that are critical to its business worldwide.

The loss of more than a billion dollars through the purchase and subsequent sale of a company called Musicland taught Best Buy a significant enough lesson to catalyze a complete rethinking of its leadership construct. “The acquisition made sense to people at the top,” says Kal Patel, Best Buy’s enthusiastic executive VP, who spends his time in Asia and Silicon Valley searching for innovative people and ideas. But while the company’s executives were busy spinning out a rationale for buying a retail music company, Napster burst onto the Net and changed all the rules. Suddenly millions of teenagers decided that music should be downloadable—and free. “That was a pivotal moment for

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us,” Patel recalls. “We became much more focused on recognizing and fulfilling both articulated and unarticulated consumer needs.” Best Buy launched an internal initiative to listen much more closely to the employees who were talking to customers every day.

An acceptance of failure as a necessary stepping-stone to success is an integral part of the culture of Silicon Valley. As a partner at Kleiner Perkins, one of the Valley’s major VC firms, Kevin Compton met with industry leaders from other countries who were visiting the Valley in hopes of learning the secrets of its entrepreneurial magic. He would try to communicate the Valley gestalt with a story. “You’re getting ready for your country’s version of Thanksgiving dinner with the family. You’re 32 years old, you have kids, and you’re going to your in-laws’ for dinner,” says Compton. “After working at your version of IBM for ten years, everything was going great. But all of a sudden you left that job to go to a high-profile start-up that raised a whole bunch of money and completely flamed out 18 months later. I would ask these guys, ‘Do you go to the family dinner?’ They would usually say no. And I would tell them that in Silicon Valley, not only do you go to dinner, but your brother-in-law comes up and gives you a high five, saying, ‘I wish I had the courage to do that.’ As a risk taker, you got his attention. That’s in our DNA.”

This willingness to give it a shot and allow people a second, third, or fourth act in their careers has differentiated not only Silicon Valley’s but also America’s culture from that of other countries. Nokia researcher Henry Tirri says, “If I pose a question to a class of 100 students at a university in Finland, I’ll get only one hand up, but I’ll be totally convinced that the answer will be correct. If I do the same in the United States, I get 99 hands raised, out of which 90 are probably wrong. But they’re willing to try.”

Under the right leadership, even conservative government organizations like the Food and Drug Administration (FDA) can take informed risks and make a difference. When David Kessler became commissioner of the agency in 1990, processing of applications for new drug trials averaged 33 months—way too long a delay when lives are at stake. Kessler's response was to create a policy called Accelerated Approval. Then in 1996, when applications came in for protease inhibitors—a class of drugs that has radically boosted survival rates and improved the quality of life for those with HIV—they were approved within 47 days. "We set out a new policy, the industry cooperated, and it worked. We were transparent with the American people about the risks, and we ended up being right," he says. By the time Kessler left the FDA, 13 new antivirals had been approved that changed the course of a devastating disease.

Many gifted innovators are attracted to projects with a high probability of failure. "I *like* doing things that I am not sure will work out or not," says networking pioneer Paul Baran. "The element of risk adds excitement." Baran, who is still starting new companies at 80, is a stellar representative of America's scientific culture, with a willingness to venture where no man or woman has gone before.

The more successful you are, the more you have to lose, and the less likely you are to come up with disruptive innovation. But the failure *to* innovate often has a greater negative impact than the failure *of* innovation. The founders of Apple and FedEx, Steve Jobs and Fred Smith, have contrasting leadership styles and backgrounds, and are successful in completely different industries. But they share an eagerness to take bold yet calculated risks. Both survived very costly and public failures—Apple's Lisa computer; FedEx's ZapMail service—but that has not stopped them from pursuing grand new ideas with passion.

Openness

Innovation requires an open mind and an atmosphere that encourages people to imagine, think broadly, collaborate, capture serendipity, and have the freedom to create. Curiosity needs to be coupled with the ability to critically evaluate data, accept input, and be ready to adapt to change.

Lack of imagination kills many a project. At Zilog in the late 1970s, we developed a networked computer system that was years ahead of its time, nearly the equivalent of a PC running Microsoft Word. We demonstrated one of these machines to the management of Exxon, Zilog's main investor. Exxon, however, had also poured millions of dollars into typewriter companies that were developing dedicated word processors. Our group had a vision of the future, but Exxon's management couldn't imagine why anyone would want a general-purpose personal computer. As my former boss, Joe Kennedy, recalls, "They had already invested in these typewriters that they were calling word processors and said, 'Why do we need another one?' If Exxon had taken the time to understand what we had, Zilog could have beaten both Microsoft and Apple to market." Instead, Exxon passed, and many Zilog employees left to start their own companies. Silicon Valley is filled with successful new ventures launched by innovators who became entrepreneurs when their management would not consider new ideas.

Some of the most significant inventions in history—from penicillin, to Viagra, to Post-it Notes—were created because someone was open to looking beyond the original plan. Viagra was originally developed as a drug for hypertension. By paying attention to one of the compound's unanticipated side effects, Pfizer launched a new era of drugs that treat sexual dysfunction, and created one of its bestselling products. Capturing

serendipity requires flexibility and being open to surprise. “The greatest innovations come from accepting that unknown chance in your life,” says Yogen Dalal, managing director at Mayfield Fund. Without a culture of openness, deviations from plan are often covered up, instead of coming to light early so that the company can adapt.

Openly sharing information also creates pathways for valuable feedback. Some of the most costly failures in Silicon Valley were the result of projects that had been kept under wraps for too long. Roger McNamee, managing director of the private-equity firm Elevation Partners, points to the collapse of many early “pen computing” companies as the result of people “thinking they had something so incredible they couldn’t show it to anybody. As a consequence, they never got feedback saying, ‘Guys, this is stupid; you’re making a brick with a pen that doesn’t work.’”

There’s a natural tension between openness and focus in all areas of innovation, especially in the development of products or programs. It’s possible to be *too* open, always changing direction or specifications so that nothing gets done. But too much focus can overly constrain innovators. At the beginning of a project, when you are looking at needs, framing questions, and coming up with ideas, you want to encourage broad thinking and experimentation. Once a specific path has been agreed upon, it’s time to execute and not constantly reformulate the solution or add “just one more” feature. But it’s important to open your mind again when you are periodically assessing and making decisions as to how to proceed. Otherwise, you can end up with focused execution toward a goal that may no longer be the right one.

Microsoft, which began as a software tools company, ended up in the operating system business to meet the demands of a very large customer—IBM. “If Gates had sat down and

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said, “No, I’m focused on tools,” says entrepreneur Marc Andreessen, the coinventor of the Web browser, “someone else would have been Microsoft.”

Patience

Patience is a mandatory condition if innovation is to thrive, and it doesn’t have to be a passive process. Innovators need to be comfortable with abiding ambiguity for a time instead of jumping on the first idea or solution that comes along. They also require *active patience*: the tenacity to overcome technical obstacles and to champion their bold new ideas in the face of disbelief. Because of the persistence of Genentech’s scientists, a drug called Avastin received FDA approval for treatment of colorectal cancer in 2004—15 years after the initial research began. You can have patience and still do business with a sense of urgency.

If a new technology requires a major change in infrastructure, the time and money that will be needed for it to become pervasive are substantially increased. “The automobile remains a plaything until you have a highway system. The telephone system didn’t work unless we strung a million miles of wires,” says former HP Labs director Joel Birnbaum. In such cases, it is particularly important to spend the time up front on research and experimentation so that the infrastructure is built around solutions that are right for the long term.

Leaders and financial backers need to have the patience to let ideas ripen. If they sense impatience, employees either will not take the time to try something new or will take the quickest path rather than the best. Projects and companies that might have produced great products and profits can be shut down as a result of lack of patient capital. In the late 1990s, 3Com was in a battle with Cisco for market share in the networking market. But the 3Com board demanded a faster path to profitability. “So

we pulled out of the enterprise business,” recalls 3Com’s chairman, Eric Benhamou, “thus setting the company back five to ten years.” The result was that few people today remember 3Com, while Cisco grew to dominate the networking market.

The time frames and measurement techniques that are appropriate for development efforts are not the same as those for research projects. “There are periods where you can’t tell whether an individual thread is going to succeed,” says David Clark, a senior research scientist at MIT who was instrumental in the development of the Internet. “You can’t have some bean counter always looking over the wall with their clipboard saying, ‘How are you doing?’”

Trust

As a company leader or financial backer, you must trust your people and the innovation process. Only with this foundation will employees and executives allow themselves to be vulnerable, take risks, and have the freedom to create. When trust erodes, horizons get pulled in as innovative potential is sacrificed to meet demonstrable milestones.

Innovators must trust themselves enough to push through obstacles and realize their vision of what could be, while still being open to new ideas and relentless self-assessment. Best Buy’s Kal Patel calls this state of mind “living in the world of self-confidence *and* self-doubt.” You have to both believe in your vision and be open to not believing at the same time, because trust without sufficient questioning can lead to disaster.

Each of the companies that I cofounded developed products that pushed the edge of technology and targeted markets that did not yet exist, as many start-ups do. Our early investors and employees had to trust in our vision. We, in turn, had to trust

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our small, select teams, giving them the freedom to execute the steps necessary for us to realize our dream. Entrepreneurship is all about trust.

Building partnerships around innovation requires extending trust beyond a single organization. Long-term partnerships, rather than project-by-project transactions, enable openness and sharing of information.

Genuine trust gives people the freedom to question. A start-up called Gavilan lost tens of millions of dollars of its investors' money in the 1980s by developing a portable computer boasting several technologies that were way ahead of their time, including a touch pad and an LCD display. Customers were lining up to buy this technical marvel; there was a \$70 million backlog of orders. But the company tried to cram too many new technologies into the same machine and ended up with an unreliable product. "I was demoing the product to the secretary of the interior," recalls Wes Raffel, who was responsible for Gavilan's marketing and sales. "I had two machines with me, and both of them failed." No one was willing to stop and face the fact that the technology just wasn't ready for prime time. Eventually the company crashed, hitting the wall at 100 miles an hour, because it did not balance technical risk with honest self-assessment and accountability. But Raffel ended up learning a valuable lesson. "Gavilan's CEO had this magnetic personality and blind allegiance from his team," he says. "They all drank the Kool-Aid, and nobody was willing to say, 'Let's slow down.'"

AN INNOVATOR'S MIND IN ACTION: HAWKINS'S FOUR QUESTIONS

Jeff Hawkins is the brilliant scientist behind the Palm Pilot and the Handspring Treo. But his real passion is not for designing handheld devices. It's for understanding how we think. "When

I was a teenager, I made a list of the biggest questions I could muster,” he recalls. “Why does the universe exist? Why are the laws of physics as they are? Why is there life, and where did it come from? And given life, what is intelligence? I stopped there, because it seemed to me that we might be able to solve my last question.” If we understood how our own brains work, hoped Hawkins, we might be able to build tools that would help us answer the *first* three questions. At his father’s suggestion, Hawkins studied electronics, and upon graduating from college, he took a job at Intel as an engineer. But he hadn’t lost sight of his list of questions. He read an article in *Scientific American* written by biologist Francis Crick, the codiscoverer of DNA, which said that we were lacking a framework for understanding the brain. Hawkins decided to tackle the problem.

At Intel, he valiantly tried to convince his bosses and others in the tech industry that studying the brain could have enormous potential for advances in computing, but no one listened. Hawkins did not let this stop him. He quit his job and enrolled as a graduate student at UC Berkeley to study neuroscience, only to come up against more obstacles. “I wanted to study theories of the neocortex, but they said I couldn’t do it as a graduate student,” says Hawkins. “At that time there was nobody researching the area I was interested in, and they wouldn’t let a graduate student pursue independent research. I had to work for somebody else on their project.”

Eventually Hawkins decided that he would need to go back into business. “First of all, I had to put some bread on the table for my family. I wanted the financial resources to pursue my research,” he says. He also realized that he needed to learn how to effect change at the institutional level, influencing decision makers to change their opinions. He wanted to make a name for himself so that he would have enough credibility to marshal the resources he needed to take on the big questions.

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While working on the first tablet computer for a company called Grid, Hawkins got hooked on mobile computing and launched Palm in 1992. At first, the company almost didn't make it. A hardware partnership with Casio didn't work out, and the whole nascent mobile-computing industry seemed to be imploding. But one board member at Palm trusted Hawkins, and asked him if he knew what product people really wanted. Hawkins went home and designed the Palm Pilot that same night. The rest of the board thought he was crazy to want to build the whole product from scratch, including the operating system, the hardware, and the software. But this time he was able to convince others of the potential of his ideas. "We had \$3 million, little support, and just 27 employees," he says. "We could have just died a slow death. But instead we said, 'Let's go for it.'"

With the spectacular success of the Palm Pilot, Hawkins finally gained the financial independence and credibility he needed to tackle his research. In 2002, he launched the Redwood Neuroscience Institute in Menlo Park, funding it himself and working with academic institutions like Stanford and Berkeley to realize his vision. In the next three years, over 120 scientists came to RNI, bringing their intelligence to bear on understanding the neocortex. "There was no other place like this, where you had unfettered energy focused on a particular scientific problem," says Hawkins.

Eventually Hawkins decided that if RNI could turn its theories into a workable technology, he could get more people involved in furthering his work. He cofounded a company called Numenta to build a tool set developed from the institute's new understandings of how the brain works. "Numenta may take four to five years to get to profitability," says Hawkins. "The keys to success will be going slowly, not getting ahead of ourselves, and not trying to be too big."

Hawkins embodies the core values of innovation. He has always been intensely curious, he is willing to take risks, he is open to change, and he is tenacious and patient, gaining the trust of others while never losing faith in his own vision.

THE PROCESS OF INNOVATION

There is no one predictable path to successful innovation. “Half of the great innovations in the world happened from great insights, the other half happened by accident, and none of them happened on a schedule,” says long-time technology investor Roger McNamee. But behind the chaos there is a process: identifying a need and a set of questions to explore; trying and testing new ideas; and assessing whether to go forward or to return to generating more ideas, questions, or needs.

The innovation process is driven by the need to understand how something works or why it doesn't; to grow revenue, reduce costs, or increase productivity; to solve a customer's problem; or to keep people healthy and save lives. “If done well, this process of identifying and characterizing needs becomes the DNA of invention,” says Paul Yock, a professor of bioengineering at Stanford. In business, the trick is to identify the needs of your potential customers before they do. “By the time your customers tell you they want something, it's too late,” says Carol Bartz, executive chairman and former CEO of Autodesk.

By designing inexpensive and powerful software products like Quicken, QuickBooks, and TurboTax, Intuit has revolutionized the ways in which individuals and small businesses pay their bills and taxes, manage their accounting, and handle their payroll. At first, it seemed that the company could do no wrong. But when Intuit introduced eight new products that flopped between 1994 and 1999, founder Scott Cook was determined to find out why. Analyzing these failures, he was surprised to dis-

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cover that the same employees, types of technology, brand names, distribution channels, and target customers were often involved in both the company's flops *and* its successes. The difference was that "the successful products addressed an important unsolved customer problem," he says. "Nobody had tried to solve the problem yet because they didn't see it. But suddenly we did. That required us to undergo a mindset change, so that we could see a different paradigm from what we and others had believed."

Even noncommercial organizations can think in terms of their "customers" whose needs must be met. For an academic institution, the customer is society at large—the people and organizations that leverage the institution's research and hire its students. Government organizations must be clear about the evolving needs of the country's citizens as changes in demographics, economics, or foreign affairs affect defense, education, health care, and business policies. Funding agencies can learn to allocate their funds more effectively by viewing the recipients of their grants as their customers, understanding how best to enable the grantees to do their research, enhance their education, launch businesses, or lead productive, independent lives.

Behind each need is a set of questions to explore. *Is there a better way of doing this? What if we . . . ? How does this work? Why doesn't this work? What does the customer really need? What will the problem look like 10 years from now?* Learning how to frame the right questions is not easy. Asking a customer, "What features do you want in this product?" is certain to evoke a much more limited set of answers than, "What problems are you trying to solve?" Going a step further to understand the specific requirements and constraints of an application enables innovators to anticipate the customer's unarticulated needs as well, which can lead to even more significant innovation. Questions can also be employed to add useful constraints to a proj-

ect. There are times when it is important to focus on a specific problem and times when you want to encourage broad exploration.

Our ongoing struggle in Iraq is a disastrous example of the importance of framing questions correctly. We went to war with the technology to support a precision military campaign with minimal casualties. But we had the answers to the wrong problem. The military was prepared for a soldierless attack, but occupying a country requires boots on the ground. We were not prepared technologically, financially, or emotionally for the actual problem we're faced with now.

Brainstorming for *ideas*—new ways to address perceived needs—is often thought of as the “magic” part of innovation. It takes the right combination of research, creativity, and enough time to think. Once a promising set of ideas has been identified, it's time to *try and test* them through market research, scientific experimentation, or prototyping, at which point methodology and discipline become crucial.

Think back to your high school science classes when you learned how to design experiments. My son and I spent an afternoon firing a Nerf bow and arrow down the hallway for a high school physics assignment. After several hours of shooting arrows and calculating the propulsive force of the string, our results were inconclusive. Though we had fun, the longest section of David's lab report dealt with margins of error, because we didn't have the tools to accurately measure the arrows' trajectory or the force of the string. Lesson learned: experimental design is critical. Deciding how to test, where to get feedback, and critical analysis of data are all key to successful experimentation.

The Internet has transformed the relationship between companies and their customers, opening up direct and unfiltered channels of communication that were unimaginable in previ-

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ous eras, and providing companies with instant access to feedback and ideas from their customer base. With this free flow of information also comes the burden of filtering out the relevant information from the noise. Focus groups are useful only if you're asking the right questions of the right people; as Henry Ford put it, if he had asked his customers what they wanted, they would have said a faster horse. If an idea is significantly ahead of its time, early market feedback can be misleading. You have to decide whether you believe strongly enough in the concept to risk taking the next step *in spite of* not getting positive feedback.

Once the testing is done and the data have been analyzed, *honest self-assessment* is required. Does the proposed solution really answer the question at hand? Is the anticipated need significant enough to justify moving forward? Is it necessary to go back and test more, try another idea, or reframe the questions? The journey from the initial idea to success may take only weeks or months for a new product feature. But the development and testing of a new drug or a paradigm-shifting product can go on for years or decades.

Reed Hastings launched Netflix in 1998 as a frustrated video renter who was tired of paying late fees. The company started with a single-rental model: users paid \$4 to rent a single DVD for a week, plus a \$2 shipping and handling charge. "It was just not a *wow*," admits Hastings in retrospect. "It was OK, but we needed a *wow* to break through." Looking harder at the business, he concluded that a monthly subscription model—with the addition of a "dynamic queue" so that customers could always have a DVD to watch and more to look forward to—might just work. Netflix relaunched in September 1999, and this time it was a *wow*.

It can take multiple cycles of brainstorming, testing, analyzing, and adapting to get a project right—or to sensibly call it

quits. The process involved in innovation is often like riding a unicycle. To balance and keep moving ahead, you have to pedal both backward and forward.

ORTHOGONAL INNOVATION

The innovation process can result in life-changing breakthroughs or incremental improvements to existing ideas or products. There is a third type of significant innovation that comes from applying existing technologies in new ways. I call this *orthogonal* innovation.

The iPod is a great example. Apple was not the first company to offer a portable MP3 player, downloadable music, or software that allows users to “rip” and “burn” CDs. But the iPod packaged existing technological elements in an easy-to-use fashion. The integration of the elegantly designed physical device with the iTunes software is what shook the foundations of the music industry, opened up new markets for Apple, and enhanced all of our lives. “It was not just engineering, or downloading music, or third-party peripherals, or even the marketing,” says Jon Rubinstein, the former engineering vice president at Apple who oversaw the development of the device. “It was all of them combined, plus the retail stores where people got to actually handle an iPod for themselves. It all played really well together. The iPod was a product we all wanted. It was something we were all passionate about. But when we started, I never envisioned that it would sell 100 million.”

In fact, the vertical integration that many analysts saw as Apple’s core weakness turned out to be the factor that enabled the company to turn the iPod into a company-defining milestone success. Apple took the unique approach of looking at downloadable music as an entire system—complete with copy protection to appease the recording industry’s concerns—rather

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than just another new gadget or Web site. Apple leveraged the Internet to provide users with a great music *experience*, rather than just the ability to play MP3 files.

The credit card was introduced in the 1920s as a quicker and easier way for the growing number of automobile owners to buy gas. As companies like Diners Club and American Express made it possible to purchase meals, lodging, and merchandise with a swipe of the plastic, the concept of the credit card became a hugely disruptive innovation. The *debit* card, on the other hand, was an orthogonal innovation. It used the same basic technology as the credit card, with a different business model, to provide services that we now take for granted, but that we would not have thought to ask for before they became available.

Breakthroughs take time to be widely adopted. Incremental and orthogonal innovations typically have a more immediate impact. It is important to have the right balance of all three types of innovation. Breakthrough and orthogonal ideas and products can initiate new market cycles, driving opportunities for significant growth, whereas incremental innovations keep each cycle going.

NO BIGGER THAN A JAZZ BAND

If you talk to anyone who is in a leadership position, that person will tell you that attracting and retaining the best talent are top priority. What does this mean in the context of innovation?

The best talent embodies the five core values and has the right combination of aptitude, skill, judgment, passion, and drive. Such people's curiosity and openness to new experience are as important as their pedigree. They require deep understanding to garner respect, a sense of infectious excitement to rally the organization around them, and an almost compulsive

drive to tinker. “What we always looked for were people who were born with soldering irons in their hands,” says Jon Rubinstein. “People with a passion for products, for the creation process, and for technology itself.”

Many innovators do not have a firm idea of what obstacles they will face when they launch something new. They have a certain dose of naïveté that prevents them from being daunted by the problems that inevitably lie ahead. Reid Hoffman, founder of the LinkedIn social network, has personally mentored many of the founders of start-ups like Facebook, Flickr, and Digg. In the late 1990s, he joined PayPal and ended up being responsible for all of PayPal’s external relationships, including coping with banking regulations. “By not knowing about government regulations, banking, fraud, financial structure, and a whole bunch of other things,” says Hoffman, “we basically ran out into the middle of a minefield, not even knowing that there *were* minefields. But once we were there, the only thing we could do was to go forward—and we pulled it off, while most of the people in the banking industry were sitting on the sidelines.” Akin to this naïveté is a sense of play, even in the midst of very demanding work. “I have a category of people in my network who really enjoy playing with technology,” says Hoffman. “They start with an artifact and say, ‘What can I make out of this?’ This is different from goal-driven behavior.”

Magic happens when small groups of the most talented people have a sense of purpose and shared values, are provided with sufficient resources, and are empowered to come up with something great. Even for complex projects that ultimately may require significant resources to implement, the initial teams should be kept small, cutting down on communication overhead and ensuring that the group can change direction quickly if necessary.

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In Silicon Valley, the optimal size of these groups is often described by the “two-pizza” rule, which says that nothing amazing ever happens in a group that can’t be fed by two pizzas. Nokia researcher Henry Tirri refers to the right size of these groups as “no larger than a jazz band,” so that individuals can improvise and play off of one another without requiring a conductor to stand before them, orchestrating every move.

Every jazz aficionado knows that the best bands are made up not just of musicians who can play killer solos, but of those who know how to listen to one another and serve the collective vision of the music. Particularly now, when products and projects often call upon a broad range of expertise, finding team members who know how to collaborate with one another—and with the world at large—is crucial. Increasingly, leaders are recognizing the value of what IDEO, a leading product design company, calls *T-shaped people*—those who have a depth of knowledge in a particular area, but also the breadth to communicate well with people in other disciplines.

It wasn’t just the technology of Apple’s iPhone that made it a landmark product that grew the market for smart phones generally. It was also the elegant and imaginative product design, and a marketing team that knew how to build public expectation into a frenzy. Innovation grows out of the combination of diverse sets of expertise. Facilitating communication between the various groups, and creating the right balance of rewards for all, requires leadership that understands and appreciates the importance of the entire cast of characters.

“There are half a dozen words in the English language that are substitutes for *substance*. Three of them are *innovation*, *accountability*, and *leadership*,” says retired Intel CEO Andy Grove. “Companies that let people get away with murder talk too much about accountability. Those that don’t have the courage to leave the handrail talk incessantly about leadership.

And people who are incapable of changing what they are doing, or even analyzing what's wrong, go on and on about innovation." Innovation is not just another pat phrase with little meaning beyond the latest hot start-up. We need real, sustainable innovation, which can come only with courage on the part of leadership and an Ecosystem that is in balance.

