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Science and Business: Moving Beyond Lab and Board Room

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Humans have been seeking new knowledge and new ways of applying it since the dawn of civilization, and science and business have been intertwined nearly as long. For centuries, the pursuit of knowledge proceeded at a measured, even courtly pace. The turbulence of breakthrough invention was followed by long periods of adjustment and stability. And the businesses that launched those inventions often had years to rest on their laurels until the competition caught up.

Not anymore. New tools, new technology and new competitors are dramatically changing both process and pace. And there is certainly no time for a break.

- As technology evolves, it takes less and less time for new products to spread into the population. Radio took 38 years to reach 50 million users, 13 years for television, four years for the Internet, three years for the iPod and one year for Facebook.[1]
- Estimates indicate that 40 exabytes (4.0×10^{19} bytes) of unique information will be generated worldwide this year. That estimate is more information than has been generated in the previous 5,000 years.[2]
- Business now faces an age of extreme competition. Because the line between leader and also-ran is razor thin, companies must innovate faster, operate leaner and think globally just to survive. Many do not make it. McKinsey estimates that the topple rate for corporations—as measured by the exodus from the S&P 500—doubled between 1975 and 1995.[3]

There are new feedback loops between business and science in this age of technological turbulence. For example, technology has accelerated the pace of global economic integration, which has heightened competition and put pressure on profit margins. That, in turn, has shrunk the capital available to invest in research and development. Similarly, the fast pace of technological change has compressed product cycles, which in turn have constricted the time horizons for business research. In a nutshell, there is little commercial value in investing in research that may no longer be relevant by the time it is ready to deploy.

Thinking through what is changing and what it means could be the competitive differentiator for the 21st century—for companies as well as countries.

1 Fisch, Karl Scott McLeod, and Jeff Brennan—video: "Did You Know?" http://bostonkayakguy.wordpress.com/2008/11/19/did-you-knowdid-you-john-prescotts-the-metwest-scene/.

2 "Shift Happens" http://shifthappens.wikispaces.com/Various+Versions+of+the+Presentation.

3 Hyett, William and Patrick S.Viguerie, "Extreme Competition: The forces of globalization, technology, and economic liberalization are combining to make life harder than ever for established companies", The McKinsey Quarterly, (Feb. 2005). http://www.mckinseyquarterly.com/Extreme_competition_1564.

The Power of Tools: How Science Is Changing Everything (Including Business)

The pace of change is being driven by powerful new tools that tackle challenges at the digital, genetic and atomic levels. These tools are creating new knowledge at extraordinary rates in their own domains and spilling over to drive ever-faster rates of change in others.

Information Technologies

Imagine the economy without computing power: most control systems for utilities and telecommunications would fail. Air traffic control systems could not handle today's volume. There would be no Google searches, no diagnostic medical imaging, no DVDs, no electronic funds transfers, no e-commerce.

IT has spawned a new class of companies and capabilities:

- The first web browser was released commercially in 1994. In March of 2009, there were 14 billion web searches.
- The first text message was sent in 1992. Today, the number of text messages sent every day exceeds the population of the planet.
- Skype launched computer-to-computer communications in 2003, registering 445 million users by first quarter 2009 and logging in 24 billion call minutes. The company was acquired in 2006 for $2.3 billion.
- Twitter was launched in 2006. Now there are more than 32 million users.[4]

In a world in which everything is connected, the opportunities for disruptive business process innovation are skyrocketing. Although most businesses see IT as a way to make processes more efficient and effective, Nick Earle and Andy Mulholland describe the three strategies some leaders are applying to create new business value through Mesh Collaboration:

- Collaborative eco-systems: engaging partners in co-creation of an enhanced customer experience.
- Personalization of the long tail: large numbers of unique items and services in small quantities.
- Smart services: gathering information for every IP-enabled device and analyzing it centrally to create market insights and value-add products and services.[5]

The combination of fast connections and even faster computers creates new opportunities to leverage IT tools to turbo-charge the innovation landscape.

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4 http://shifthappens.wikispaces.com/Various+Versions+of+the+Presentation.

5 Mulholland, Andy and Nick Earle, *Mesh Collaboration: Creating New Business Value in the Network of Everything*. Evolved Technologist Press, May 2008.

Connectivity: In 1985, when the National Science Foundation linked up research centers for the first time, the transmission rate was 56 kilobits per second—50 times faster that the standard modem of the day. When that network was rolled out as the Internet in 1995, its connection speeds of up to 45 megabits per second were 1000 times faster than just 10 years before. What is next? Japan has tested a fiber optic cable that pushes 14 trillion bits per second down a single fiber.

The speed advantage will enable high-definition transmissions over the Internet, enabling major strides forward in telemedicine (potentially even remote surgery), telecommuting, teleconferencing, full-screen video entertainment over the Internet, and improved overall broadcasting quality and capability.

Computing Power: In 1990, the leading edge of computing technology was the Cray Y-MP (about 300 million operations per second). Today, the next generation petascale computers are a million times faster, operating at speeds of quadrillion calculations per second.

The capacity to process such large data sets in real time yields new capabilities, including the ability to model systems as complicated as Earth's climate.[6]

Companies which use high performance computing find that such tools can generate new insights, cut costs by reducing the number of physical prototypes needed, reduce time to market, and optimize complex functions like supply chains or risk management assessments.

Three real-world examples of high performance computing in action come from DreamWorks Animation, Proctor & Gamble (P&G) and Boeing. DreamWorks is only able to create animated creatures like Shrek on high performance computers. P&G used computational models to solve the problem of the "flying Pringles." Without the right geometric shape, the chips would literally fly off the manufacturing line instead of dropping into the can. Boeing used high performance computing to reduce the number of physical wing tests for the 787 to just 11, versus 77 for the 767.[7]

Increasingly, companies are finding that to out-compete, they must be able to out-compute.

Genomics

The most powerful codes are no longer in strings of ones and zeroes, but in four letters: A, T, C and G. This is the programming language of life. Different combinations of those four letters—DNA-bases—describe every life form on earth. The ability to understand and manage them will revolutionize the competitive landscape in every sector, from medical to agricultural.

6 Council on Competitiveness, *Advance: Benchmarking Industrial Use of High Performance Computing for Innovation*. Washington, DC, 2008, available online at http://www.compete.org/publications/detail/486/advance/.

7 Council on Competitiveness, "High Performance Computing: Accelerating Innovation to Enhance Everyday Life" (DVD), 2005, available online at http://www.compete.org/publications/detail/409/high-performance-computing/.

In the medical arena, the ability to treat disease by turning genes on and off may make some of today's medical therapies—amputations, consumption of toxic chemicals and irradiation—look as primitive as the practice of bloodletting to release evil spirits.

With genomics, medicine can become predictive, preventive and personalized. And the industry will look considerably different when information technology—capturing the DNA profile for every individual—is as important, if not more so, as identifying chemical compounds with useful properties in treating disease. Decoding the first human genome took 10 years and $3 billion dollars. The ability to produce a personal genetic code for about $5,000 in an hour or two is not far off in the future.

Scientists are not just reading genetic code. They are writing it as well. DNA is being inserted into cells, rebooting them to create either a different species entirely or stem cells that can regenerate into any organ.

In agriculture, plant genomes are being engineered to meet new challenges:

- DuPont is a leader in creating next generation sources of biofuels to meet global energy demand in a sustainable way—potentially a $75 billion dollar market.[8]
- The U.S. Agricultural Service is working on genetically engineered extra firm tomatoes that will take longer to soften—with a potential market value of more than $600 million.
- Japanese researchers are working on suppressing the caffeine gene in coffee plants to produce decaffeinated beans with a market potential of $400 million.

Ultimately, genetic engineering may even revolutionize the information industry. While humans have 3.2 million base pairs of genetic coding, a type of amoeba has been discovered that has 620 million base pairs—200 times more base pairs than a human. It could be the ultimate information storage device.

Nanotechnology

In 1959, physicist Richard Feynman introduced the concept of manipulating individual atoms and molecules in a talk entitled "There's Plenty of Room at the Bottom." It was not until years later that the term "nanotechnology" was coined to refer to this concept. Operating on the world's tiniest stage, a nanometer is to a tennis ball what a tennis ball is to the Earth.

Nanotech is not always a "what." Increasingly it is a "how"—how existing products can be improved; how physical matter can be created at the molecular level; how atoms can become usable as a natural resource. The term nanotechnology is becoming so ubiquitous as to be almost invisible as a game changer.

8 See the recent Council case study on Pioneer Hi-Bred, a DuPont company, at http://www.compete.org/publications/detail/683/pioneer-is-seeding-the-future-with-high-performance-computing/.

Today, nano-materials dominate the $12 billion nanotechnology market. These new materials have specialized properties:

- Electrically-active silver coatings on refrigerators to inhibit bacterial growth;
- Scratch resistant and stain resistant coatings;
- Golf balls engineered for less spin;
- Water repellent coatings that could eliminate the need to de-ice a plane or shovel a driveway; and
- Super strong fibers that duplicate the durability and strength of a spider web.

The vision for nanotechnology goes well beyond current reality. In 1966, the film *Fantastic Voyage* imagined a microscopic submarine with a tiny medical team injected to treat a life-threatening blood clot. In the nano-world of today, scientists are trying to create microscopic nano-capsules that hunt down diseased cells and deliver precise drug doses.

There are similar hopes that the ability to manipulate atoms will achieve breakthrough capabilities in many other areas:

- Solar cells that are as cheap as newspaper and tough enough to use for resurfacing roads;
- Molecular manufacturing that requires no burning, oiling, washing with solvents and acids, or toxic chemical disposal; and
- Pocket-sized high performance computers with molecular transistors.

Science is spinning off opportunities for businesses, potentially faster than businesses can absorb them. Curt Carlson, CEO of SRI, remarked: "If you're not terrified, you're not paying attention. On the other hand, if you're not excited, you're also not paying attention."[9]

The bottom line is that businesses around the world must believe that investment in research is a good idea because they invested about $545 billion in research and development in 2008—a 10 percent increase from the year before. And those bets can pay off big.

Consider the new generation of billion dollar babies:

- Cisco was founded in 1984; 2008 revenues were $39 billion.
- eBay was founded in 1996; 2008 revenues were $8.5 billion.
- Google was incorporated in 1998; 2008 revenues were $22 billion.
- Salesforce.com (using cloud computing for customer relationship management) was founded in 1999; it broke the billion dollar threshold in 2009.

9 Conversation with Curt Carlson, June 17, 2009.

However, the exponential pace of change might make these bets harder to place.

Futurist Ray Kurzweil notes:

> The first technological steps—sharp edges, fire, the wheel—took tens of thousands of years. For people living in this era, there was little noticeable technological change in even a thousand years. By 1000 A.D., progress was much faster, and a paradigm shift required only a century or two. In the 19th century, we saw more technological change than in the nine centuries preceding it. Then in the first 20 years of the 20th century, we saw more advancement than in all of the 19th century. Now, paradigm shifts occur in only a few years time.[10]

In essence, instead of 100 years of progress, the 21st century will see something more on the order of 20,000 years of progress.

The implications for business are profound. Historically, the pattern of scientific revolution was major breakthrough and disruption, followed by stabilization and adjustment. Innovation gurus like John Seeley Brown suggest that advances in today's core technologies—computing, storage, bandwidth—are not stabilizing; that the pattern of stabilization itself has been disrupted. Today, business is facing a shift into ***a world without equilibrium:***

> A world in which companies lose their leadership positions at an increasing rate. A world in which extreme events, such as the ongoing financial turmoil across global markets, becomes increasingly likely. A world of shifting product economics and increasing volatility in brand equity.[11]

As technological change puts pressure on business, survival may depend on flexibility and adaptability—resilience in the face of innovation-driven turbulence. Perhaps one of the most promising arenas of innovation for business will not be technological but organizational. MIT professor Wanda Orlikowsky suggests that, to manage change, the current orchestral corporate organization needs to be replaced with a jazz combo model:

> When the bounds and scope of change are uncertain, an organization needs not predetermined plans, but flexible improvisation. The maestro's careful direction should give way to the ad hoc creativity of a group's accomplished practitioners, who improvise within a set of rhythms and chord changes, but without a precise and pre-defined composition.
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> In fact, contrary to conventional wisdom, the most successful business transformations aren't always those with the most detailed upfront plans. Think of the massive

10 Kurzweil, Ray. "The Law of Accelerated Returns", kurzweilAI.net, March 7, 2001.

11 Hagel, John and John Seeley Brown, "The Next Wave of Open Innovation", BusinessWeek, April 8 2009, http://www.businessweek.com/innovate/content/apr2009/id2009048_360417.htm.

technology-related organizational changes most companies have undertaken over the past decade, for example. Corporations have wired themselves to the Internet, enterprise resource planning systems have re-mapped corporate processes, and groupware technologies have afforded new ways of organizing. But few companies knew in advance precisely how these technologies would affect them. It was the organizations that stayed flexible that best took advantage of new opportunities, explored new ways of working and resolved unanticipated consequences.[12]

Other Potential Game Changers for Business

Science and technology are driving other changes around which businesses may need to improvise.

A Shift From the Few to the Many

The authorship of innovation is shifting from the few and the "expert" to the many. Traditionally, creativity and innovation were thought to be the province of special people (scientists and engineers) in special places (laboratories). The logical endpoint of this model is that to encourage innovation, the nation must have more special people in special places. That might be a necessary condition for innovation, but it is no longer sufficient.

Increasingly, the center of gravity is shifting as innovation becomes a collaborative effort—innovation co-creation. The Internet allows innovators to organize without being in an organization. This environment facilitates both user-driven innovation and potentially more disruptive innovation than many established companies are willing to pursue.

Emerging markets are becoming a breeding ground for passionate innovation. The mountain bike was created in the 1970s by a group of users in California who mixed and matched various elements and called their creation the clunker. Thirty years later, the clunker accounts for a $58 billion dollar market.

When Apple launched iTunes and the iPod, it had no idea that podcasting would be a big deal. In the open-source model, innovation comes from hundreds of thousands of people. Creativity and innovation of the many are enabled by YouTube or Google Video, where anyone can upload a three minute movie. On eBay, anyone can create a new business.

Technology will enable the transition from an innovative nation to a nation of innovators. How businesses seek and sense for new ideas may determine which thrive and which survive.

Global Internet-based Innovation Platforms

With R&D productivity flat at most mature, innovation-based companies and with costs rising, the "invent it alone" model is no longer capable of sustaining high levels of top-line, innovation-led

12 Orlikowski, Wanda J. "Jazz-Inspired: Manage Change by Improvising", Theory and Practice, MIT Leadership Center, July 2006. http://www.google.com/search?hl=en&ei=hyU5SsgqhMIz5rLgIA0&sa=X&oi=spell&resnum=0&ct=result&cd=1&q=jazz+inspired%22+manage+change+by+improvising&spell=1.

growth. Increasingly, companies like P&G are looking to connect external sources for innovation. Its Connect + Develop program set an ambitious goal: half of new products would come from P&G labs and half would come through them. The upshot: R&D productivity of P&G has been increased by almost 60 percent. The success rate of innovations has been doubled, while the costs of innovations declined. Investments in R&D relative to sales have been reduced from 4.8 percent in 2000 to 3.4 percent today.[13]

New open platforms are emerging around the world to create new ways to manage innovation globally, connecting seekers with research challenges to solvers with creative solutions. One of the first companies, Innocentive, offered a monetary reward of up to 1 million dollars for successful solutions. Since 2001, more than 170,000 participants from more than 175 countries have registered as Solvers. More than 800 problems have been posted, and almost 400 solutions have been found. This represents almost a 50 percent success rate on problems that had stumped internal research and development staffs. Almost $20 million in awards have been posted, while almost $4 million in awards have been paid out to successful Solvers.

In a study of open innovation platforms, Professor Karim Lakhani from the Harvard Business School has documented that many of the awards went to Solvers outside the discipline of the problem. Lakhani's research report observed that, "the further the focal problem was from the Solvers' field of expertise, the more likely they were to solve it."[14] That finding should have enormous implications for the way businesses organize their internal research process.

Twitter: Revolution Spelled in 140 Characters

Created in 2006, microblogging platform Twitter has 32 million users, an increase from about 2 million a year ago. Twitter promises to change the face of disaster response and political dialogue.

The *Los Angeles Times* used Twitter to publicize emergency information during recent fires in Southern California as to where the fire lines were breaking. Twitter users knew that a plane had landed in New York City's Hudson River within minutes of the event. President Obama now speaks directly to more than 1.3 million followers on Twitter (a number that increases every day), while members of Congress are using it to communicate with constituents. And the administration recently asked Twitter to forgo a routine maintenance shutdown so it could continue to carry messages out of Iran after the regime blocked media coverage of the street protests following the disputed presidential elections.

13 "P&G—Probably the Largest R&D Department in the World", Openeur, Dec. 3, 2006, http://www.openeur.com/blog/en/2006/12/03/pg---probably-the-largest-rd-department-in-the-world/.

14 Hagel, John and John Seeley Brown, "The Next Wave of Open Innovation", BusinessWeek, April 8 2009, http://www.businessweek.com/innovate/content/apr2009/id2009048_360417.htm.

The power of Twitter may extend beyond emergency information and political punditry. Twitter is increasingly become a place where companies build brands, do research, send information to customers, conduct e-commerce and create communities for their users. Here are a few examples from @24/7Wall Street:

Hyper Local Marketing: As Twitter is coupled with GPS, business-to-consumer interactions can be more targeted. JiffyLube can target local customers with oil change specials. Or what if a large MNC oil company with local gas stations could tweet people who want to save money on gas when the price at the pump drops a few cents? Such new services can be enabled because Twitter users can follow local businesses and companies closely by zip code.

Twitpay, or Twitter as microfinance: One model that is being tested allows consumers to put cash into a Twitpay account. Twitter could well be the basis for a service in which florists, bars or restaurants could set up payment networks.[15]

A Final Grain of Salt

The last 100 years is littered with famously failed forecasts

- "Heavier-than-air flying machines are impossible."—Lord Kelvin, British mathematician and physicist, president of the British Royal Society, 1895.
- "Lee DeForest has said in many newspapers and over his signature that it would be possible to transmit the human voice across the Atlantic before many years. Based on these absurd and deliberately misleading statements, the misguided public…has been persuaded to purchase stock in his company…"—a U.S. District Attorney, prosecuting American inventor Lee DeForest for selling stock fraudulently through the mail for his Radio Telephone Company in 1913.
- "There will never be a bigger plane built."—a Boeing engineer, after the first flight of the 247, a twin engine plane that holds ten people.
- "Computers in the future may weigh no more than 1.5 tons."—Popular Mechanics, 1949.
- "There is practically no chance communications space satellites will be used to provide better telephone, telegraph, television or radio service inside the United States."—T. Craven, FCC Commissioner, in 1961 (the first commercial communications satellite went into service in 1965).
- "The world potential market for copying machines is 5,000 at most."—IBM, to the eventual founders of Xerox, saying the photocopier had no market large enough to justify production, 1959.

As Yogi Berra once remarked: "Prediction is very hard, especially when it's about the future."

15 *Time Magazine*, "Top 10 ways Twitter Will Change American Business," June 4, 2009.

About the Council on Competitiveness

WHO WE ARE

The Council's mission is to set an action agenda to drive U.S. competitiveness, productivity and leadership in world markets to raise the standard of living of all Americans.

The Council on Competitiveness is the only group of corporate CEOs, university presidents and labor leaders committed to ensuring the future prosperity of all Americans and enhanced U.S. competitiveness in the global economy through the creation of high-value economic activity in the United States.

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HOW WE OPERATE

The key to U.S. prosperity in a global economy is to develop the most innovative workforce, educational system and businesses that will maintain the United States' position as the global economic leader.

The Council achieves its mission by:

- Identifying and understanding emerging challenges to competitiveness
- Generating new policy ideas and concepts to shape the competitiveness debate
- Forging public and private partnerships to drive consensus
- Galvanizing stakeholders to translate policy into action and change

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