An Executive Guide For

Deploying Innovation

A COMPREHENSIVE APPROACH TO INSTITUTIONALIZE BUSINESS INNOVATION

PRAVEEN GUPTA

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CHAPTER ONE

HISTORY OF INNOVATION

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In the chronology of social development, when human beings started to acquire assets, competitive desires evolved—a desire to have more, a desire to have something better, a desire to have things that make life easier. When these desires became strong enough, they transformed into a need or necessity, and as the old cliché goes, "necessity is the mother of all inventions." Historically, knowledge was limited to a few. However, in today's knowledge age, where information is shared widely, future innovation will result from individual and collaborative discoveries at an increasingly faster rate. Studies show that innovation is built on past knowledge and continuous experimentation. Rather than accepting it as an ad-hoc process with unknown outcomes, innovation can be developed into a structured process and a more predictable system.

Innovation has always been a part of mankind. Since the discovery of fire by rubbing two stones together, humans have been innovating. Innovation is probably the oldest known process; in other words, innovation is an extension of a person's creativity. We have always used our innate skills to create many new things and to help mankind.

Imagine when the human evolved and discovered fire. What was the knowledge level then based on what we know today? What was the level of excitement at the discovery of fire? As people gain new understanding by trial and error, they transform it into new knowledge and then use that knowledge to gain new understanding, discover more unknowns, and become even more curious. Thus the cycle of experimentation, knowledge, and innovation continually repeats. The outcome of the knowledge-experience cycle has led to continual creativity and innovation.

HISTORY AND EVOLUTION OF KNOWLEDGE: FROM STONE DAGGERS TO METAL

Before discovering fire, humans discovered simple rocks that could be used as tools. Getting ideas from human or animal teeth, a thought of a dagger could have arisen, and so daggers of stone were made. A dagger provided protection from animals and probably was used as a tool to prepare cold food which was then warmed by the sun's heat. Daggers could easily have evolved into knives and spears. These tools could be used to tame animals or even for hand-to-hand fighting.

Humans discovered fire more than 50,000 years ago. Fire, which could be very destructive if not controlled, could be a great friend when controlled. The discovery of fire led to further human knowledge, as the fire could be used for making tools, keeping humans warm, keeping animals away, cooking meals, lighting dark caves, or even melting ice. Therefore, the discovery of fire could be considered a great breakthrough in human evolution because it was critical for survival.

How could the early humans or hominids get an idea about fire? They must have observed fire caused by lightning, or sun heat, or volcanic eruptions. They could have even observed fire while throwing rocks which produced sparks when they hit other rocks. The discovery of fire led to humans thinking about how to use fire and how to protect themselves from it.

Thousands of years later, humans did invent the bow. The idea of a bow could have come from tree branches loaded with fruit. In thunderstorms or high winds, tree branches often throw their fruit far away. The tree branches may have been the catalyst for the invention of slings for throwing rocks, and slings led to bows to launch arrow-like spears. The arrow could be considered an evolution of spears adapted to work with bows for throwing longer distances.

The discovery of daggers, knives, fire and bows and arrows may have led to the preparation of warm meals. Warm meals resulted in warmer bodies and may have led to the need for clothes to satisfy the demand for warmth. Clothes made out of grass and roots evolved to clothes made of animal skins with the help of a needle. Therefore, the discovery of the needle was a breakthrough. The early needles were like a hook to stitch two pieces of skin or fabric to replace the series of knots previously used to put two pieces together. The knots could have been discovered from natural entanglements of long string-like objects, or even tree branches or bushes.

Early civilization appears to be based on the seven metals, as the remaining known metals were discovered since the 13th century. The seven metals are gold, copper, silver, lead, tin, iron and mercury. Early tools and weapons were made of copper, which was discovered around 4000 BC, and tin and iron were discovered around 1500 BC. The discovery of copper was more significant, as the first set of tools, implements and weapons were made of copper. Early applications of copper were made with hammer and chisel.

Copper smelting was probably learned while throwing copper waste into fire. The first copper-smelted artifacts were found in the form of rings, bracelets, chisels, and weapons about 500 years after the discovery of copper. By the 17th century, an additional five metals were isolated, which are platinum, antimony, bismuth, zinc, and arsenic. By this time, metallurgy was a well-developed discipline. Post 17th century discovery of metals accelerated as twelve new metals were discovered in the 18th century.

HISTORY AND EVOLUTION OF KNOWLEDGE: LANGUAGE, NUMERALS AND ART

Panini (6th century BC), an Indian mathematician, developed a theory of phonetics, phonology, and morphology, and provided formal production rules and definitions describing Sanskrit grammar in his treatise called *Asthadhyayi*. Basic elements such as vowels and consonants, and parts of speech such as nouns and verbs, were placed in classes. The construction of compound words and sentences was elaborated through ordered rules operating on underlying structures in a manner similar to formal language theory.

In the modern world, around the 12th century, Raymundus Lullus invented the logical machine, *Ars Combinatoria*, in a deep crisis of communication. Lullus started a revolution of formalistic thinking to produce declarations in a mechanical manner. He founded the concept of organizational thinking by constructing a paper-machine to combine language and geometrical figures (represented by signs and letters) for capturing various declarations the human mind could conceive. It consisted of three circular paper disks that were fixed on an axis on which they could be turned for producing possible combinations of letters and symbols, thus leading to the development of deciphering signs, creating organized thoughts and the processes of decoding and encoding. In other words, language was born out of graphic representations of signs and studying their associated patterns.

Language evolved based on natural sounds and representations as well as circumstantial human body expressions (i.e., pain, anger or joy). Physical gestures led to oral expressions. Humans have evolved upright teeth, small mouths to make sounds, intricate muscles in lips, a very flexible tongue, and a resonating larynx. The desire to express personal feelings led to communication or the interactive language, and describing natural phenomena led to the development of transactional language or communicating observations, knowledge, or skills. This transactional language led to the development of a written form of language. In other words, written language must have evolved from the spoken word, pictograms, syllabic writing, and alphabetic writing.

In India, the decimal system existed in the pre-1000 BC era and migrated to the Middle East through the translation of Indian literature. Even though the Indian-Arab numerals had been in existence in 300 BC, the use of numerals began to grow in Spain in 900 AD. Leonardo Fibonacci introduced the Indian-Arabic numerals to Europe in 1200 AD. However, it was not until the 15th century that the European tradesmen, bookkeepers, and surveyors started using Arabic numbers instead of Roman numerals.

With the understanding of natural phenomena in mathematical terms as well as through language, society moved into innovating through art first by building large temples, churches, palaces, pillars, tombs, pyramids, and monuments. These monuments demonstrated innovative thinking and its manifestation through combining various patterns and through the evolution and discovery of new structures.

As society grew, population increased and grouping took place. With the accumulation of assets, competitive desires evolved and the race to discover more progressed. This interaction probably led to comparison and competition to have more than the other. All this evolution eventually leads to greed, wars, destruction, renewal, and a continual, growing demand for innovation.

EVOLUTIONARY TIMELINE

Figure 1.1, Understanding Art and Science, shows that looking at objects, rituals or practices creates curiosity, a questioning mind, and a decision to like or dislike the input. If an activity is desirable, attempts to replicate it are probable. If similar desirable results are achieved, the activity is reproduced for more and better results. When an activity is repeated without recognizing its details, it becomes an art; thus it possesses more perceptual and tacit knowledge.

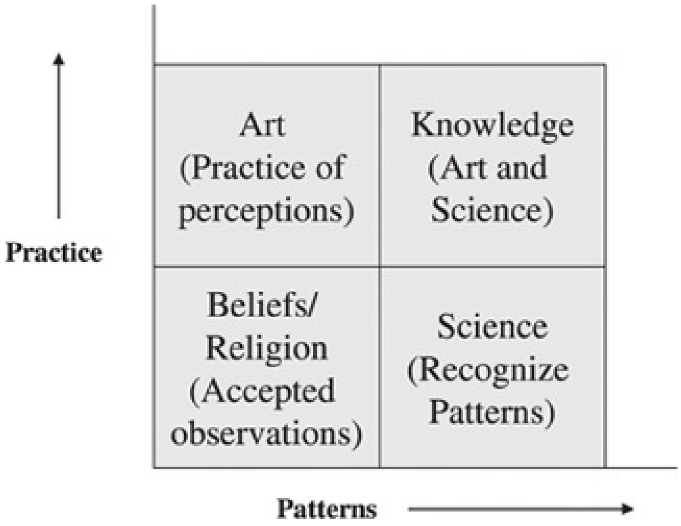

FIGURE 1.1. Understanding Art and Science

A belief is formed and is accepted when its understanding and practice are not questioned. A set of beliefs may define a religion for most of us. When an activity is understood through its patterns and repeated practice, it represents a methodical study of an observation. Science is defined as a methodical study of a subject that leads to an understanding of cause and effect. When the art and science of a subject are understood, greater competence is achieved and a certain level of knowledge is acquired. Therefore, a person is knowledgeable when he or she understands the art and science of a topic.

Figure 1.2, Timeline of Innovation, displays human evolution through growth in art, science, and language. History shows that art and science go together and sometimes build on each other. Since the discovery of fire and through general observation, reflection, and the desire to do something different, humans have innovated from bows and arrows to rockets and the space shuttle. We have progressed from simply being able to stand straight to flying in space, from throwing a rock to firing rockets in space, and from launching spears to launching nuclear warheads.

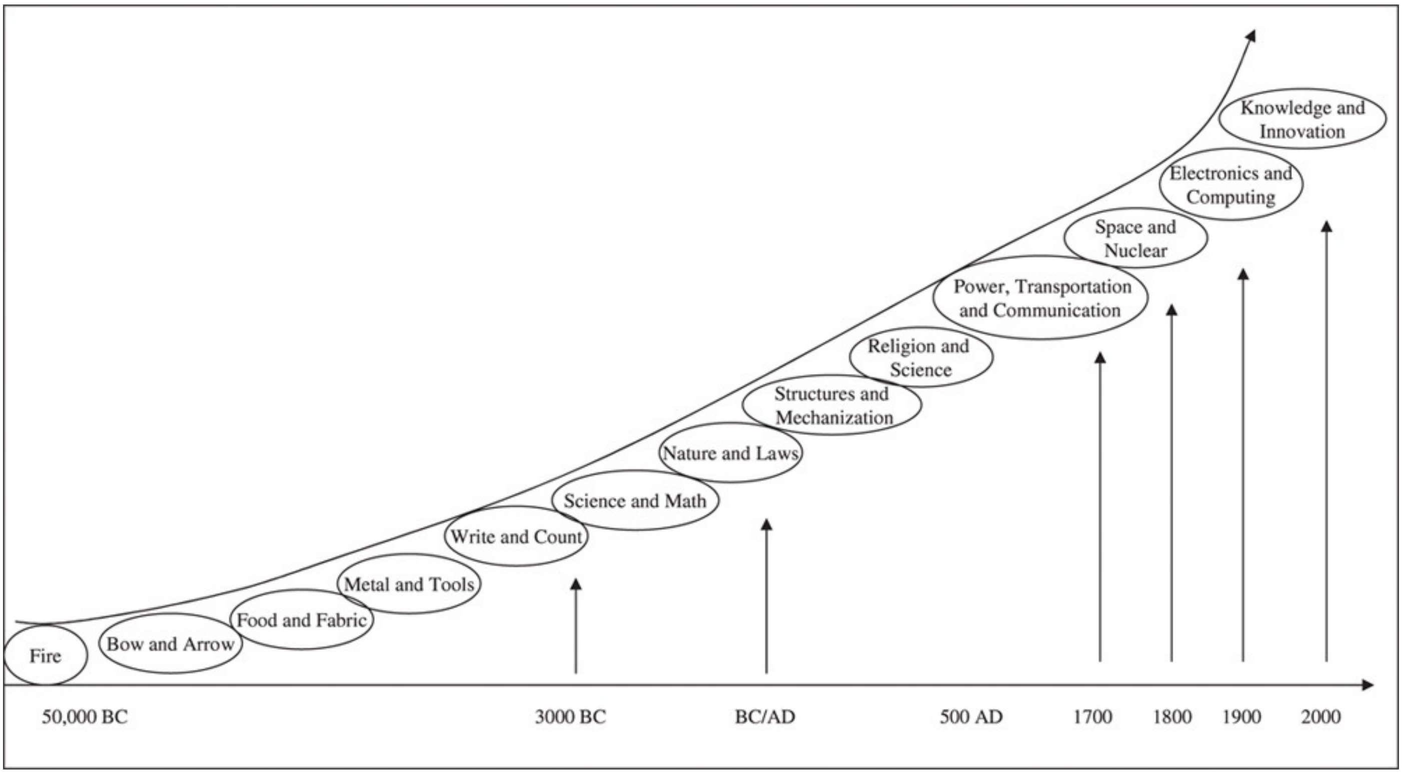

FIGURE 1.2. Timeline of Innovation (Not Plotted to Scale)

With this evolution in knowledge, expertise has evolved and diversified to that possessed by philosophers, priests, artists, mathematicians, scientists, engineers and the SMEs (Subject Matter Experts). One can see that discoveries are always built on prior but insufficient knowledge. An observation counter to existing knowledge generates more questions and answers to those questions create more knowledge, and results in more discoveries.

The Information Age, which started in the 1980s, lasted to the end of the 20th century. The impetus for the information age began with an observation by Thomas Edison, which led to development of the diode, transistor, semiconductor chip, computers, and super computers. The information generated during the last two decades is leading to more questions about utilizing that information, providing business intelligence, and raising more questions about potential new discoveries.

In the 21st century, people are at a much more advanced stage of materials, information, science, art, and language. The new era of information mining is requiring new business intelligence about optimizing business performance. The process of quickly creating new knowledge from existing knowledge demands a better understanding of the innovation process. Therefore the knowledge age, which has already arrived, must accelerate innovation through the collaboration and intellectual involvement of humans.

Such innovation will accelerate knowledge creation as well as product and service development. The efficiency of innovation will require clustering, enhanced team-intelligence, intellectual engagement, and better understanding of the innovation process. Ultimately, humans are the building block of innovation, whether the innovation is occurring due to collaboration involving individual innovators, or is distributed to multinational innovation teams. In other words, future innovation results from individual and collaborative discoveries at an increasingly faster rate.

Figure 1.3, Influencing Innovations of Recent Centuries, illustrates that by the end of the 18th century, a turning point occurred that led to a higher number of discoveries or innovations. The 18th century was a renaissance of innovation when people started to think about a system of innovation. The establishment of the U.S. Patent and Trademark system evolved from the understanding that innovation would be a critical component of the American economy. The founding fathers must have been thinking that innovation would become a normal phenomenon, and they prepared to handle it, protect it, and accelerate it.

18th Century	19th Century	20th Century
Sewing Machine	Refrigerator	Air Conditioner
Electronic Battery	**Telephone/Fax Machine**	**Theory of Relativity**
U.S. Patent System	Electromagnetic Induction	**Mass Production System**
	Elevator	**Traffic Light**
	Dynamite	Television
	Typewriter	Xerography
	Wireless telegraph	Nuclear Reaction
	Light bulb, Electric Power	Transistor/Integrated Circuits
	Business management principles	Digital computers/PCs
	Motorcycle/Automobile/Airplane	**Internet/World Wide Web**

FIGURE 1.3. Influencing Innovations of Recent Centuries

The fact that the 19th century led to more innovations than the 18th century is evidence of a mature understanding of the innovation process. During the 19th century, many products addressing improvement in human existential capabilities were developed such as the refrigerator, transportation, and telecommunications. Significant innovation also occurred in the arenas of thermodynamics, electromagnetics, gravity and electricity, which became the seedbeds of Einstein's discoveries.

The 20th century led to the commercialization of many scientific discoveries of the prior century. Major commercialization was realized in the fields of nuclear physics, mass production systems, telecommunications, xerography and photography, television, and outer space expeditions. The most significant discoveries of the 20th century were achieved by Einstein and Edison. Einstein developed the theory of relativity, and Edison discovered Edison's effect. Einstein's theory helped people understand the basic dimensions of the universe, time and space. Edison's effect led to the evolution of the electronics industry, which was started with the development of diodes. The diodes led to triodes, pentodes, transistors, semiconductor chips, integrated circuits, and the computer. Computers which helped increase the pace of information processing and analysis became the catalyst for the advent of the information age.

THE WORLD OF INNOVATION

Understanding the roles of, and methods deployed by, Einstein and Edison requires looking at their accomplishments in a "big-picture" context. Figure 1.4, Fundamental Innovations, and Figure 1.5, Business Innovations, enable us to review scientific evolutions at a higher level from the beginning. These two figures display the role of each great innovator in the context of the big picture, and they also provide a comparative analysis.

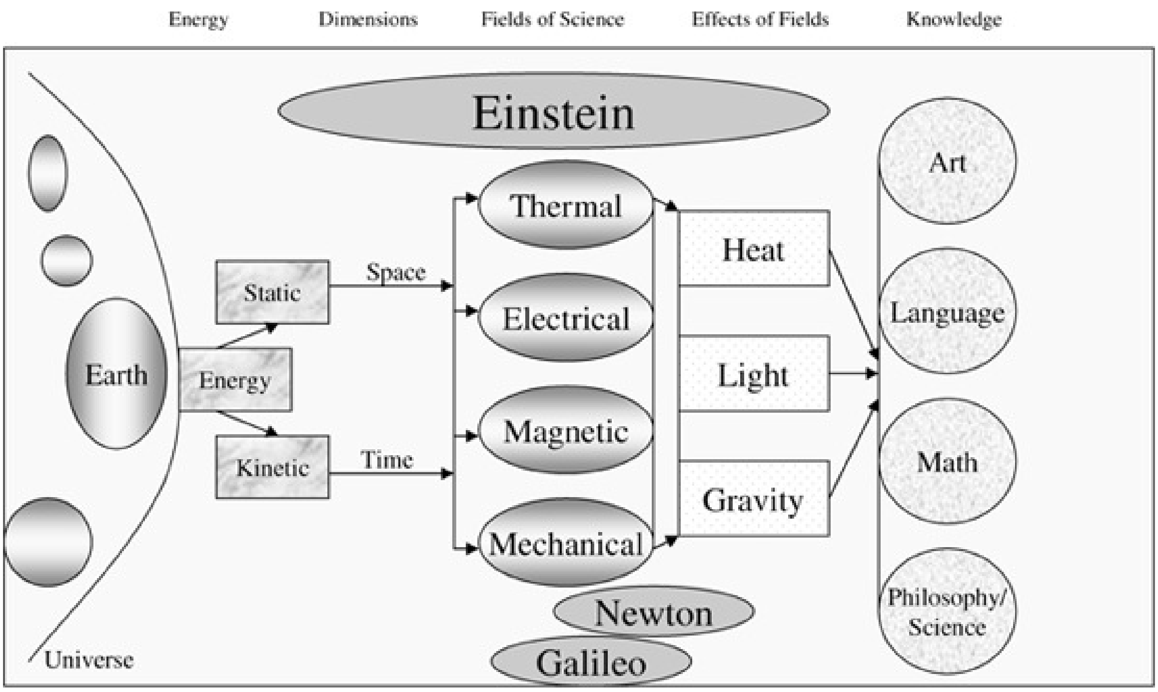

FIGURE 1.4. Fundamental Innovations

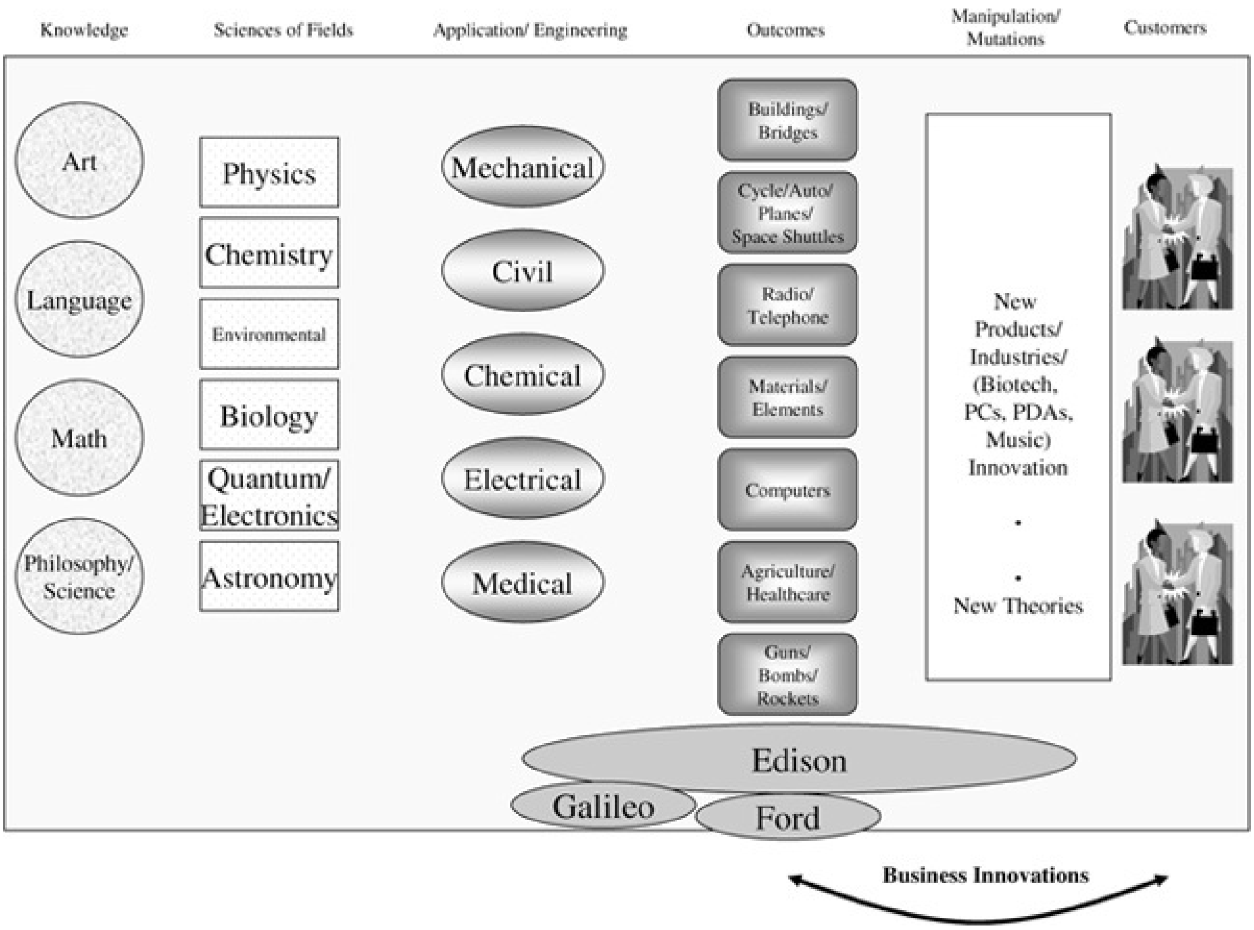

FIGURE 1.5. Business Innovations

The work of Galileo, Newton, Edison, Ford, and Einstein represents a period from the 16th century to the 20th century, which was an era of super-scientific discoveries. These innovators either made significant contributions or recognized major natural phenomena that helped humans understand the universe better, thus leading to extensive further discoveries.

Figure 1.4, Fundamental Innovations, begins with the so-called Big Bang theory, which represents time t = 0. In other words, at some point in time the universe was formed. It grew tremendously in its first few fractions of a second of existence. The universe is associated with some level of energy, which is split into kinetic and static energy. Kinetic energy relates to the motion of objects in planets. Kinetic energy is associated with the dimension of time, which represents the change in distance with respect to time. Static energy relates to the space or distance between objects, including that of planets.

The four basic fields of nature are mechanical, electrical, magnetic, and thermal. The first three fields happen to be associated with the intrinsic properties of objects. The mechanical field represents static (location) and dynamic (movement) positions of objects, while the electrical and magnetic fields represent stored forms of energy due to the structure of objects. The thermal field represents a conversion of energy from one form to the other due to changes in space, position, size of the objects, and inherent (unknown) properties of the material.

These fields of science manifest themselves in the form of heat, light and gravity. Gravity is a force between two objects dependent on the total energy associated with larger objects, or objects with higher specific density. The larger object cancels out the gravitational effect of the small object and applies net gravitational effect on the smaller object. Light and heat represent a spectrum of energies when the state of the material is changed. For example, the Sun is emitting both heat and light based on the conversion of energy due to a change in the state of material with which the Sun is composed. The ratio of heat and light depends upon the nature of objects and their extent of transformation from one form to the other.

An assumption being made here is that the universe preceded living organisms. Humans evolved from other species as the universe and living organisms co-existed over time. People evolved over time and started observing the various effects of these fields. They could feel the heat, see the light, and walk a distance. People tried to understand and communicate these observations about nature's effects. When they could not explain them, these unexplained observations became beliefs, and their view of the world became their philosophy.

As they learned more about nature, they started to refine their model of the world by observing patterns. They also developed different models of communication. For example, when people quantify an effect, it becomes math. When they describe observations of objects, they utilize language, and when they display what they see, we call it art. In other words, art, language, and math are all human expressions of what is going on in the world or universe. Knowledge is a combination of art, language and math. The process of exploring objects utilizing art, language, and math is called science, and science is a collection of knowledge about various objects.

Figures 1.4 and 1.5 show the types of innovation various innovators produced. For example, Newton studied in the field of mechanics, while Galileo worked at the science level as well as the product level. Galileo developed products such as the pump and compass, while Ford was more of an innovator in business processes such as lean manufacturing. Einstein focused more on the basic science of fields. Edison was committed to developing new products and processes. Edison have filed and received the most patents (over one thousand) in the world.

Figure 1.5, Business Innovations, represents an iterative utilization of known effects and knowledge of the universe for creating new knowledge. From knowledge of the universe in terms of art, language, and math (collectively called science), humans created studies of major aspects of the universe for further exploration. These studies promote ongoing learning regarding the universe and lead to applications for the betterment of mankind. In other words, the methods of applying science to develop new products define various engineering branches such as mechanical, electrical, materials, civil and chemical.

Engineers develop new products that are used by people to provide new solutions for making life better (i.e., creating new knowledge). People adapt to these conveniences and demand more products or services. The cycle of demand and supply begins and thus business starts. Businesses package these solutions for customers based on the current knowledge and supply them to customers in return for considerations in kind or currency.

The development of new processes, products, services or solutions to continually create more value for customers is called business innovation. Business innovation occurs when a process or product offers such a significant change in creating value that customers benefit from the increased value. Business innovation can disrupt the current method of utilizing a solution or doing business; business innovation can even create new business or possibly a new industry.

As Figure 1.5 shows, business innovation occurs through the mutation of various dimensions of a solution (in the scientific realm) which promotes better-performing solutions or applications for us in our everyday lives. New products, new services, and new solutions are continually developed as a result of these mutations. Some mutations lead to an incremental change in performance, while others cause a radical change in performance. The extent of change in performance of the new product or service determines the type of innovation (i.e., incremental or radical).

These new products or solutions enable the creation of newer knowledge and add to the existing knowledge base. Most product innovations occur between the customer and the engineering or development teams. Sometimes, however, new cumulative knowledge leads to the discovery of new engineering solutions, or even a new science. Figure 1.6, Paths to Continual Innovation, shows that innovation can occur at all levels. The farther the path of innovation goes, however, the harder it becomes to innovate, and the lapsed time between innovations is longer.

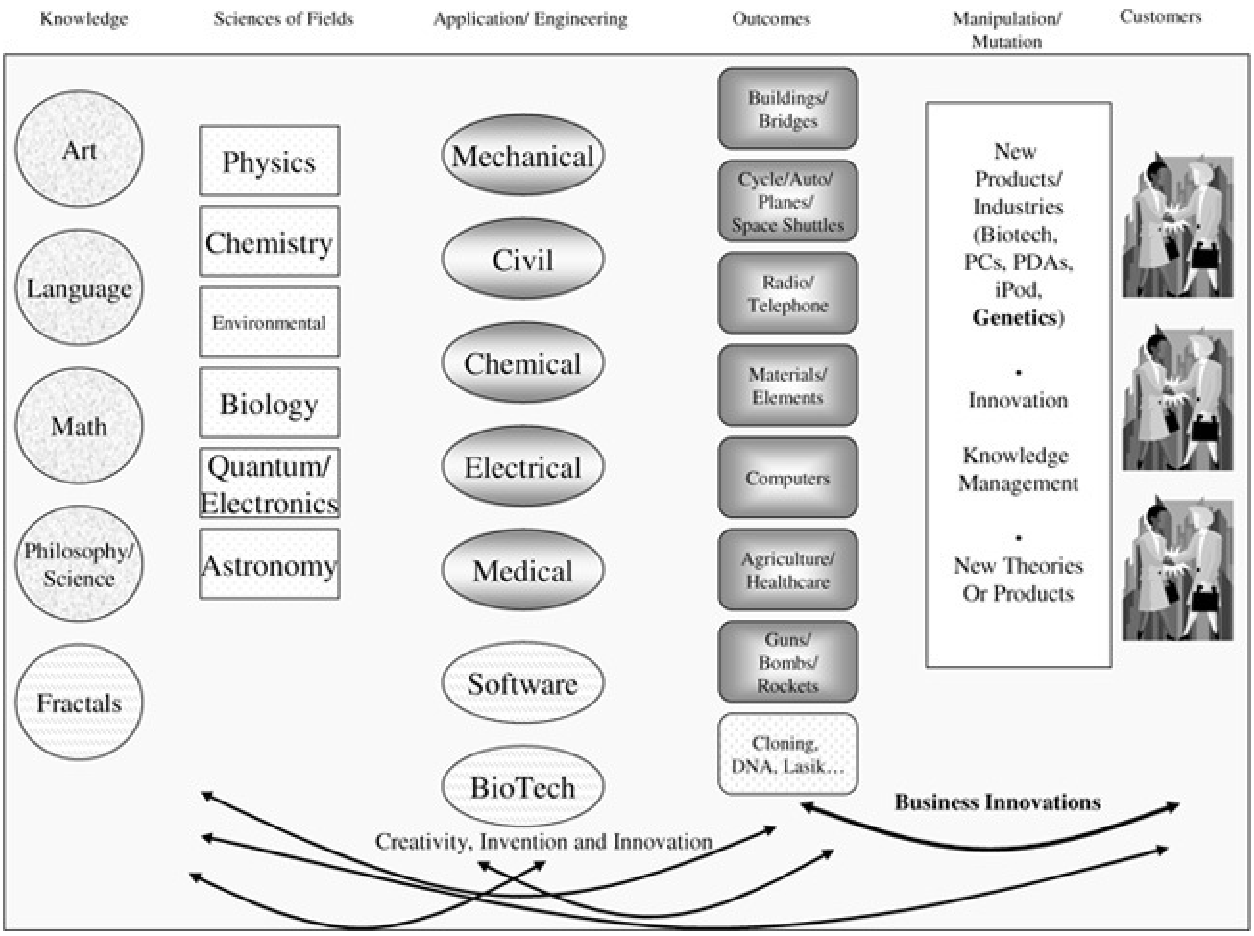

FIGURE 1.6. Paths to Continual Innovation

While Einstein published four major papers in 1905, and Edison planned a patent per week, now more business innovations are to be expected compared with basic scientific discoveries. Many business innovations occur on a daily basis. As mentioned previously, every once in a while, however, a new field of knowledge, such as fractals, is created. In addition, new engineering disciplines such as software engineering, bio-tech engineering and human engineering arrive on the scene. These new disciplines lead to new products such as Lasik surgery, DNA testing and cloning.

GREAT INNOVATORS: FROM GALILEO TO EDISON

To establish a standard process of innovation, observation of the details of innovations from great innovators should occur. Figures 1.7a, and 1.7b Great Innovators, depict a lifetime engagement in discovery and innovation from some of the greatest individuals who took a unique approach to their accomplishments. Galileo, Newton, Einstein, Ford, and Edison all excelled in scientific, technical, industrial and business innovation.

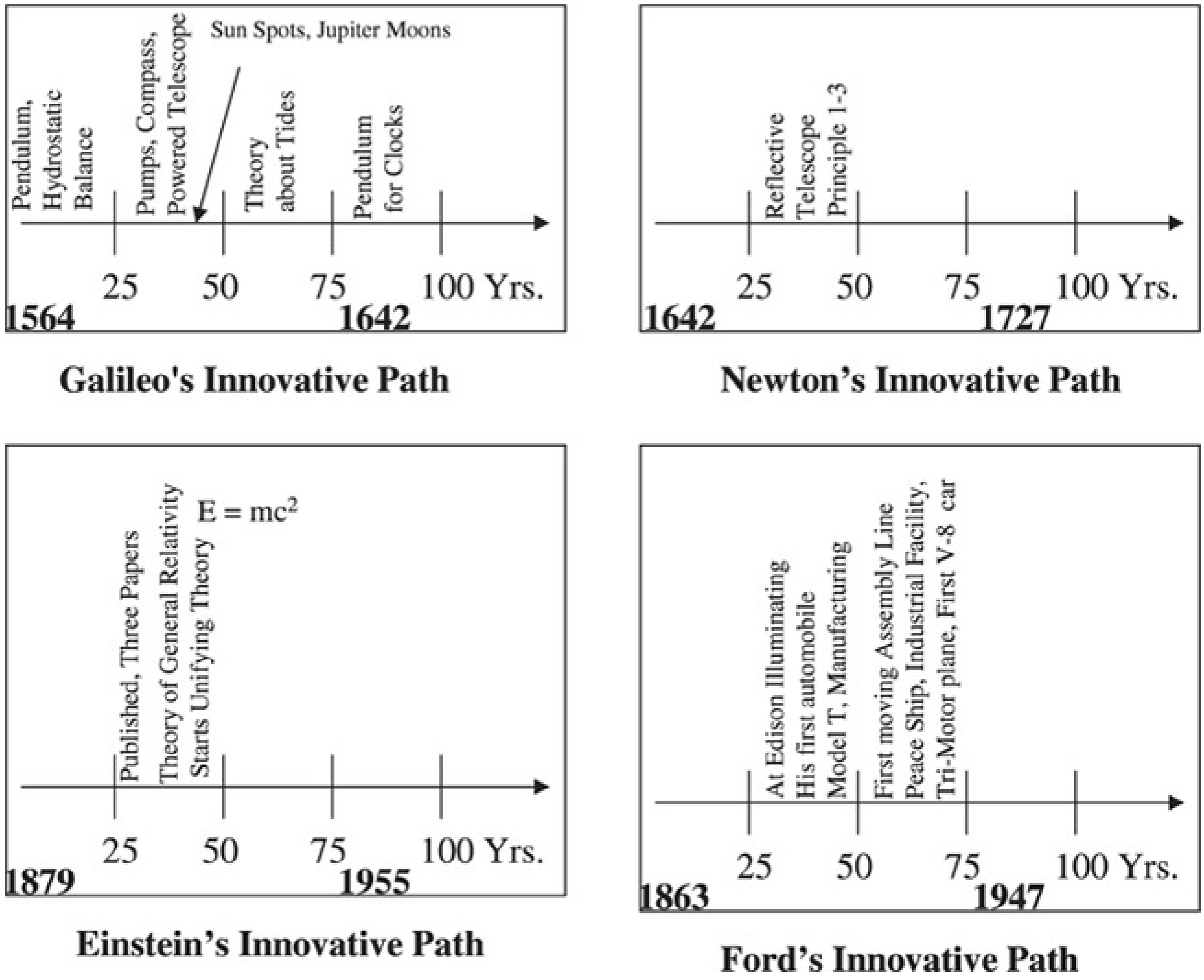

FIGURE 1.7a. Great Innovators

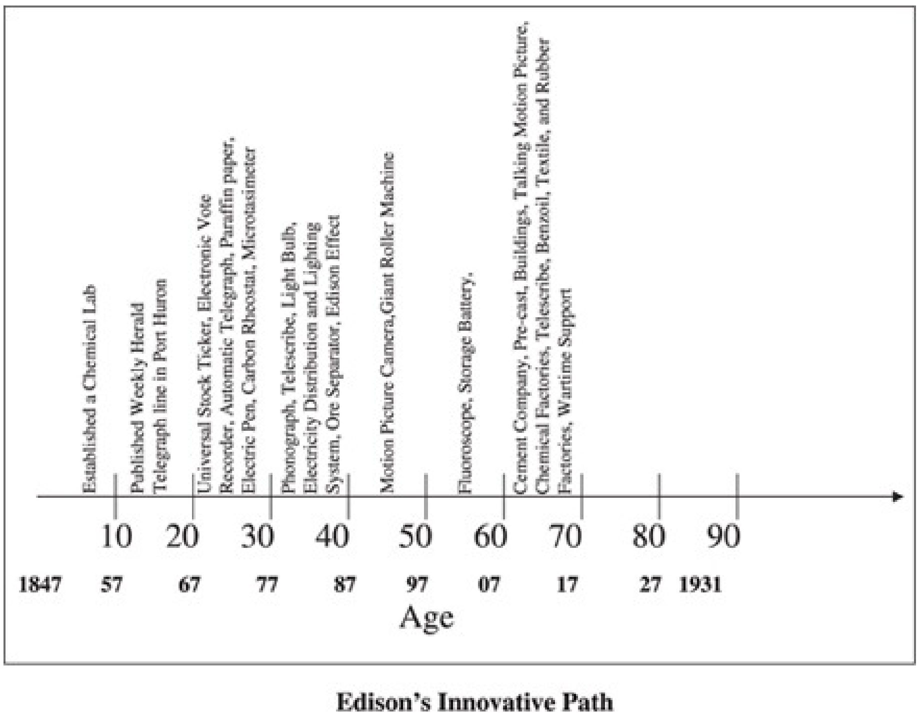

FIGURE 1.7b. Edison - The Greatest Innovator

Galileo was an Italian astronomer and mathematician. He studied the works of Euclid and Archimedes, developed a pump for raising water and a high quality refractory telescope to study stars, invented a geometric compass and a thermoscope (i.e., thermometer), developed hydrostatic balances, designed pendulums, and applied the concept of pendulums to clocks. He observed that objects of different densities achieved the same rate over an inclined plane. Galileo utilized his own telescope to make celestial observations about sunspots and star formations, and he discovered new stars and their movement.

Galileo was a mathematician as well as a craftsman. He made great observations and posited bold theories when the war between religion and science was at its peak. He was convicted by religious leadership and imprisoned in his house for his belief that Earth rotates around the sun. Risk, part of an innovator's life, was experienced first-hand by Galileo. Galileo explored and innovated for about 55 years in a variety of fields, even during his imprisonment.

Galileo died on January 8, 1642, and Isaac Newton was born on December 25 of the same year. Newton studied mathematics and started to make his mathematical entries in 1664, completing his legendry publication *Anni Mirabilis* in 1666. In 1669, Newton developed a reflecting telescope and studied light and colors. Newton then studied planetary motion and observed Halley's Comet in 1682.

Newton's best published work is *The Mathematical Principles of Natural Philosophy*, or *The Principia.* Newton proved Kepler's Third Law about the motion of elliptical bodies in orbits. *The Principia*, completed in 1686, became the most comprehensive book on forces of gravity and motion between objects. *The Principia* includes definitions, rules, laws of momentum (mass and motion), forces (inertial, impressed and centripetal), and definitions of time, space and motion.

Newton then applied his laws of motion to the motion of planets, moons, and comets as well as to the behavior of Earth's tides. Newton built on the work of Kepler, Galileo and others. *Principia* was the most scientific approach to studying physics at that time. In Newton's own words, he researched his topics of interest and advanced the prior work. He also recognized his own possible "defects" in such a difficult subject and encouraged further investigation by his readers. Newton was a trained scientist who studied natural phenomena in a systemic fashion and who knew how to innovate methodically.

At the age of five years, Einstein was mesmerized by the movement of the needle of his personal magnetic compass. The continual orientation of the needle northward pointed to the existence of some invisible forces somewhere. At the age of 12, when he studied Euclidean plane geometry, he concluded that certain truths can be proven without doubt and with a sense of certainty. Einstein developed an uncanny ability to concentrate on topics leading to fundamentals and to clear a multitude of distractions out of his mind.

Einstein generally was a good student, was outstanding in mathematics, and hated memorization. He enjoyed studying mathematics, physics, and philosophy. He was even considered a distraction in his class at times.

In 1901, Einstein had a temporary teaching assignment and worked in the patent office in Bern from 1902 to 1909. While in the patent office, he wrote on theoretical physics on his own without being associated with a science community. During this time, he also earned his Ph.D. from the University of Zurich in 1905, which happened to be the year he made history. He revealed his breakthrough research in March, May, June and September of 1905. In March, he published his theory of light quanta (i.e., the particles of energy versus the conventionally accepted theory of light as oscillating electromagnetic waves). In May 1905, Einstein submitted his theory of kinetic energy explaining the so-called Brownian motion, which reinforced the kinetic theory and helped in the study of atom movement. Actually, Einstein's light quanta theory was based on his experiments on particles.

In June 1905, Einstein published his work unifying the application of the relativity principle between electromagnetic waves and motion. Earlier Galileo and Newton had studied relativity for mechanical objects, while Maxwell and Lorentz studied the effects of relativity on electromagnetic effects. Their electromagnetic theory predicted that the velocity of light would show the effects of motion, but they could not prove it in the lab.

Einstein theorized that both mechanical and electromagnetic effects would be affected by the principle of relativity. In September 1905, continuing his work on the principle of relativity, Einstein reported that if a body emits certain energy, the mass of the body must be reduced proportionately. The relationship between mass and energy was defined by the famous equation, $E = mc^2$. Einstein unified interactions among particle motion, optics, and electromagnetic waves based on the prior work of Galileo, Newton, Maxwell, Lorentz, and many more.

Henry Ford, born in 1863, had an interest in mechanical activities. He worked with steam engines, farm equipment, and factory equipment. He had a sawmill business in early adulthood. Later he joined the Edison Illuminating Company where he became chief engineer in two years. During that time he experimented in internal combustion engines, which led to the development of his own self-propelled quadricycle and the formation of the Ford Motor Company in 1903.

Ford became a social entrepreneur and improved his manufacturing processes to produce cars at a reasonable price. He combined precision machining, standardized processes, interchangeable parts, division of labor, and assembly-line manufacturing, where the product passes by the worker for assembly. On the assembly line, Ford used conveyor belts, conducted time studies, and accelerated the Industrial Revolution. He significantly reduced the cost of manufacturing for his famous Model T cars.

Around 1920, Ford built the world's largest industrial complex which included a steel mill, glass factory, automobile assembly line, rolling mills, forges, assembly shops and foundries. Basically all processes from refining raw material to the finished automobile were now performed at one plant. Ford created the concept of mass production and all the components associated with it.

As a social entrepreneur, Ford cared about his employees' lives at home and at work, built cottage industries in rural areas, established schools in several areas country-wide, and created the Henry Ford museum to preserve past innovations for future generations. At the Ford museum, the evolutionary nature of the innovation process is seen in living color when viewing old methods of washing clothes compared to automated washing/drying using the latest washers and dryers. Clearly innovations are built on what came before or on observations of an existing natural fact.

Thomas Alva Edison was born in 1847, a few years ahead of Ford. Edison had only about three months of formal education and became the greatest innovator of all time. He established a chemical laboratory at the age of 10. Edison's exemplary discovery was the light bulb, and hence the entire lighting industry was born. Edison's greatest contribution was the first practical electric lighting.

Edison invented the phonograph, telegraph and telephony components, such as the carbon microphone, motion picture camera, electronic vote recorder, and the universal stock ticker. Edison also assisted on the production of the typewriter, electric pen, paraffin paper for wrapping candies, wireless telegraphy, dictating machines, shaving machines, improved electric railways, roller machines to break large masses of rocks, fluoroscope, storage battery, Portland cement, electric motor, phonograph, kinetophone (sound and motion), and carbolic acid for explosives in World War I.

Edison figured out the innovation process in his early childhood. Edison epitomized the innovation process by combining scientific, industrial, and business innovation through his desire for continual innovation and growth. Edison continually grew professionally, personally, and financially through his endeavors. He was a gifted innovator who believed in working hard, learning from everything he did, and improving and innovating on everything he did. As a result, he expanded experience more, learned more, and innovated continually. He was so fascinated by creating new products that he set up the first modern-age research laboratory where he facilitated and accelerated innovation.

Edison really mastered the innovation process. He had over 1,000 patents—the most issued to an individual. His famous quote: "Genius is one percent inspiration and 99 percent perspiration" still reverberates throughout the world. Edison loved physical and intellectual work. His heart, head, and body must have been busy all the time. He believed that innovating new things was a good task to undertake in order to gain fame and fortune while also benefiting society.

NATIONAL INNOVATION INITIATIVES

In response to the growing need for innovation, several countries have already developed national policy regarding innovation. These policies were developed based on status of innovation, expected economic growth, and necessary infrastructure to achieve desired results in terms of new industries, new products, or new services.

For example, The Organisation for Economic Cooperation and Development (OECD) is a group of 30 countries that share democratic governments and market economies. OECD's work addresses social and economic issues from macroeconomics to trade, education, development, science and innovation. OECD's Science, Technology, and Innovation initiative looks into developments in the area of innovation policies in member countries and provides direction based on surveys, research, and benchmarking.

The Lisbon European Council launched the European Innovation Scoreboard (EIS) in 2000 to support the European Union's (EU) goal of becoming the most competitive and knowledge-based economy in the world. The EU's industrial policy emphasizes innovation. The EU's Innovation Policy stresses entrepreneurial innovation or knowledge innovation. In 2003, the EU established a framework of common objectives for strengthening innovation. The EU's Innovation Scorecard and European Trendchart on Innovation provide analysis of national innovation policies and benchmarking. The EIS provides overall national innovation performance, while the Trendchart policy database provides country reports and continual lessons learned on specific issues.

Iran's government has formulated a project to study innovation. This project, called the National Innovation System, was created for visualizing effective policy measures, exploiting the potential of emerging sectors, reducing its dependence on the oil sector, and highlighting potential opportunities for growth.

China's new science and technology policy statement calls for greater efforts to instill a spirit of innovation in its society. Its policy also addresses the need to develop and commercialize high technology, such as software. China's drivers for innovation include eradication of poverty, improvement in the quality of life, and strengthening its defense. The Chinese are using innovation, science, and technology to fend off so-called pseudoscientific ideas or cults.

India recently established a National Knowledge Commission for three years, comprising of experts in various fields. These experts advise India's national leadership on policy matters primarily regarding its education system and how to build India's "knowledge power" in the world. Its focus, the Knowledge Pentagon, includes excellence in education, research in science and technology, intellectual property management, knowledge application in agriculture, and knowledge capabilities in making the government more effective and transparent. To ensure collaboration of various government organizations, India's Prime Minister heads the Steering Group overseeing the Commission's work.

In the U.S., several organizations are raising awareness of the need for innovation. To meet the slide in its economic performance, a nongovernmental organization, the Council of Competitiveness (representing industry, education and labor), was formed. Its guiding mission is to set an action agenda that drives economic growth and raises the standard of living for all Americans. The Council's Center for Regional Innovation facilitates innovation-driven economic growth through benchmarking.

UNDERSTANDING INNOVATION MODELS

After reviewing work on developing national policies and corporate strategies, and speaking with professors at leading universities, it appears that the main methods of innovation are collaboration, networking, and brainstorming. Some of the innovation classes show that the innovation process consists of interaction among people and sheds no light as to what the interaction does. One of the proposed theories, based on extensive research led by Prof. Michael Porter of Harvard University, calls for the creation of Clusters of Innovation. The U.S. Council of Competitiveness proposes to oversee such regional clusters of innovation. Accordingly, a cluster is defined as a geographical concentration of competing and cooperating companies, suppliers, service providers, and associated institutions. One of the examples cited as a well-recognized cluster of innovation is Silicon Valley.

The Clusters of Innovation appear to be an observation about how strategically resources are committed for regional economic development. They shed little or no light, however, on the process of innovation—in other words, how the clusters of innovation create innovative solutions, how efficient these clusters of innovations are, and how repeatable and reproducible these clusters of innovations can be.

Mere observations and statistical correlations between these clusters and evidence of innovations do not establish a causative relationship between the cluster and innovation. We must understand the building block of innovation so that it can then be institutionalized to accelerate innovation. Normally, these clusters have evolved over time, with significant resources, and were initiated by a larger institution. At a smaller level, these clusters could even be compared with incubators that promote and support entrepreneurship. The question still remains, however, regarding how to innovate efficiently and create new knowledge and new opportunities for continual growth and scientific evolution.

KNOWLEDGE INNOVATION

With the advent of the Internet, information is becoming available quickly. The Internet has already provided tools to collaborate among people globally; in other words, we can have clusters of innovation without clustering geographically. Moreover, the rate new information is being added on the Internet is itself exploding exponentially.

This information explosion looks like it will continue, and the protection of intellectual property could become trivial in many cases. The future need for innovation on demand in real time will mandate that corporations create new solutions to meet customer needs and then quickly move on to create other innovative new solutions to meet the next wave of customer needs. In other words, the laws to protect intellectual property will have to be re-examined as the rate of innovation increases. Current slow bureaucratic systems will not be able to keep up with the explosion of innovative solutions and related intellectual property.

In the upcoming and exploding knowledge age, customer-supplier relationships will appear to be very close, interdependent and insistent on innovative solutions. Current application of lean thinking demonstrates that business systems will be designed to produce to order, rather than produce to create demand. In such a scenario, if each item shipped by a company is unique, the innovation process must be institutionalized throughout corporations.

The expected extent of innovation goes far beyond development of products and services. Instead future customer demands will mandate innovation at every level in an organization in order to be able to serve customers and grow profitably. In other words, this type of innovation outlook is how a company can grow making millions of unique widgets.

Utterback, in *Dynamics of Innovation,* explores the relationship between process and product innovation. Product innovation leads to process innovations and vice versa. However, the success of a business is not ensured by just product or process innovation. Sometimes, very innovative products do not live up to their potential, and simple innovations exceed their expectations.

Figure 1.8, Dynamics of Innovations, shows paths to innovation beyond process and products. A process is composed of activities which are outcomes of ideas. The resulting products, when sold to customers, bring more business; that is what the corporations are all about. In other words, if there are no ideas, there will be no new activities or experiments, and if no new activities are performed, new processes will not evolve. Fewer new products or solutions, therefore, will be available for fueling business growth. Lots of ideas are needed on a continual basis to make the idea-to-business-cycle work. Dauphais, in *Straight from the CEO,* confirms this and likewise mentions a lot of ideas are needed to arrive at one new innovative product. Dauphais also asserts that businesses need many new products to hit a homerun.

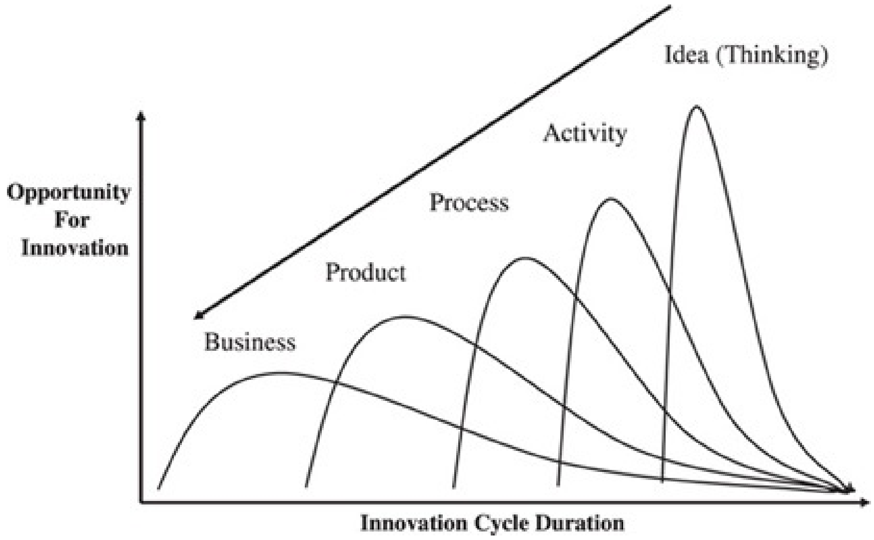

FIGURE 1.8. Dynamics of Innovations

If a business is internally driven to create demand, a continual stream of ideas leading to new products must be flowing. In other words, innovation begins with ideas. To generate a stream of ideas, a corporation must utilize all its intellectual resources (i.e., its entire workforce). When a corporation is engaging in *customer-driven* innovation on demand, speed of innovation counts. In some cases, the current sequential innovation process tends to be ineffective; instead the knowledge age innovation process is the place where many minds collaborate to create an effective solution on demand. In either case, many minds in a corporation must be involved to generate new ideas for innovative products and solutions. Excellence in idea management will become a corporate imperative in order to grow profitably.

INSTITUTIONALIZING INNOVATION

Involving all employees requires that we understand how to utilize their intellectual potential in creating the new intellectual property. The process must be standardized to a great extent, with some exceptions. Therefore, the innovation process must be well understood. One cannot accelerate innovation as an art; it must become science in order to accelerate. The paradigm of innovation must be that it is a science as much as it is an art. In order to innovate with a higher probability of success, corporations must look into various elements of the innovation process and practice them just like any other existing standard process.

In the early years after the discovery of electricity, businesses used to have a Chief Electricity Officer. As electricity matured and commoditized, it became a utility, and no longer was there a need for the electricity officer. Similarly in the information age, we have a Chief Information Officer to glean tons of information. To utilize the information, businesses now are trying to extract intelligence, so business intelligence is becoming an important issue that people are addressing through dashboards and scorecards. However, the application of business intelligence is to create new knowledge and new solutions. Therefore, the position of Chief Innovation Officer is going to become a natural evolution of the changing business model.

Studies show that innovation is built on the past. In other words, all innovative solutions are based on past knowledge, continual experimentation, and extension of this past knowledge and experimentation. The *process* of innovation appears to be evolutionary in nature as well. People must understand this evolutionary nature of the innovation process, open new doors to new insights in the world around them (or even the universe), and search for new solutions. Einstein implied that all innovations are merely discoveries. Therefore, people must continually strive to discover new aspects of business and the world. Once people accept that innovation is a result of the discovery process, not a subconscious effort, the process of innovation can be easily understood and established as a predictable system.

TAKE AWAY

1. All discoveries were the result of some observed phenomenon.
2. Discoveries are always built on prior knowledge.
3. Knowledge generates more questions, creates more knowledge, and produces more discoveries.
4. Learning from the work of great innovators, such as Galileo, Newton, Edison, Ford, and Einstein (representing the thinking of five centuries), is essential in order to become a great innovator.
5. Einstein mastered the thinking process, while Edison perfected the innovation process.
6. Many countries have established a national policy for promoting innovation to maintain economic progress in the 21st century.
7. At present the perceived understanding of the innovation process relates to brainstorming and collaboration.
8. The concept of ‘clusters of innovation’ is an observation of collaborative innovation in resource-rich areas. This concept, however, does not take into account the process of innovation.
9. To meet growing customers’ demands for innovative solutions, the innovation process must be standardized.
10. Innovation begins with an idea; thus excellence in employee idea management will be the competitive edge and catalyst for continual innovation.
11. In order to institutionalize the innovation process, it must be understood better.
12. The innovation process is a process of discovery and is evolutionary in nature.