Thoughts on the Evolution of Technology: America as a Case Study.

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Prefix

While over the past 25 years I have written magazine articles, hundreds of consulting proposals and many significant business plans I have not created a single work which would be appropriate as part of an application to a history graduate program. This paper was prepared specifically in fulfillment of the requirements of the application to the Northwestern University Ph.D. in History program.

I found myself faced with a number of interesting challenges. Should this paper be a brief summary of a topic or an attempt at true scholarship? What is the appropriate length for a writing sample submitted with a graduate application? Should this paper attempt to demonstrate my research skills, my writing skills or my knowledge of the industry in which I have spent the last 25 years.

What you are about to read is a brief overview of a potential future work on the question of the development of technology in America. Its goals are modest; define the key question, present briefly the factors that lead to a potential answer, demonstrate that the factors influencing the evolution of American technology are still applicable today though the use of analogies and examples from the computer industry, and finally, propose a theoretical answer to the questions posed which will create future opportunities for research and study.

I thank you in advance for your patience in reading the writing of a recent refugee from the world of computers and business.

Introduction

America began the formal study of science in 1767, with the creation of a professional chair of Agriculture, Natural History, and Chemistry at Columbia College.[1] Over 70 years later in 1846, funded by a gift of $500,000 from a British chemist James Smithson, the Smithsonian was the first institution in America dedicated to scientific research.[2] In contrast to America, 100 years earlier, in 1662 the British Royal Society, the oldest surviving organization dedicated to the study of science obtained its first formal charter.[3] The creation of American scientific institutions in the 18th and 19th centuries trailed the creation of similar institutions in Europe by over 100 years.

Perhaps more importantly, American scientists and inventors initially focused their observations of the world around them on collecting facts, that is to say the study of what existed around them that could be usefully in their efforts to tame their new environment. The necessities of everyday life in the colonies forced American inventors to concentrate on innovations that addressed everyday needs. Americans by necessity focused on what and not why.

Europe placed little value on the American experience in learning. Daniel Boorstin, in “The Americans: The Colonial Experience” quotes the French savant Abbe’ Raynal as stating in 1774; "America has not yet produced one good poet, one able mathematician, one man of genius in a single art or a single science".[4] In contrast to the Americans, in the 1700s Europeans, Galileo,

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[1] Paul Johnson, “A History of the American People,” (Weiden & Nicolson, 1997).

[2] Ibid.

[3] John Cannon, “The Oxford Campanion to British History,” (Oxford: Oxford University Press, 1997).

[4] Daniel J. Boorstin, “The Americans: The Colonial Experience,” (Random House, 1958).

Descartes and Newton advanced the formal study of science from observations of what to explanations of why. Before this work in the early 1700s, much of science focused on the observation and the categorization of information. The transition of science from an emphasis on investigations of what things are to investigations of why things work forged the path from an age of observation to an age of reason.[5]

America was not initially ready for this transition. Representing the American view, Benjamin Franklin believed science advanced by experimentation and not contemplation and lengthy theoretical discussions. Boorstin paraphrased Franklin as saying:

> ’Disputes’ he retorted to European critics of his ides on electricity, ‘are apt to sour one's temper, and disturb one's quiet.’ If his observations were correct he said, they would readily be confirmed by other men's experience; if not they ought to be rejected.

While Europeans, postulated and pondered, Americans such as Franklin experimented without the constraints of intractable theoretical positions, often supported and promoted by the Church. If this defined America as a backwater of scientific discovery, this limitation did not curb its advancement for long.

America caught up fast. In spite of its initial concentration on the practical needs of everyday life, by 2000, the Nobel Institute had awarded American technologists and scientists over

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[5] Charles Van Doren, “A History of Knowledge,” (Ballantine Books, 1991).

40 percent of the 469 Nobel Prizes in physics, chemistry and medicine.[6] What were the factors that propelled America from a laggard in Science to a leader?

To provide a foundation for this analysis digress for a moment and discuss the evolution from inventions to technology. We will observe shortly that this evolution mirrors the evolution of American science and technology.

Inventors practice the art of day-to-day innovation, and then engineers build on these innovations by applying them to a broad range of problems, while scientists generalize these discoveries and advance our understanding of nature. The sequence of development may follow a path from invention to technology and then to science or a path from invention to science and then technology. Today's advanced technology is often the application of science in the construction of solutions for everyday problems. Therefore, the term engineer describes a user of technology vs. a developer of science or an inventor of ideas. Throughout this paper, three disciplines: invention, science and engineering, will play important roles in discussions of the developments in America. We will see that Americans were inventors first, than engineers and finally scientists, while at the same time Europe had evolved a system where inventors where viewed as inferior to engineers who shared the stage of professionals with scientists. Science and engineering in Europe was becoming pure while inventing was messy and imprecise.

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[6] The Nobel Foundation, *Nobel E-Museum* (The Nobel Foundation, 2001 [cited October 2001]); available from http://www.nobel.se.

The nature of inventing fit the nature of the new world. This new world was also messy and imprecise. The people that prospered in this environment thrived on innovation and daily discovery. It is ironic that the messy nature of invention propelled much of America's rapid advancement in the areas of science and technology. America was in need of inventors and engineers who would reshape the bountiful resources across this great land into solutions for the newly evolving society.

Lightning was starting fires, which in turn destroyed property and cost lives, the colonists needed a solutions. Farming was difficult because of a shortage of human capital. The South used forced labor as a solution to this problem, while the North sought a mechanical solution. Manufactured goods took months to arrive from Europe; Americans needed these goods today. American inventors, and technologists, worked to solve these problems without regard for the science of the solution.

The evolution of science and technology interacted with the social fabric of America. The pressing and immediate needs of the developing American society dictated the direction of technology development. In fact, Ken Alder in "Engineering the Revolution" points out that society interacts with most technology developments.

> Ours is a world in which human interests are myriad and circumstances vary. In such a world, technology is the physical embodiment of that form of knowledge which we call power. This knowledge is not the outcome of private ratiocination or access to some abstract truth, but of a public engagement with recalcitrant "thick" objects. Shaping these obdurate objects so that they can be brought to bear on social problems is a daunting challenged and one which admits of many possible solutions.[7]

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[7] Ken Alder, "Engineering the Revolution, Arms and Enlightenment in France, 1763-1815," (1997).

The nature of Americans and American society significantly influenced the direction and rate of evolution of American science and technology. In addition, the vast needs of the new world drove the open nature of American society and its acceptance of new technology. No guilds, classes or aristocracy where threatened by the introduction of new technology in America.[8] The classless American society reduced the power conflicts caused by the introduction of new technologies.

Morphing a couple of terms, in common uses today in the world of engineering, let us refer to the collection of inventors, scientists and engineers as "knowledge entrepreneurs". A knowledge entrepreneur is a person who advances our knowledge in an evolutionary manner. The geographical, economic and political environments in America created a laboratory where the skills necessary for successful knowledge entrepreneurs grew and flourished more rapidly than for their European counterparts. To understand this fertile knowledge entrepreneurship laboratory, we must address the following questions. Where did early Americans come from? What motivated them to leave their roots and journey to a far away place? What did they teach their children? With a better understanding of the successful colonists, and later revolutionaries, that is to say early Americans, we can map their skills to the skills most useful in the acquisition of knowledge. As part of this mapping exercise, we will improve our definition of knowledge so we may enhance our ability to understand the factors that influence its advancement. Finally, we will look at the impact of the unalienable rights afforded Americans on the democratization of science and technology.

[8] Further study is necessary into the acceptance of farming technology in the south. It is possible that technology was seen as a threat to the slave based economy of that region.

Early Americans

One of the first British explorers to attempt to profit from the colonization of America was Walter Ralegh.[9] Born in Devon England in approximately 1554, Ralegh was a man of action, conversant in the science of the day, and in general charming. He convinced the Queen to grant him a charter to found a colony. His first exposition consisted of two ships, which on July 13, 1584 found a passage through the Carolina banks that led to Roanoke Island. Upon the return of the ships to England Ralegh began to raise funds from investors for the development of the new colony of Virginia, named after the Queen. In April an expedition of seven ships, with half of the 600 men being solders left Plymouth. Most of the crew perished at sea. After difficulty in finding a suitable location for a harbor, Ralegh's military commander, Ralph Lane, had just 107 men to build and man a fort north of Roanoke Island. Their provisions rapidly diminishing the remaining men returned to England for reinforcements and new supplies. Along the way, the fleet commander, Sir Richard Greville, captured a Spanish vessel, the Santa Maria, and brought it into port in Plymouth. Paul Johnson notes in "A History of the American People" that "But for the fact that Grenville had allowed himself to be diverted in commerce-raiding betrayed the confusion of aims of the Ralegh enterprise. Was its object to found a permanent, viable colony, with an eye to the long term, or was it to make quick profits by preying on Spain's existing empire?"

A second expedition of three ships launched for Roanoke on May 8, 1587. While this expedition did include some women and children, it still suffered from a split of motivation between

[9] Johnson, "A History of the American People,".

those interested in creating a permanent colony and those interested in a quick profit. One hundred and fourteen colonists where left at Roanoke while the fleet returned to England. The colonists failed to receive reinforcements and supplies in time and perished.

The difficulties of Ralegh's efforts where typical of all of the early explorers who were interested in quick profits and not truly concerned with the development of permanent settlements. Later charter holders, motivated by the opportunity to build a new home in a new world recruited very different members for their expositions.

The landing at New Plymouth on December 11, 1620 of the pilgrim settlers from the Mayflower may be the most significant event in the constitution of the American people. The makeup of these Americans profoundly influenced the development of technology in the new world. Paul Johnson states in "A History of the American People" that:

> The original Virginia settlers had been gentlemen-adventurers, landless men, indentured servants, united by a common desire to better themselves socially and financially in the New World.

He then goes on to state that:

> The Mayflower men—and women—where quite different. They came to America not primarily for gain or even livelihood, though they accepted both from god with gratitude, but to create his kingdom on earth.[10]

These pilgrims were committed to building a new world.

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[10] Ibid.

This creation required different skills from the exploration of the Americas for economic gain. While the earlier adventures brought guns for conquest and defense again the natives, the later pilgrims brought seeds, and tools to build homes and protect their new land. These pilgrims were well suited to the task. Back in England the persecution of their religious practices forced them into isolation from the English communities aground them. They often held services in secret cellars and functioned much like a medieval brotherhood.[11] This tendency towards self-sufficiency created an environment well suited to the development of entrepreneurship and inventors.

The following letter written by Mr. John Robinson and Mr. William Brewster in response to a request for more information from Sr. Edwin Sands regarding the desires of the Brewster congregation reinforces the nature of the pilgrim community.

> 1. We veryly beleeve & trust ye Lord is with us, unto whom & whose service we have given our selves in many trialls; and that he will graciously prosper our indeavours accordingly.
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> 2ly. We are well weaned from ye delicate milke of our mother countrie, and endured to ye difficulties of a strange and hard land, which yet in a great parte we have by patience overcome
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> 3ly. The people are for the body of them, industrious, & frugall, we thinke we may safly say, as any company of people in the world.
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> 4ly. We are knite togeather as a body in a most stricte & sacred bond and covenante of the Lord, of the violation wherof we make great conscience, and by vertue wherof we doe hould our selves straitly tied to all care of each others good, and of ye whole by every one and so mutually.
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> 5. Lastly, it is not with us as with other men, whom small things candiscourage, or small discontentments cause to wish them selves at home againe. We knowe our entertainmente in England, and in Holand; we shall much prejudice both our arts & means by removall; who, if we should be driven to returne, we should not hope to recover our present helps and comforts, neither indeed looke ever, for our selves, to

[11] Carleton Beals, "Our Yankee Heritage: New England's Contribution to American Civilization," (Freeport, NY: Books for Libraries Press, 1970).

> attaine unto ye like in any other place during our lives, wch are now drawing towards their periods. These motives we have been bould to tender unto you, to ye simplicitie of our harts therin. which you in your wisdome may also imparte. to any other our worpp: freinds of ye Counsell with you; of all whose godly dispossition and loving towards our despised persons, we are most glad, & shall not faile by all good means to continue & increase ye same. We will not be further troublesome, bat doe, With ye renewed remembrance of our humble duties to your Worpp: and (so farr as in modestie we may be bould) to any other of our well willers of the Counsell with you, we take our leaves, comiting your persons and counsels to ye guidance and direction of the Almighty.[12]

Mr. Brewster clearly highlights that the pilgrims are a community of solid families, industrious, and frugal. They are bound together in the name of god to create a new colony where they can practice their religious beliefs freely. Finally, they recognize they are a burden to the English society around them and recognize that they will have little opportunity to return to English should this endeavor fail.

The desire to build a home, as opposed to a desire to quickly capitalize on the resources of the New World and return home, drove the pilgrims to success. There desire for freedom from religious persecution was supported by the pilgrims belief that god was on their side. Innovation never before had such a strong ally and they could not envision failure.

The significant time required for travel from England to the New World reinforced the independence of the settlers. These permanent settlers quickly discovered they could not depend on shipments from England for critical supplies. Instead, they learned from the Native American Indians how to cultivate corn, trap animals and catch fish. In New Plymouth if you wanted to live

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[12] William Bradford, “Bradfords's History "of Plimoth Plantation."” (Boston: Wright & Potter, 1901).

in a house of your own, you got together with your neighbors and cut the wood, leveled the ground and built the house.

This independent spirit and self-reliance influenced the next generation of Americans. Children grew up watching their parents make do and more importantly watching them creating and inventing solutions. This was very different from England in the 17th century. The English society the pilgrims left was highly stratified. An excellent example of this stratification was the position of a "gentleman" in England.

To be an English gentleman one had to own land. Most of the land was already allocated in the land locked British island. With the land already allocated, little opportunity was available for a commoner to gain the status of gentleman. The division between those with land, the aristocracy, and those without was an impenitratable barrier in England. Not so in the New World.

The New World settlers looked west and saw unlimited opportunity, in essence land for the taking. With limitless land but a limited population, land was cheap, and labor was expensive. Boorstin points this out when he states:

> "Waste" is, of course, a relative term. To the American colonists for whom labor was scarcer than land, it seemed more economical use up the land and move on than to spend precious hours in cultivating and fertilizing. In their own way, the colonists were very much interested in economy. But they wanted "labor-saving" devices. And in these early years the most obvious labor-saving device happened to be the wasteful use of land.[13]

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[13] Boorstin, "The Americans: The Colonial Experience,".

The scarcity of people forced the new Americans to innovate. Once again, the children of these innovators watch and learn to innovate. This innovation ultimately led to the evolution of a population of innovators, inventors, technologists and scientists.

Knowledge

Invention, science and technology are three stages in the evolution of knowledge. Aristotle stated in the Metaphysics, "all men desire to know"[14]. What is it they want to know?

Socrates' addresses this question in a broader context when he asks the question "What is f-ness". Examples of Socrates' question might include what is beauty and what is virtue. This classic Socratic question is not only important to full time philosophers; a definition of "f-ness" is necessary for meaningful conversations among thinking people. Shared conversations require share definitions or understandings. Creation of these definitions is a prerequisite in the acquisition of knowledge, which is a prerequisite for the evolution of science and technology. Hugh Benson in "SOCRATIC WISDOM, The Model of Knowledge in Plato's Early Dialogues" using a framework provided by Belnap and Steel in "The Logic of Questions and Answers" places the

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[14] Jonathan Barnes, ed., *The Cambridge Companion to Aristotle* (New York: Cambridge University Press, 1995).

question of f-ness into a framework which will assist us in our understanding of technology and science in America.[15]

An answer to a Socratic f-ness question consists of two parts; a matrix of choices that define the parameters of f-ness and a universal classification. For example, if the question asked is what is a prime number between 10 and 20; the matrix consists of prime numbers between 10 and 20 while the universal is the statement that the prime is an integer, or more precisely that a prime number is an individual integer. Definition of a set of possible solutions to a question is a classification exercise. Classification does not require any specialized training, a structured scientific method or a goal of advancing science. Each of us naturally classifies the world around us as a direct consequence of our interaction with our environment. The world surrounding the early Americans was vast. These early Americans wanted to know. Much of the knowledge acquired by early Americans was a consequence of this classification activity.

To clarify the parts of an f-ness question, we can turn to the discipline of computer science. We will see that even today the process of classification affects the evolution of knowledge. In computer science today, object oriented frameworks are in fashion. A computer program represents the real world through the definition of objects each consisting of attributes and methods. Put into non-computer science terms; objects consist of data selected from a matrix of choices and universal actions one may perform on those choices. We label the choices, object

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[15] Hugh H. Benson, “Socratic Wisdom: The Model of Knowledge in Plato's Early Dialogues,” (Oxford US, 2000).

instances and the actions, methods. The generic form of an object is a class. Good computer design requires the proper definition of the classes in your application and the relationships between classes.

For this design to succeed, one must begin by collecting lists of possible object instances. That is to say, lists of things affected by the application. This collection activity is a form of classification, which we earlier indicated was the first step in defining f-ness. Once we have a collection, or classification consisting of multiple instances of an object we can begin to look for generalizations that belong in the base class. These generalizations are the universal actions, i.e. methods and data i.e. instances used as the building blocks of our programs.

A simple example of the discoveries required for the development of a computer program which simulates the operation of an automobile will assist us in understanding the thinking required for the definition of a base class. Let us begin by examining the cars outside our front door. We quickly notice that all automobiles have four tires, a steering wheel, a gas pedal and a brake pedal. As we continue the classification of automobiles, we discover that while some attributes are common to all automobiles, others are unique. At this point inexperienced computer programmers will begin to write separate programs for each type of automobile. Those with just a bit more experience will complete the simulation program for one type of car and then after making a copy, modify the copy for a second car. Sophisticated computer programmers reuse software components by abstracting the object instances into a base class made up of attributes, that is to say facts, and methods that is to say actions applied to manipulate the facts.

This process of classification and abstraction continues to drive productivity improvements unless the programming organization loses touch with the goal and over generalizes. They forget that the reason we abstract the specifics is to improve performance by reusing program components. Before long instead of abstracting and generalizing the programming team spends more time looking for generalizations than the time they will save in reusing program components. In the programming business, we call this "analysis paralysis". Over time, the programming organization will discover they have succumbed to the "analysis paralysis" disease and readjust their priorities. To an outsider looking in on the programming organization it will appear that productivity cycles between periods of significant gains and stagnation.

The evolution of science and technology follows these same paths. First information is classified, and then we search the catalogue of information for potential abstractions, which become natural laws. Progress moves in a jerky process between long periods of time cataloging followed by rapid development in abstraction followed by over analysis and a time of potential paralysis. Europeans with a relatively advanced scientific infrastructure in the 17^{th} and 18^{th} centuries' succumbed at times to the disease of analysis paralysis. During this same period in America the vast expanses of the undiscovered new world in conjunction with the elimination of class mobility barriers produced a highly effective culture of innovation.

Early Americans began as catalogers of information around them. In fact, the virtually unlimited expanse of America westward presented what seemed to be a virtually unlimited opportunity for discovery and classification. With the rapid advancements in knowledge available through the classification process, they saw little need for the development of abstract knowledge.

This lack of interest in the process of abstraction protected early American inventors from the trap of analysis paralysis.

Experimentation presents an interesting set of challenges for the classification process. The experimenter creates a special environment desired to promote the collection of data. The results of an experiment are then used to better define the next experiments. Early experimenters continue along this path, rapidly moving from one experiment to another, building a collection of data. The limitations of knowing too much rarely burden these experimenters. They do not limit their experiments because of traditions or establish expectations.[16]

Benjamin Franklin, a statesman, philosopher, politician and inventor spent thousands of hours as an experimenter. Many European scientists where often critical of Benjamin Franklin's experiments, as they did not derive from European science, instead focusing on observation and experimentation. This is not to say that Franklin ignored established science. In 1746, Franklin met a "Dr. Spence" who presented his electricity show for him. Later Franklin corresponded with member of the British Royal Academy and discussed his observations about electricity.[17] Franklin was unique as compared to his European counterparts in his ability to experiment unconstrained by the limitations or one might say paralysis of his peers across the ocean.

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[16] Numerous examples of the burdens of knowledge are found in the study of the history of medicine and the history of map making.

[17] H. W. Brands, "The First American: The Life and Times of Benjamin Franklin," (New York: Doubleday, 2000).

As the years passed Europeans began to recognize the contributions and advantages of American science created by the vastness of the new world. Marquis de Chastellux observed in 1782:

> The more the sciences approach perfection, the more rare do discoveries become; but America has the same advantages in the learned world, as in that constitutes our residence. The extent of her empire submits to her observation a large portion of heaven and earth. ... Matural history and astronomy are her peculiar appendages, and the first of these sciences at least, is susceptible of great improvement.[18]

Franklin was well aware of both his supporters and his critics in Europe. In spite of any criticism, he was dedicated to the experimental approach. The following quotations from Franklin summarized by Boorstin support Franklin's avoidance of "analysis paralysis" and his dedication to the American way in science.

> Franklin refused to engage in learned controversy. "Disputes" he retored to European critics of his ides on electricity, "are apt to sour one's temper, and disturb one's quiet." If his observations were correct he said, they would readily be confirmed by other men's experience; if not they ought to be rejected.[19]

In fact, we may be able to attribute Franklin's success to his lack of respect for scientific tradition. It is interesting that historical success in many endeavors breeds future failure.

To highlight this point let us look at another example of success, from the current computer industry, which bred failure. In the late 60's and early 70's International Business Machines, IBM, was the clear leader in the computer industry. Yet, in spite of their position of dominance a small

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[18] Boorstin, "The Americans: The Colonial Experience,".

[19] Ibid.

startup company, founded in Albuquerque New Mexico, soared right past IBM to claim the top spot in the computer industry. This process continues; Microsoft now the leader in the industry is as vulnerable today as IBM was in the late 60's and 70's. Why? Success in the computer industry burdens the successful company with a yoke of users of earlier releases of their systems. IBM was not free to the 60's to innovate without concern for their installed base. They needed to ensure that software created for earlier releases of their operating systems would operate properly on new releases. In the late 70's, Microsoft with no installed base was free to innovate.

Microsoft is no longer free to innovate because of their installed base. The Linux, open source world, is. In fact, some industry analyst question Microsoft's ability to remain the leader in the industry because of the burden of their installed base.

The lack of innovation by leaders in the computer industry is caused by both a need to make new software compatible with currently installed computers and software and a desire to respect tradition. Processes, algorithms, approaches that have worked in the past become the traditions in the software industry. The software industry is often hesitant to change software that works.

European scientists faced the same fundamental issues in the 1700's that IBM faced in the 60' and Microsoft faces today. In all three examples, there was a hesitance to rock the boat, to break things that seem to work, to question tradition. America scientists in the 1700's were not burdened by the yoke of success forced on European scientists by their early successes. Everything was new in America. Their were no scientific traditions to break, no established church to threaten, each day American scientists and inventors where forging new traditions.

Invention, Science and Technology

The distinction between inventors, scientists and engineers provides another opportunity for understanding the rapid advancement of American science and technology. These three overlapping disciplines are distinct in the motivations of their practitioners. Inventors seek to solve problems of today with an eye for easing their own burden and the burden of those around them. The successes of inventors are often the result of trail and error, possible even a random process without formal discipline.

In contrast to inventors, scientists use a formal process of classification based on observations of either the natural world or well-structured experiments to collect information. They seek to collect sufficient information so they may form a hypothesis, which they may further test. Upon sufficient testing, this hypothesis becomes a theorem. In the language we used earlier, a theorem is a universal law describing a general case. An engineer then uses the theorems developed by scientists to design and build new solutions to problems covered by the theorems.

In fact, while it appears there is a natural progression from invention to science and then to technology, these processes often overlap. For example, when an engineer faces a unique problem, not easily addressed by current theory, the engineer will often invent a solution to the particular problem at hand. A scientist will postulate a new hypothesis and using a time consuming yet highly reliable process will begin to explore this new problem. Differences in approaches between scientists and engineers relate to differences in needs.

The engineer needs to solve the problem, quickly, and cost effectively. Engineers are concerned with optimizing what needs to be done. Scientists are interested in the why. An investigation of why has no natural period, and in fact it is the search and not the discovery with often invigorates the scientist. This implies that scientists often move slowly while inventors and engineers often move to solutions quickly. American inventors moved quickly because their needs were great. Their inventions were necessary for survival.

The time required obtaining supplies from Europe forced the Americans to function more as engineers and less as scientists. When one needs to invent to survive, the theory behind the invention is less important then the invention itself. In colonial America, lighting was a significant problem, causing fires and extensive property damage. Benjamin Franklin and his invention of the lighting rod presents an outstanding example of the American scientist as engineer and inventor first, and scientist later. Bernard Cohen describes Franklin in “Benjamin Franklin: His Contribution to the American Tradition” as follows:

> Franklin believed in the exercise of reason to make life healthier, more comfortable and more secure. Science, he conceived, bears continual fruit in the production of useful devices based on discoveries which are the outcome of even such research as might not at first have seemed likely to have such an end product. This is the sense in which he took such pride in the lightning rod, a practical issue of his general exploration of electrical phenomena. But Franklin knew that inventions and useful discoveries are only abstractions in the minds of their creators until people accept them and apply them in their lives. Thus a major part of his program of doing good for the sake of man and the community was to advocate the introduction of new and worth-while practices, whether his own inventions or those of others. [20]

If nothing else, this example from Franklin describes the practicality of the leading American inventor of the time.

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[20] I. Bernard Cohen, “Benjamin Franklin:His Contribution to the American Tradition,” (Indianapolis, IN: Bobbs-Merrill, 1953).

American Freedom and its Effect on Innovation

As the former Soviet Union disintegrated, a joke often told by new Soviet emigrants to this country goes as follows; what does freedom in America give you? It gives you the right to starve. The new freedoms in America gave the early settlers the opportunity to starve. With little infrastructure, limited human capital, and long waits for manufactured goods, Americans had to innovate and invent. While in Europe the "Gentleman" was well versed in the liberal arts, Americans had little time for non-vocational education. Boortin states this argument as follows:

> The traditional list of "liberal" arts, already beginning to break down in Europe, would no longer liberate man in America. Here men found it hard to prepare for any role, even that of a "liberally" educated man, simply because their roles had not yet been sharply defined. Similarly, in the professions, no traditional preparation could actually prepare a man for the novel tasks of clergyman, doctor, lawyer, or professor in America. Where the learned professions were loosely organized, where nearly everybody was doing some of the work of the doctor, the lawyer, or the teacher, the criteria of professional eminence became vague. A successful New England clergyman was also likely to be something of a physician, a politician, and a teacher, and perhaps to have other jobs as well.[21]

An important characteristic of the loosely organized new world was that children from any family were free to pursue any occupation. In Europe, it would be unthinkable for a child of an aristocrat to pursue a career as a silversmith or carpenter, in America the impediments of class had melted away. This classless career selection process was equally applicable to people of the

[21] Boorstin, "The Americans: The Colonial Experience,".

common class, without significant land or financial resources. Their children were also free to select careers based on acumen.[22]

Summary

The development of science and technology in a society is not only an interaction between people and nature; it is also an interaction between people and people. Five factors significantly influenced the evolution of science and technology in the new world.

Firstly, the needs of early Americans forced them to be practical people. The needs were immediate, children had to be fed, towns needed to be built, homes needed to be protected. Little time was available for pure science. These societal needs spurred the development of inventors as apposed to scientists. Inventors with a sense of urgency.

Secondly, these inventors where not shackled by the traditions of the past. They had little respect for what was, instead focusing on what could be. In fact, due to an initial focus of American Universities on biblical and practical vs. theoretical skills, many inventors lack the mathematical skills to pursue the evolving science of Europe.

Thirdly, the successful colonists traveled to America to build a new world. They could not and would not return to persecution in Europe. Their isolation as a community in Europe caused them to develop a sense of independence and the ability to fend for themselves. The seeds of

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[22] It is important to note that this freedom did not apply to African immigrants, forcibly brought to America living as slaves in the south, and was severely limited for African Americans living as "free-men" in the north.

invention laid in this independence. These pilgrims recognized they needed carpenters, coopers, and farmers in the collection of settlers to survive.

Fourthly, the vast western expanse, which appeared infinite, provided limitless opportunities for classification. This classification was necessary since supplies from Europe took months to arrive. To succeed the settlers needed to learn about and leverage the resources of their new home. The process of classification progresses more rapidly then the process of analysis. The focus on invention and classification delayed the development of analysis paralysis in America.[23]

The Darwinian evolution of the American community produced a fertile climate for inventors. Children of successful settlers watched their parents and neighbors create solutions to problems. They learned to create, to invent, and to innovate. These children were the offspring of farmers, carpenters, and coopers. The community in effect self selected for optimal survival skills. Those poorly suited to survival in the new world often perished the first winter.

Finally, Americans were free. Free to think, free to select trades based on personal preference and skills. Free to innovate. While Europe was struggling with the remnants of a class-based society, the new Americans invented a new government, new technologies, and a new society.

The lessons learned from the evolution of science and technologies in early America come into play yet today. As the examples from the computer industry highlight, the yoke of success,

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[23] It could be argued that the rapid advancement of technology in Japan after World War II was the result of analysis paralysis in America and an inventor's environment in Japan.

burdens of traditions and analysis paralysis are still factors in the evolution of technology and science.

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