Technology's Limits: Amplifier of Human Capabilities or Abrogation of Responsibility?

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"Man's power over nature
is really the power of some men over others
with nature as their instrument."
- C. S. Lewis

As civilization stands amidst the full flowering of a highly-technological 21st Century global society, 6.5 billion humans live, in large measure, due to the advancements in food production, potable water, medicine, energy, shelter, and clothing that was unimaginable even one century ago. However, accompanying these benefits has been a fear of technology, or at least a fear of our inability to wisely apply technology. Goethe's **Faust** (1808 and 1832), Shelley's **Frankenstein** (1818), and Huxley's **Brave New World** (1932 and 1958) have been part of the popular psyche throughout the very period that society has benefited the most from the rise of industrialization and the machine world view. These works of literature warn of the dark side of technology, an aspect that must be constrained in order to prevent the worst of disasters. Likewise, the criticisms of philosophers Oswald Spengler, Max Horkheimer, and Theodor Adorno mirrored this somewhat pessimistic view. The alternative perspective, espoused by philosophers such as Germany's Martin Heidegger, Spain's José Ortega y Gasset, and France's André Leroi-Gourhan, as well as by Britain's scientist-writer

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Lord C.P. Snow, was a much more optimistic vision of technology's role in both cultural and human evolution. They argued that arbitrary fear-based constraints on technology are tantamount to placing limits on what is unique in humans -- our tools and techniques.

Has technology outpaced our values to such a degree that it is no longer controllable? Or, has technology advanced to the current state because it has helped shape our values? Should there be limits on scientific research and technological creativity? Or, should we accept that trial-and-error and survival-of-the-fittest are the natural paths of life on this planet and, as such, one must go down this technologically enabled evolutionary path, regardless of where it leads? Is there a way to embrace technological evolution but enhance our survivability, indeed, enhance our probability of thriving by practicing science and technology in a very different manner than those engineers of the Industrial Age? Can a more holistic approach to technology, surpass the sterility and the false sense of security engendered by the overly linear thinking styles and the rational questioning advocated by Descartes, that seems so inadequate in the face of modern technological threats?

Contrasting Philosophical Perspectives of Technology

At the crest of the 19th Century's Enlightenment Movement, the prevailing view of technology was that it inherently produced positive benefits. This era was replaced by a 20th Century that soon realized Totalitarianism, two World Wars, the creation of the atomic bomb, eugenics,[1] and the start of a life-threatening global Cold War. Several influential European philosophers began to challenge technology's promise of inevitable progress. Collectively, this group believed that somehow humanity had been cut off from the core cultural values that made life worth living, and as such, engineers risked becoming technically competent barbarians. Oswald Spengler (1880-1936) thought the ground had been pulled from under society. He saw the money-based machine society as being a sign of social decline. "A century of purely extensive effectiveness, excluding big artistic and metaphysical production – let us say frankly an irreligious time which coincides exactly with the idea of the world city – is a time of decline…the early winter of full Civilization." Spengler thought society had shed every vestige of romanticism in favor of a "megalopolitan philosophy that was not speculative but practical, irreligious, social-ethical" (Spengler 34). Likewise Theodor Adorno (1903-1969) and Max Horkheimer (1895-1973) of the 'Frankfurt School' of philosophy saw inherent dangers in technologies focused on the "means as ends" without a strong sense of connection with nature.

> "At the moment when human beings cut themselves off from the consciousness of themselves as nature, all the purposes for which they keep themselves alive – social progress, the heightening of material and

[1] Eugenics is the study of human improvement by genetic means. The term was coined by Sir Francis Galton, a cousin of Charles Darwin, who was among the first to recognize the implications of Darwin's theory of evolution. Galton's science of planned human betterment through selective mating was meant to create a population consisting entirely of superior men and women (**Encyclopædia Britannica**. 2005).

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> intellectual forces, indeed, consciousness itself – become void, and the enthronement of the means as the end, which in late capitalism is taking on the character of overt madness, is already detectable in the earliest history of subjectivity" (Horkheimer 42-43).

To Spengler, Adorno, and Horkheimer, without grounding in moral values and without the spiritual and emotional guidance of religion and the arts, technology provided an unabated threat to humanity.

Offering an alternative view that moderated technological utopianism with what seems to have been reasonable cautionary guidance, were intellectuals such as Heidegger, Ortega, Leroi-Gourhan, and Guardini. Martin Heidegger (1889-1976), widely regarded as one of the most original and influential 20th-century philosophers, was influenced by Catholic theology and Edmund Husserl's phenomenology.[2] He argued that the danger inherent in how humans use technology also embodies the potential for great progress. Quoting the poet Hölderlin, Heidegger noted that "Where the danger is, grows the saving power also."

> "If the essence of technology, Enframing, is the extreme danger, and if there is truth in Hölderlin's words, then the rule of Enframing cannot exhaust itself solely in blocking all lighting-up of every revealing, all appearing of truth. Rather, precisely the essence of technology must harbor in itself the growth of the saving power. In technology's essence roots and thrives the saving power" (Heidegger 28-29).

Jose Ortega y Gasset (1883-1955) reminded us that when a society delegates its work to machines, the technology is no longer just an extension of human physical capabilities and man is not just a technician; this empowerment of technology makes humans free-willed engineers of their own collective "program" (Ortega 124, 148-149). The Catholic theologian Father Romano Guardini (1885-1968) focused on the potential for salvation, if technology could only be focused on the morally correct objectives. He stressed that machines give us freedom, but freedom 'for what' and toward what 'meaning' (Guardini 110-112). The French anthropologist André Leroi-Gourhan (1911-1986) took a more fate-based view that our technology evolves as a natural part of who humans are, just as culture evolved away from hunter-gatherers and toward sedentary agriculture-based toolmakers. To Leroi-Gourhan, some will live and some will die, but the evolutionary path for the survivors is unavoidable and will be defined as evolutionary progress. He notes that, "Human beings became the instrument of a technical and economic ascent to which they lent their

[2] According to the Center for Advanced Research in Phenomenology, Phenomenologists tend to oppose the acceptance of unobservable matters, grand systems erected in speculative thinking, and naturalism (also called objectivism and positivism). They justify cognition with reference to what Edmund Husserl called *Evidenz*, and hold that inquiry ought to focus upon what might be called "encountering" as it is directed at objects and, correlatively, upon "objects as they are encountered."

brains and hands. In this way human society became the chief consumer of humans, through violence or through work, with the result that the human has gradually gained complete possession of the natural world" (Leroi-Gourhan 184-185).

While these philosophers dealt with industrial-era machine-based paradigms, do their admonitions transfer to the level of control we have delegated to modern machines? Do they apply to the cadre of technologies that are so complex that the result of even accidental failures can be permanently devastating on humans as a species? Does this mean that the whole category of complex systems operations, such as those found in nuclear power plants, automated stock trading, financial data mining, and automated surveillance systems take humanity into a new realm, unimagined by Leroi-Gourhan, where not only are the machines doing physical work, but they are doing the mental work of human decision-making in operational areas where catastrophic failures are suddenly 'no one's fault'? Has modern technological society delegated so much to machines that we have, in effect, voluntarily enslaved ourselves to a complex web of automated interactions that we no longer understand, much less control?

Defining Technology

Before examining the limits of technology, it is perhaps useful to define what one means by *technology* and its related term *science*. The origin of the word *technology* gives valuable indications as to its meaning. It is derived from the Greek words, *techne* and *logos*. The former means art or craft, and the latter signifies discourse or organized words. Much of the relevancy of science to society arises by way of technology.[3] There are close relationships between science and technology; yet science is not technology and technology is not science. Technology is how we do things, not how we think of them. To this extent, technology is not neutral. Technology is applied, but is not necessarily based upon science. In fact, as the astronomer Robert Fischer notes, "to define technology as applied science is to miss much of the significance of the relationship that exists between science and

[3] Technology also involves our attempt to control and shape the environment and to make use of whatever resources are available in that environment (Fischer 77). The basic motive for "bringing about technology" is the desire to obtain more or better material things. According to José Ortega y Gasset, technology is not man's effort to satisfy his natural necessities; technology is a reform of nature. "The necessities are imposed on man by nature; man answers by imposing changes on nature. Technology, in contrast to the adaptation of the individual to the medium, is the adaptation of the medium to the individual. Thus technology is man's reaction upon nature or circumstance. It leads to the construction of a new nature, a supernature interposed between man and original nature. Man without technology – that is, without reaction upon his medium -- is not man" (Ortega 95-96). "Technology, then, is the means by which we shun, entirely or in part, the 'things to do' which would have kept us busy under natural circumstances" (Ortega 106). The concept of technology as 'more and better material things' is a Western concept born out of the flowering of knowledge and materialism that was the European Renaissance. Therefore, *technology* is relatively new. While science is the study of the nature around us and subsequent development of scientific laws, technology is the practical application of those laws, in sometimes non-rigorous ways, toward the achievement of some purpose -- usually material (Dorf, 1). Suffice it to say for our purposes that technology is science plus purpose.

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technology." He defines technology as the totality of the means employed by peoples to provide material objects for human sustenance and comfort (Fischer 76).

One may develop a working definition of *science* as the body of knowledge obtained by methods based upon observation. Derived from the Latin word *scientia*, which means knowledge, the modern usage employs the German concept of *wisenschaft*, which means systematic organized knowledge. Thus, science implies not mere isolated facts, but knowledge that has been put together in some organized manner (Martin). In particular, the science with which we are concerned is a body of knowledge which derives its facts from observation, connects these facts with theories, and then tests or modifies these theories as they succeed of fail in predicting or explaining new observations. In this sense, science has a relatively recent history – perhaps four centuries (Platt). Although science as an activity has existed as long as humans have existed, the modern Western notion of science begins with the European awakening during the High Middle Ages, the Renaissance, and the Enlightenment.

In addition, the underlying principles in modern scientific inquiry assume that nature (the physical realm) is real, orderly, and, in part, understandable (Fischer 64). Heidegger notes that, "…science, as a theory of the real, …stakes everything on grasping the real purely. It does not encroach upon the real in order to change it. Pure science, we proclaim, is disinterested" (Heidegger 167). Science may be a search for the real, but it historically did not have to be a search for the practical. C.P. Snow (1905-1980) noticed that, "We [Cambridge research scientists] prided ourselves that the science we were doing could not, in any conceivable circumstances, have any practical use. The more firmly one could make that claim, the more superior one felt" (Snow 32).

The more ideal and noble definitions of science are traditionally described as a search for the *truth* in a society that bends the truth to suit its needs.[i] Jacob Bronowski stated it this way:

> "The society of scientists is simple because it has a directing purpose: to explore the truth. Nevertheless, it has to solve the problem of everyday society, which is to find a compromise between man and men. It must encourage the simple scientist to be independent, and the body of scientists to be tolerant. From the basic conditions, which form the prime values, there follows step by step a range of values: dissent, freedom of thought and speech, justice, honor, human dignity, and self respect" (Bronowski 68).

In an absolute sense, *truth* and *neutrality* in science are limited to the facts of nature that are there for observation via our senses. In a less absolute sense, truth in science is limited to that which is directly observed and sensed by the observer. Even here, any expression of absolute truthfulness is limited by the time and space relationships between the observer and that which is being observed, and also by the restrictions inherent in the use of language to express the observation. It is impossible to separate fact in nature from one's own interpretation of it, as voiced by Robert Fischer:

> "The two criteria for scientific truth -- which, by the way, is a dynamic rather than a static entity -- either one of which is generally sufficient to cause persons to accept a principle are that, (a) it can be checked by observation or, to state it differently, its consequences lead to its support rather than to contradictions, and (b) it can be derived from intelligible principles" (Fischer 49).

Ortega observed that, "People believe modern technology more firmly established in history than all previous technologies because of its scientific foundation. But this alleged security is illusory and the unquestionable superiority of modern technology as technology even implies an element of weakness. Since it is based on the exactness of science, it is dependent on more presuppositions and conditions and is, consequently, less spontaneous and self-reliant than earlier technologies" (Ortega 104). Within the community of scientists, the validity of scientific truth, or probable truth, is based on statistical arguments. The community relies on truth by consensus, better known as 'peer review.' This peer review is based on a shared paradigm or worldview on how to evaluate evidence and come to agreement, or at least temporary agreement, until it is overruled by new insights and information.[4] K.C. Cole describes scientific truth as "…less a collection of facts than a running argument" (Cole 127). Likewise, Heidegger is also a critic of the way in which modern society views technology and the way science classifies objects. The Aristotelian classification puts boxes around (Enframes) knowledge that likewise needs to remain open to new revealings (unconcealments).

Ideally, science seeks to be pure neutral knowledge extracted painfully from nature through systematic means for dissemination to all humanity.[5] However, much of the

[4] Over twenty years ago, University of Kent Professor A. J. Skillen refuted the statement that value judgments do not belong in science. The long held view that science is neutral was shown by Skillen as a fallacy. Specifically, since science dominates our image of empirical rationality and rationality is dominated by abstractness that exists in the mind of feelings, commitments, and attitudes, it should come as no surprise that science (its methods and interpretations) must also be influenced by feelings or values (rather than facts). When we consider that our individual interpretations of phenomena will likely depend upon our view of the world, it is reasonable to assume that our practice of science will likewise be biased. In effect, our perceptions of facts will contain value judgments that are, in turn, framed by certain paradigms (Skillen).

[5] Scientists and engineers, being fully human, are influenced by the mainstream of social thought framed by current technology and prevalent belief systems, both of which are subject to change. As Heidegger reminds us, "[Even though] every phenomenon emerging within an area of science is refined to such a point that it fits into the normative objective coherence of the theory…that normative coherence itself is thereby changed from time to time" (Heidegger 169). Even Aristotle was willing to reject or change his theories when a closer examination of nature proved them wrong. He was quite aware that his work was only the beginning, to be corrected and developed by those who came after him, citing, "Inventions are either the elaboration by later workers of the results of

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relevance of science to society arises by way of *technology*. As Heidegger observed, "…the only important quality has become their readiness for use…their only meaning lies in their being available to serve some end that will itself also be directed toward getting everything under control" [6] (Heidegger xxix). Even Aristotle, in his *Metaphysics*, distinguished between theoretical knowledge, whose goal is truth, and practical knowledge, which seeks action (Loomis 11). As such, technology is how we do things, not how we think of them. While science is the study of the nature around us and subsequent development of scientific 'laws,' technology is the practical application of those laws, in sometimes non-rigorous ways, toward the achievement of some material purpose (Dorf 1).

Even though we do not normally think of technology as consisting of written or spoken words, as implied by logos, it does involve the systematic organization of processes, techniques, and goals. As Ortega sees it, "Without technique – the intellectual method operative in technical creation – there is no technology. But with technique alone there is none either. [ii] The existence of a capacity is not enough to put that capacity into action" (Ortega 154-155).

Modern technology's relationship to science is so intertwined that the distinction between the two is irrelevant. As Ortega would put it, "New technology proceeds in exactly the same way as the *nouva scienza*. The engineer no longer passes directly from the image of the desired end to the search of the means which may obtain it. He stands before the envisaged aim and begins to work on it. He analyzes it. That is to say, he breaks down the total result into the components which have formed it, e.g., into its causes" (Ortega 159). There is also a strong influence in the reverse direction. Modern science relies largely upon existing technology as well as upon prior scientific knowledge. Science and technology reinforce each other by complex interactions. Each one, science or technology, can build upon itself or upon a cross linkage from one to the other. Technology is dependent upon science for knowledge of the properties of materials and energy and for predicting the behavior of natural forces. Science is dependent upon technology for its tools and instruments, for the preparation of materials, for the storage and dissemination of information, and for the stimulation of further research (Fischer 77). Indeed, science is not technology and technology is not science but they are forever interrelated. One could not exist in modern society without the other.

previous labor handed down by others, or original discoveries, small in their beginnings but far more important than what will later be developed from them" (Loomis xxv).

[6] Heidegger refers to the undifferentiated supply or 'standing-reserve' of the available matter that is objectified by man via technology as a means to an end (Heidegger xxix).

Technology the Amplifier

To what degree is technology merely the amplifier of innate human physical and mental capabilities? Technologies are concrete manifestations of a culture's worldview, because it is technology that is the explicit use of a society's knowledge for a certain set of aims. As the science writer Robert Pool would state it, "One must look past the technology to the broader 'sociotechnical system' -- the social, political, economic, and institutional environments in which the technology develops and operates. Modern technology is not simply the rational product of scientists and engineers that it is often advertised to be. Look closely at any technology, from aircraft to the Internet, you'll find that it truly makes sense only when seen as part of a society in which it grew up" (Pool 5-9).

According to André Leroi-Gourhan, the body social forms the prolongation of the anatomical body (Leroi-Gourhan 20). There is a balance between the body social and the individual's 'indefinitely perfectible extension in action' and the extension of paleontological trajectory (Leroi-Gourhan 20). This trajectory, from a social evolution perspective, is inherently a function of values. As Leroi-Gourhan would state it, those sets of values give every human group a personality, unique at each moment in history (Leroi-Gourhan 20). As such, technology has been driven by society since the earliest of recorded history.

Technology has developed separately from science throughout most of recorded history. Ortega categorizes the progression of technological sophistication in this order: the *Technology of Chance*, *Technology of the Craftsman*, and the *Technology of the Technician*.

Primitive man uses the *Technology of Chance*, what Ortega calls the 'aha-impression.'[7] "He is not aware of his technology as such; he is unconscious of the fact that there is among his faculties one which enables him to refashion nature after his desires. His inventions are not the result of premeditated and deliberate search. He does not look for them; they seem rather to look for him. Primitive man does not look upon himself as the inventor of his inventions. Invention appears to him as another dimension of nature, as part of nature's power to furnish him – nature furnishing man, not man nature – with certain novel devices" (Ortega 142-144).

The *Technology of the Craftsman* causes society to recognize technology as a conscious independent entity performed by artisans, the peculiar set of activities of which are not natural to all men" (Ortega 146). For example, many science historians argue that ancient Mesopotamian and Egyptian advanced civilizations were purely the result of applied engineering and skilled trades, rather than any formal theories of the underlying physical phenomena.[8] According to McClellan and Dorn,

[7] Guardini distinguishes this primitive phase of tool making as "something that we relate to the function of the body in order to enhance what our members and organs can achieve" (Guardini 98).

[8] Mesopotamia shows evidence of being the most advanced technological society of its era. Over a 6,000 year period, Mesopotamian technology included advances in carpentry, glassmaking, textile manufacture, leather-

> "In most historical situations prior to the 20 Century, science and technology have progressed in either partial of full isolation from each other – both intellectually and sociologically" (McClellan 2). "Since higher learning was heavily skewed toward useful knowledge and its applications, in this sociological sense applied science, in fact, preceded pure science or abstract theoretical research later fostered by the Greeks" (McClellan 46). The Mesopotamians recorded knowledge in lists, "rather than in any analytical system of theorems or generalizations…[and pursued it with] a notable lack of abstraction or generality and without any of the naturalistic theory or goal of knowledge as an end in its own right that the Greeks later emphasized" (McClellan 47).

They argue that practical knowledge embodied in the crafts is different from knowledge derived from some abstract understanding of a phenomenon (McClellan 13). They believe that Mesopotamia achieved this level of advancement without the kind of abstract science and mathematics, later practiced by the Greeks.[9] The University of Chicago's renowned

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working, perfume-making, farming, food preparation, irrigation, flood control, canal-building, water storage, drainage, brewing, and their tablets also provide detail on the economics of various industries (Roaf 126). The most basic indication of a settled, rather than nomadic, lifestyle is pottery. Decorated pottery found at Tell Hassuna indicates a mastery of kilns providing higher temperatures for baking non-porous jars as early as the middle of the 7th millennium BC (Roaf 39). "During the 4th millennium, there were major developments in metallurgy," according to Roaf. Smelted copper, alloys of copper and arsenic, lead, gold and silver ornaments benefited from the use of lost-wax casting techniques (Roaf 72). Sir Leonard Woolley's excavations of more than 1,000 graves in the Royal Cemetery at Ur show a complete mastery of jewelry making techniques using composite objects, inlaid stones, and sophisticated geometric designs (Roaf 92). Intensified agriculture based on large scale water management networks constructed and maintained as public works by conscripted labor gangs (corvee) and slaves under the supervision of state-employed engineers is the critical foundation of their civilization. Main canals were nearly 75 feet wide, had hundreds of connecting channels, and ran for several miles (McClellan 31-35). Perhaps the most impressive engineering achievements of ancient Mesopotamia are the series of ziggurats found throughout the region as early as 2100 BC in Ur, 1900 BC in Babylon, and 900 BC in Assyria.[8] In addition, the Assyrians of Nineveh under the leadership of Sargon II (722-670 BC) and his son Sennacherib dominated the Near East with its iron-equipped armies, battering rams, and horse-drawn chariots (Derry 12). Writing appeared in Mesopotamia in the 4th millennium BC. Mathematics was supported by the state and temple authorities, principally to maintain its agricultural economy. For example, 85 percent of cuneiform tablets uncovered at Uruk (3,000 BC) represented economic records (McClellan 47). This administrative nature of mathematics also explained the Mesopotamians' tradition of recording verbal and quantitative information in the form of lists.

9 Alternatively, archaeologists, such as Jean Bottero of the Ecole Pratique des Hautes Etudes in Paris, argue that Mesopotamia indeed practiced an early form of abstract thinking and used mathematical astronomy as the bridge between engineering and science. Since the ancient Mesopotamians considered every aspect of the material universe as appropriate subjects of study for the purpose of extracting the plans of the gods, a deductive form of divination can be inferred from the writings found in texts such as *The Great Treatise on Astrology*. Divination was originally empirical, based on a simple set of observations of historical events that the Mesopotamians thought would repeat itself. These unusual events, and similar appearances, were grouped and were "multiplied in the eyes of the people who believed in them," notes Bottero. The first phenomenon would signal the second, and the two together were recorded as an oracle of universal value. To our modern sensibilities this would seem extremely

Assyriologist A. Leo Oppenheim also notes that, "They convey the procedure as such without the elaboration of the numerical results, using measurements and other given numbers solely to illustrate the operations described" (Oppenheim 307).

Ortega's *Technology of the Craftsman* would also apply to ancient Egypt. While Mesopotamian society, with its collection of cities, is perhaps the first known civilization, in the strictest sense of the word, Egypt was the first state and was by far the oldest continuous state.[10] Like Mesopotamia, Egypt showed evidence of having a very advanced engineering capability.[11] As Basil Davidson notes, "The time span from *homo habilis* with his earliest tools to Neolithic man with his farming cannot in any case be much less than two million years. Yet not much more than two thousand years separate the earliest farmers who settled along the river Nile from the mathematically precise builders of the monuments of Egypt" (Davidson 14). They benefited from a fruitful interaction with the environment through invention, and they experienced a 'feedback relationship' between environment, biological evolution, and cultural change. The settled life enabled the Egyptians to be

superstitious, however, to the Mesopotamians, this allowed the practitioners to expect to see a repetition of an analogous event in the destiny of the king or the land, whenever the anomaly was noticed again (Bottero 131). As the practice became institutionalized, Bottero believes that the Mesopotamians' desire to analyze and systematize their observations led to a deductive reasoning that went beyond the observed reality into the realm of the possible. "Mesopotamian divination attempted to study its subject as universal, and in a certain sense *in abstracto*, which is also one of the characteristics of scientific knowledge," explains Bottero (Bottero 127-135). He drives the point further, especially as divination was increasingly linked to mathematical astronomy:

> "From a knowledge based on pure observation *a posteriori*, starting from individual cases that were fortuitous and unforeseeable, divination became thus *a-priori* knowledge, before the end of the third millennium at least. That knowledge was deductive, systematic, capable of foreseeing, and had a necessary, universal and, in its own way, abstract object, and even had its own manuals. That is what we call a science, in the proper and formal sense of the word" (Bottero 136).

[10] Urban-based civilizations unfolded independently in multiple centers across the world. A pattern of Neolithic settlements coalescing into centralized kingdoms based on intensified, hydraulically-enabled, agriculture occurs at least six times in different sites: Mesopotamia after 3500 BCE, Egypt after 3400 BCE, Indus River Valley after 2500 BCE, along the Hwang Ho (Yellow River) after 1800 BCE, Mesoamerica after 500 BCE, and South America after 300 BCE (McClellan 32).

[11] Settled city life facilitated new forms of technologies, such as metalworking, pottery, stone carving, and new forms of social organization. Bronze metals (copper alloyed with tin) offered distinct advantages over stone as tools and weapons, so control over Sinai copper mines was of great importance to Egypt. Metalworking involved a complicated set of technologies, including mining ore, smelting, hammering or casting the metal into useful tools. Bronze metallurgy required furnaces with bellows to raise temperatures to 1,100 degrees Celsius (McClellan 41). Increased crop yields, surpluses, and wealth led to a desire to trade with neighbors, even distant ones, for luxury items and raw materials, including Nubian gold. By the close of the Bronze Age, the tomb of Tutankhamen showed the exquisite achievements of the Egyptians in fine arts, in the service of the religious mortuary cults. Here we find works in gold, silver, semi-precious metals, ivory, and curved furniture unrivalled by European technique until the Renaissance (Derry11).

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handier, more skillful, and better able to think and to act by thought than their ancestors (Davidson 13).

In Ortega's *Technology of the Craftsman* or what Guardini called a *contrivance*, technological change has generally been empirically derived, simply by trial and error. The method used in proceeding to the development of new technological advances is determined primarily on the basis of two factors: the existing technology and the existing knowledge of the properties of matter and energy, i.e., existing scientific knowledge.[iii] This scientific knowledge used in technology is not a replacement for the trial-and-error methodology of technology. Rather, it provides a means of selecting what trial to undertake next and thus contributes to the efficiency and effectiveness of the trial-and-error method. Technology can use scientific knowledge and, in this sense, it can be sometimes viewed as applied science. Yet, much technology continues to be developed with little or no basic scientific knowledge.[12]

Regardless of the causal effect, it is clear that there is interplay between the cultural philosophy of an era and the approach to that era's application of knowledge through technology.[13] Robert Hammond defines technology (engineering) as a means by which the knowledge of mathematical and rational sciences is applied with *judgment* to develop ways to utilize the materials and forces of nature for the benefit of mankind (Hammond 5). As a result of overt human goals and subjective human judgment, technology is never neutral because it is directed in specific instances toward specific material objects. It is just these value-based judgements that are being questioned today.

Technology Beyond Control?

In the past the actions of individuals or single industries or even single nations mattered little to the outcome of the world. Modern technology is quantitatively more pervasive in society and leads to qualitative changes. To what degree are these new technologies radically different in how they open entirely new doors for human control, extension, non-physical evolution, or catastrophic destruction? Let us now examine what Ortega called the *Technology of the Technician*, which happens when the tool works by itself to produce the object. It is also what Guardini considered as the 'machine' whose "function is scientifically understood and technically worked out so that the mode of operation can be accurately fixed" (Guardini 100). At this point, handiwork is surpassed by mechanical production, which is then bifurcated into two components, according to Ortega – the invention the plan of activity and the handling of the raw material (Ortega 148-149). As noted by Leroi-Gourhan, what we have today is technology that is a child of human

[12] For example, the photographic process was developed to a high degree of sophistication even without the fundamental or basic understanding of the underlying chemical phenomena (Fischer 77).

[13] See Alfred North Whitehead's 1925 Lowell Lecture entitled *Science and Philosophy* for a more detailed discussion (Whitehead 173-196).

intelligence, but one completely freed from genetic ties. "Our techniques, which have been an extension of our bodies since the first Australanthropian made the first chopper, have reenacted at a dizzying speed events of millions of years of geological evolution until, today, we can already use an artificial nervous system and an electronic intelligence." (Leroi-Gourhan 173). In addition to separation of planning and work, in this mode, humans themselves risk becoming separated from the technology that is working on their behalf and from other humans in the process. As Adorno and Horkheimer warn, "Not only is domination paid for with the estrangement of human beings from the dominated objects, but the relationships of human beings, including the relationships of individuals to themselves, have themselves been bewitched by the objectification of the mind" (Horkheimer 21).

Since today's scientific and technological initiatives are driven by social values, it is instructive to explore the cultural values that 21st century Western global capitalist societies embrace and their subsequent effects on how the public is becoming increasingly skeptical of the unintentional consequences of unfettered science and technology. Those values have been derived from the worldview of a society, which includes the dominant philosophical paradigms of what is known (science), what is believed (religion), and what is desired (self-interest). Neither science, religion, nor self-interest is unbiased and they certainly actualize in the real geo-political economy as non-neutral and often unfair.

If it is true that every society determines reality, truth, beauty, and values in accordance with its own worldview and its unique historic path, then the common view among casual observers of Silicon Valley is that its extreme technology emersion can lead to a one-dimensional perspective of the world and its problems. [14] According to San Jose State anthropologist, Jan English-Lueck,

> "The notion that a culture can be identified with its economic specialization – and the technology associated with it – is a very old and widespread idea. Of course, the worldviews held by individuals or by groups are very influential in determining behavior, as well as in determining motivations, attitudes and actions. Working with technology, thinking about technology, and producing technology change the way Silicon Valley people construct reality by giving them new metaphors" (English-Lueck 66).

In Silicon Valley, people transfer engineering and entrepreneurial approaches to their understanding of the social world, such that efficiency, utility, instrumentality, and economic rationality become the philosophical underpinnings of their worldview[15] (English-

[14] The high-tech industrial base in Silicon Valley is based on such industries as aerospace, defense, semiconductors, computers, software development, telecommunications, and biotechnology (English-Lueck 82).

[15] English-Lueck draws an analogy to other cultures and worldviews. Devout Christian fundamentalists frame the happenings of the world as functions of 'good' and 'evil,' and during China's Cultural Revolution, every action was viewed as a political event – even choosing a bride from the proletariat.

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Lueck 74-77). She notes that, "In Silicon Valley, people view the daily conflicts of life as 'social engineering problems' that can be 'solved' if given thoughtful and systematic appraisal" (English-Lueck 76). So, one wonders to what degree and in what manner is Maslow's adage -- "If the only tool you have is a hammer, every problem is a nail" -- relevant or irrelevant in the social discourse of Silicon Valley?

As such, critics of Silicon Valley note that, while it is clear that technology has the power to enhance lives, it is not always as clear to the developers and consumers of high technology products that the same beneficial technology might also lead to an oversimplified public discourse of social problems, a loss of richness in human interactions, and a sense of personal alienation. As the literary character Faust sold his soul to the devil for the riches of today, one must ask if Silicon Valley's singular focus on technology and rational thinking crowd out or devalue the emotional, intuitive, creative, and spiritual aspects of civilization? Does Silicon Valley's worldview take into consideration the untidy emotional factors inherent in the social 'ends' that justify the technological 'means?' Let us examine some of the challenges and threats that have accompanied the growth and progress of the information technology industry.

Due largely to Silicon Valley, we are in the midst of an economy that defines success by the ownership and control of information and the tools that access and exploit abstract representations of knowledge. However, the public is increasingly concerned that the benefits of scientific knowledge are being outweighed by our inability to control the negative consequences. When we take that insightful second look we see the full extent to which we are mentally vulnerable. For example, in his interview with the billionaire chairman of Oracle, Larry Ellison, **New York Times** reporter Jeffrey Rosen noted, "As Ellison spoke, it occurred to me that he was proposing to reconstruct America's national security strategy along the lines of Oracle's business model," one of consolidating hundreds of separate databases into a single database on the Internet (Rosen 7). In George Orwell's **Nineteen Eighty-Four**, Oceania's 'The Party' complacently used surveillance techniques like the omnipresent telescreens that watch every waking, sleeping, and even excreting action. In the post-9/11 America, video surveillance is commonplace (Lessig 8). ID badges can track one's movements in buildings (Rosen 4). ADT's GPS system can track humans the way Lojack tracks cars (Saphir). Every web site that is visited and every email that is sent or received can be monitored (Guernsey 1-3). To 'The Party,' reality is not external. "Not in the individual mind, which can make mistakes, and in any case soon perishes; only in the mind of 'The Party,' which is collective and immortal," as the interrogator O'Brien insists in **Nineteen Eighty-Four**.

Dependency upon databanks to store transactions and to reflect reality is not an indictment of those sources per se. It is the degree to which their potential misuse can distort our view of reality that is so frightening. Specifically, malicious or accidental destruction or corruption of databanks could virtually paralyze an enterprise. For example, a hospital database could be changed to result in a patient receiving the wrong medication.

Leakage of military information could endanger national security. Erroneous information in an airline database could threaten passenger safety. Our economy also requires identification numbers, credit records, medical, dental, educational, criminal, and family records to be stored, matched, updated, and archived by computers. The ultimate threat to privacy and distortions of reality revolve around the use of our files by agencies to judge our creditworthiness, our insurability, our employability, educatability, and our desirability as neighbors or tenants. This creates an enormous potential risk to the privacy and accuracy of our personal records in databanks, nationwide. Even more disturbing, Accenture and HNC Software are building a profiling system designed to analyze airline passenger living arrangements, travel patterns, real estate history, demographics, financial, and other personal information to prepare a threat index that can be compared to a terrorist profile (Rosen 2-3). The effect depends upon not only the information itself, but also on the improper action taken against it. With such overreaching autonomous technology, through maliciousness or accident, we may become a perceived threat or at least an undesirable.

We live in a world where our 2005 is not as overtly totalitarian as Orwell's 1984, but every electronic signature, fingerprint, or transaction record we leave is a non-transitory record that is more easily monitored, more cheaply searched, transparent to the person being searched, and can lead to the erosion of personal privacy (Lessig 7-12). Orwell's Unperson was an accurate foreshadowing of our dilemma. As we dash into the electronic society, with written records and receipts fading into the "inaccuracy of individual memories," as Orwell's Party would state it, the reality of our transactions, our lives, and the lives of others become flexible. From the bureaucracy's perspective, our reality exists at its discretion.

Perhaps heeding Heidegger's cautiously optimistic approach to technology is in order. Heidegger was a proponent of technology in its broadest sense as a way for humans to fulfill our collective destiny. He understood that the danger inherent in how humans use technology also embodies the potential for great progress. He was concerned that our perspective that technology is for purely utilitarian purposes can blind us to the insight of the greater good of technology. Heidegger referred to the undifferentiated supply or 'standing-reserve' of the available matter that is objectified by man via technology as a 'means to an end' (Heidegger 32-35). He also saw the extreme focus on technology's ends as being short-sighted, "…the only important quality has become their readiness for use…their only meaning lies in their being available to serve some end that will itself also be directed toward getting everything under control." From Heidegger's perspective, one cannot avoid technical culture. Trying to do so will keep humanity from realizing the potential of 'salvation' of technology and, instead, cause it to fall into the 'danger' of technology. "Man will never be able to experience and ponder this that is denied so long as he dawdles about in the mere negating of the age" (Heidegger 136).

The raging debate centers around what can be done to alleviate these threats and who should bear the responsibility for implementing solutions. After all, when the threat of biological genocide due to a genetically engineered mutant virus having escaped a

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pharmaceutical laboratory confronts humanity, who is to blame? When our entire civilization hangs on flight time of a thermonuclear missile are scientists or politicians the culprits? Those whose education or tastes have confined them to the humanities -- whom C.P. Snow called "natural Luddites" unable to understand the industrial revolution, much less accept it -- protest that scientists alone are to blame (Snow 22). Scientists say, with equal contempt, that humanists, politicians, and the 'commercializers' cannot wash their hands of blame because they have not done anything to help direct a society whose ills grow worse from, not only error, but also inaction (Bronowski, 5). As scientist and philosopher Jacob Bronowski pointed out, there is no comfort in such bickering. Neither solves the problem. Bronowski stated,

> "There is no more threatening and no more degrading doctrine than the fancy that somehow we may shelve the responsibility for making decisions of our society by passing it to a few scientists armored with a special magic." For indeed, "…it should make us shiver whenever we hear a man of sensibility dismiss science as someone else's concern. The world today is made, it is powered by science; and for any man to abdicate an interest in science is to walk with open eyes toward slavery " (Bronowski 6).

Every technology has had its detractors, but one cannot let fear dash humanity's dreams. According to Ortega, "Man begins where technology begins. The mission of technology consists in releasing man for the task of being himself" (Ortega 117-118). "Present-day man is secretly frightened by his own omnipotence. And this may be another reason why he does not know what he is. For finding himself capable of being almost anything makes it all the harder for him to know what he actually is" (Ortega 150-151). Ortega advises, "Human life and everything in it is a constant and absolute risk. The deadly blow may come from where it was least to be expected" (Ortega 103). As such, "We are not allowed to confine ourselves within our own professions, but must live in full view of the entire scene of life, which is always total. Alertness is what we require" (Ortega 103).

Technology the Savior?

Can modern technologies be the saviors envisioned by Heidegger, and if so, what can we learn from Heidegger, Guardini, and Ortega as to how best to get control of what could otherwise be an uncontrollable spiral of dehumanization? "Man's existence is no passive being in the world; it is an unending struggle to accommodate himself in it. Man has to be himself in spite of unfavorable circumstances; that means he has to make his own existence at every single moment. He has the abstract possibility of existing, but not the reality. This he has to conquer hour after hour. Man must earn his life, not only economically but metaphysically" (Ortega 111). "Man, in existing has to make his existence. He has to solve the practical problem of transferring into reality the program that is himself" (Ortega 115).

As Ortega would argue, "In the very root of his essence man finds himself called upon to be an engineer. Human life 'is' production. By this I mean to say that fundamentally life is not, as has been believed for so many centuries, contemplation, thinking, theory, but action. It is fabrication; and it is thinking, theory, science only because these are needed for autofabrication, hence secondarily, not primarily" (Ortega 116). Therefore, "Technology is a function of the variable program of man" (Ortega 124).

If humans dare take on the responsibility for self-evolution, it would seem that scientists and engineers have a profound responsibility to society. The day is long gone when technologists could arguably claim to have no responsibility for how their innovations are used. In a world of "big science," driven by a capitalist economy, scientists can certainly stop claiming that their research is in pursuit of pure knowledge for knowledge's sake. It is hollow solace for scientists and engineers to assume that they have left their belief systems, prejudices, fears, and needs for security, egos, friendships, and enemies at the door of the laboratory.[iv]

As the historical examination demonstrates, the debate around the role of scientists and engineers as ethical social agents has been around for ages. Nearly fifty years ago, Bronowski reinforced the basic argument that scientists have a responsibility to humanity. Bronowski stated that the dilemma of today [1956] is not that human values could not control a mechanical science. It was the opposite: "The scientific spirit is more human than the machinery of governments." He saw scientists as belonging to a community that fosters free critical thinking and tolerance – just the characteristics needed by our troubled society. Bronowski argued that science is a human activity and is practiced by "very human" scientists. Although he believed that the facts produced by science are neutral, science as a human activity is not neutral. With this established, he advocated a role for scientists as educators of the public on the positives and negatives of new discoveries. Bronowski shunned the idea of scientists as governors and plead for an adoption of the scientific ethic by world leaders (Bronowski 71).

The late Dr. Bronowski eloquently and logically argued his points. He showed us that scientists are as fully human as artists and, as such, they display a full range of creative genius. Being human, however, means that scientists can no more shirk their responsibility to improve our lot than politicians. His argument, that scientists have a crucial responsibility (for which they are uniquely trained) to make the public fully aware of the implications of their work, should serve to bring the 'overly tunnel-visioned' researcher back into the realm of political activist and citizen. According to Bronowski, no longer do scientists have a right to hide behind the veil of scientific neutrality. They must participate in decision making as full partners with the public. Indeed, as C.P. Snow reminded us, "It is dangerous to have two cultures which can't communicate. In a time when science is determining much of our destiny, that is, whether we live or die, it is dangerous in the most practical terms" (Snow 98).

Scientists are not, and should not be, neutral when it comes to public policies regarding a whole new generation of weapons, microbes, and chemicals that can influence the future of the planet. From this perspective, engineers and scientists must be part of the decision-making process. Engineers as a group and as individuals have special

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responsibilities as citizens, which go beyond those of non-engineer citizens. "All citizens have an obligation to devote some of their time and energies to public policy matters. Minimal requirements for everyone are to stay informed about issues that can be voted on, while stronger obligations arise for those who by professional background are well grounded in specific issues as well as for those who have the time to train themselves as public advocates," as put forth by Philosopher Mike Martin and Engineer Roland Schizinger (Martin 29l). In addition, Paul Goodman notes, "as a moral philosopher, a technician should be able to criticize the programs given him (her) to implement" (Martin 1).

So, one sees that technologists should accept more responsibility for the implications of technologies on humanity, but how might they change the very way in which they perceive their work? A new way of thinking about technologies and engineering design is in its early stages. The new scientific understanding of life based on non-linear dynamics, or complexity theory, combined with some spectacular technological failures and risks, are forcing the technology community to re-evaluate design goals so that they can be more consistent with the principles of organization that nature has evolved to sustain the web of life (Capra, **Hidden Connections** xix). "There is a movement to build ecologically sustainable communities, designed in such a way that their technologies and social institutions – their material and social structures – do not interfere with nature's inherent ability to sustain life," observes physicist Fritjof Capra. Since the network is one of the most basic patterns of organization among living things, and since, increasingly, the most problematic technological systems to manage are complex networks – global automated financial trading, the decentralized ubiquitous Internet, space vehicular systems, untested and unintended consequences of genetic engineering in live environments – extending the systematic understanding of life to the social domain means applying our knowledge of life's basic patterns and principles of organization, and specifically our understanding of living networks, to social reality (Capra, **Hidden Connections** 81).

Robert Pool observes that engineers do not think of what they do in social terms. However, as technologies become more complex, engineers will find it increasingly necessary to take human performance and, eventually, organizational factors into account in their designs (Pool 287). For example, Pool argues in favor of high reliability organizations that build safety into the systems and processes from the start, rather than adding it on as an afterthought. Pool argues for a design approach that accepts that people make mistakes and that organizations get sloppy and takes those factors into account in the engineering process. This is in stark contrast to the machine-centered philosophy of engineering, where one designs a plant so that it does its job efficiently, then expect people and organizations to adapt to it. (Pool 280). Likewise, Lawrence Kanous of Detroit Edison castigated the electric power industry in the post-Three Mile Island reviews, for paying "insufficient attention to the human side of such systems since most designers are hardware-oriented. They focus on what is important to the physical functioning of the machine and assume that the human operators are adaptable" (Pool 283).

When it comes to complex systems, the emphasis needs to be on making operators of technology more effective, instead of making machines more effective. The industry should consider systems that inform humans, in great and varied detail, rather than blindly automate and delegate important and risky operations to machines. "Creating such informed systems is an expensive process, one that is difficult to justify for such safe and mature technologies as coal-fired power plants. But nuclear plants are a different matter," notes Pool (Pool 285). Likewise, chemical engineers need to see their design goal not simply as maximizing yield, but as finding a process with an acceptable yield that also minimizes pollution and safety hazards (Pool 291). The alternative is clear, according to Pool.

> "Yet if any lesson emerges from the studies of organizations and risk, it is that skimping on safety has been the root of many of our most horrible accidents. There is the Bhopal tragedy, with its inactivated safety equipment, poor training, and inadequate staffing. NASA's problems leading up to the Challenger explosion [and one might add, the recent fiery Columbia re-entry] can be traced to pressures to produce quickly on an inadequate budget. The 1974 crash of a Turkish Airlines DC-10, which killed 346 people on board, was the result of a penny-wise, pound-foolish approach to safety. If we are unwilling to invest in safety and to keep on investing for as long as we insist on using hazardous technologies, then our Faustian bargains will certainly prove to be no bargains at all" (Pool 277).

It seems that Pool and Capra share the opinions of Spengler, Adorno, Horkheimer, Guardini, Ortega, Snow, and Heidegger that complex modern technology will require engineers and scientists to get back in touch with humanity, and the sometimes messy, irrational, emotional, artistic, and spiritual aspects that humanity implies.[16] Western science has traditionally minimized the value to the human spirit of faith, emotion, intuition, hope, and general use of the emotional part of the brain. According to Snow, scientists reduced human subjectivity through skepticism and had very little appreciation for literature and the arts.

> "Their [scientists] culture is in many ways an exacting and admirable one. It doesn't contain much art, with the exception, an important exception, of music. Verbal exchange, insistent argument…The ear, to some extent the eye. Books very little…And of the books which to most literary persons are bread and butter, novels, history, poetry, plays, almost nothing at all…It isn't that they're not interested in the psychological or moral or social life. It is much more that the whole literature of the traditional culture doesn't seem to them relevant to those interests" (Snow 13-14).

[16] Back in the 1950's, Romano Guardini saw the beginning of the dislocation of European traditions, spiritual and religious customs, which anchored the West, and the overtaking by unquestioned secularist progress, thus de-linking humanity's spiritual side from the world and operation in it (Lombardi).

There has been a mechanistic claim among scientists that living organisms are nothing more than very complex physico-chemical systems (Hempel 101). This led to a view among scientists that scientific theories could be applied to social phenomena, and they should be described, analyzed, and explained in terms of the situations of the individual agents involved in them and by reference to the laws and theories concerning individual human behavior (Hempel 110). This view has also been called *scientism*.[17] Robert Jastrow, the founder of NASA's Goddard Institute, observes, "Scientists cannot bear the thought of a natural phenomenon which cannot be explained, even with unlimited time and money. There is a kind of religion in science; it is the religion of a person who believes there is order and harmony in the universe. Every event can be explained in a rational way as the product of some previous event; every event must have its cause" (Jastrow 113).

Because we have adopted a faith in science, it is clear that modern humanity will reject any non-rational explanation of problems and solutions.[18] However, scientific reduction of problems and solutions to pure mechanistic explanations is contrary to human experience and will also likely be rejected. Scientism's assignment of an omnipotent role to science, of solving all problems and clarifying all things, and of deifying nature while secularizing religion can lead science to be what Robert Fischer refers to as, "…like other ideologies, [science] tends to be systematic, authoritarian, and to be held tenaciously" (Fischer 68).

Science cannot ever hope to realistically answer the big questions facing humanity. Being based upon observation and testing, science is at an impasse when it comes to things that cannot be observed, measured, tested, and predicted. Social problems transcend mathematical description and involve emotions that cannot be touched, measured, or manipulated successfully. Worse still, technical solutions often only address changes in technique that might relieve the symptoms, but do not demand changes in human values or morality, which ultimately affect many underlying causes (Meadows 155-159).

Science is a search for truth and truth is limited to the facts of nature that are there for observation via our senses. As a result, technology cannot emulate human feelings

[17] Scientism is not science. It is the affirmation that there is no other realm than matter and energy, no knowledge other than scientific knowledge, and no areas of investigation, including philosophy, humanities, and social sciences, should be spared scientific scrutiny (Fischer 68). Scientism has its roots in the perspectives of many great philosophers and scientists. For example, Spinoza and Einstein believed that God was the sum total of all the physical laws which describe the universe. When Pierre Simon, the Marquis de Laplace, presented a copy of his work on the mathematics of physical laws to Napoleon in 1798, the Emperor asked as to the mention of God in the text. Laplace's response was an arrogant, "Sire, I have no need for that hypothesis" (Henahan 9). Francis Bacon proclaimed science as the religion of modern emancipated man (Durant 47).

[18] Will and Ariel Durant argue that the replacement of Christian with secular institutions is the culmination and critical result of the Industrial Revolution, which replaced agriculture and its faith in annual rebirth and the mystery of growth with the humming daily litany of machines and its resulting mechanistic outlook on life (Durant 47-48).

and science cannot define God. Heidegger believed that technology and science had certain limits on them, so assuming that they are the totality of knowledge is a mistake. In fact, just as purely technological approaches to human problems cannot solve all problems, he seemed to argue for a more balanced and broadened view of knowledge. Technology is the most dangerous when humans believe we know all the answers or when we think that the only relevant answers are those framed by the human worldview (Heidegger 21-29). To Heidegger, technology operating out of touch with Being shows human arrogance at its worst. Likewise, religions would agree that humans operating cut off from God is the source of all of humanity's problems. So, religions would advise humans to stay open to divine inspiration from God, just as Heidegger would advise that we stay open to inspiration from Being.[19]

A workable approach for modern society is the reconciliation of the religious and scientific schools of thought in a manner that recognizes that they are not inconsistent with each other when they restrict their scope and energies to what each school does best. Religion could tell us where to look, and science could determine how the process occurred. Science should focus on the physical realm of cause, effect, and solution. The scientific values of truth, objectivity, dissent, independence, respect, and supranationality could solve many of our most pressing medical problems. Religion should focus on the non-physical realm of universal meaning, personal morals, interpersonal relationships, and societal value, which often break down in periods of traumatic change.

In such a complex unknowable world of the infinitely large and the infinitely small, perhaps there is a role for art to help with nature's 'unconcealment,' as Heidegger would state it (Heidegger, *Origin of Art* 649-701). Aristotle also reminded us that art finishes the job when nature leaves something undone. In essence, he states that there is a place for both non-rational approaches and rational ones. This is an important lesson for a culture that depends heavily upon science and technology. In times of severe crisis, humanity needs the fusion of science to nurse the body plus religion and art to minister to the spirit.[20]

Since phenomena outside of our physical realm of experience are, by definition, foreign to science and native to religion, our feeling, intuition, and connectedness can certainly assist in answering complex questions. When scientists and engineers start listening to theologians and artists, and this latter group starts, not only listening, but also

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[19] Heidegger talks of man's interconnectedness with Being. Humans need Being and Being needs humans. Being's potential is achieved through human activities and human activities are pushed forward by the insightful unconcealments of Being. Heidegger seems to say that Being works through people to recreate divinity. For after all, wasn't Heidegger's Being another way to characterize the creative force of God?

[20] This is not a 21st-century concept. The 12th-century masters of the School of Chartres asserted that the laws of nature were worthy subjects of investigation by the human mind, since both are encompassed within the divine universe and its design (Goldstein 69-70). In the 13th century, Thomas Aquinas gave a sound philosophical argument that scientific rationalism and empiricism are perfectly compatible with mystic and religious concepts of the world, as long as rationalism remains aware of its metaphysical limitations (Goldstein 70).

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understanding and practicing science and technology, we may be on our way to resolving these ultimate questions in a more holistic fashion.

God is behind all things, but all things conceal God.
-- Victor Hugo

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End Notes

[i] **Can Science Really Determine Truth?**

Discovering truth is a core human passion that is also fundamental to the tangible processes of scientific inquiry. Perhaps, because we know so few things with certainty, we value the search for truth. Much of the modern scientific method owes its approach to the mimetic assumptions of Socrates and Plato, and to the substantial refinements to Plato's metaphysics by Aristotle. As such, Aristotle's metaphysics defined a valid approach to seeking knowledge and his poetics defined metrics by which the scientific community still determines truth. However, truth in science is transitory. Scientific truth evolves based upon new knowledge and an internal competition among ideas within the scientific community. By examining the structure of scientific change, one notices parallels with the evolution of aesthetic theories, each of which are products of their particular time, culture, and worldview. It is also clear that, within the scientific community, classical aesthetics frame the goals and provide the philosophical outlook that guides the search.

Plato, relaying the point of view of his teacher, Socrates, in his *Dialogues*, affirmed the belief that real knowledge was unobtainable. It depended on an absolute definition, which was inaccessible (Stone 39). To Plato absolute truth was unattainable because he believed that what we see around us is merely an image. Using an allegorical style, Plato argued that reality was to be found in 'ideas' or perfect 'forms,' not in the world of 'appearances' (Adams 11). He believed that there was another world of ideas and truth around us that we could not directly touch with our human senses.

Likewise, the late astronomer and Cornel professor Carl Sagan (1934-1996) pointed out that our modern scientific method of inquiry is also based upon our senses. Since we inhabit physical space and time, phenomena outside this realm, things of the microscopic world of the interior of atoms or the macroscopic world of the universe, are beyond our physical senses. Although, one may use electron microscopes to probe the atom or radio telescopes to study the universe, we cannot escape the fact that these are merely devices that transform signals into the forms that our senses can recognize (Sagan, **Cosmic** 15-16). K.C. Cole notes that, "…truth can be highly counterintuitive and sense is hardly common" (Cole 6). She explains that there is great difficulty in getting true information from what we call the 'real world,' since we only glimpse that world through patterns or signals that are created, at least in part, outside ourselves (Cole 39). Also, Cole notes that scientists can only measure those things that are known or suspected to actually be there (Cole 48). We also miss a great deal because we perceive only things on our own scale and the sheer complexity of nature, where every part influences every other part, creating a tight weave of causes and consequences are much too knotted to untangle (Cole 58, 77). In addition, signals make sense only in context. In a different context, the same message can have no meaning at all. Cole explains that if one sends someone a message in code, but they have no way to decode it, one's message has no more information than total nonsense (Cole 86). Therefore, if one understands human limitations, one will be forced to understand the limitations of science and why science alone cannot capture the breathtaking enormity of the world outside human senses. Plato was correct -- Humans cannot know all things.

However, Plato separated form and content in a way that allowed the power of reason, logic, and allegory to get one closer to the truth. Plato's mimetic philosophy of natural order holds that the ability to attain true knowledge is accomplished through a difficult path of acquisition -- a journey

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within the mind (Adams 11). Therefore, getting closer to the truth in the real world requires dealing with probabilities, natural variations, and perfect blocks of logical propositions. As Cole suggests, "You see something and then try everything you can think of to make it go away; you turn it upside down and inside out, and push on it from every possible angle. If it's still there, maybe you've got something" (Cole 96). Likewise, the Marquis de Laplace noted that, "… nearly all our knowledge is problematical; and in the small number of things we know with certainty, even in the mathematical sciences themselves, the principle means for ascertaining truth – induction and analogy – are based on probabilities" (Cole 147). Platonic logical truth and unambiguous conclusions are found by following clear rules of deduction. Truth, in this sense, is relative to the seeker's level of knowledge. We experience this today when science makes a discovery, it seems to only peel off layers of a never-ending "ever juicier mystery," as Frank Oppenheimer called it (Cole 49). Regardless, to Plato, truth emerged through the power of reason and we observe truth as making sense. As such, the scientific community came to understand that the physical realm of nature is real, orderly, and, in part, understandable, or as Max Planck stated, "That is real which can be measured" (Heidegger, **Technology** 169).

However, to what extent can one actually know nature? Aristotle believed that the truth was in the material and he searched for the universals that lead one to truth. Mathematics also offers powerful ways to get closer to the truth. Carl Sagan eloquently expressed our potential and limitations as he compared our physical realm to the world of a grain of salt. Since there are more atoms in salt than connections in our brains, we can never expect to know everything with certainty in the microscopic world of a grain of salt. Just as unknowable are phenomena on the cosmic scale of the universe (Sagan, **Broca** 15-16). However, if we use the empirical approach and seek out regularities and principles, we can understand both the grain of salt and the universe through extrapolation. Cole suggests that, "The fact that patterns repeat allows us to formulate laws of nature – really, recipes encoded in equations that describe relationships that repeat over and over again" (Cole 72). She concludes that math helps scientists articulate, manipulate, and discover reality (Cole 7). We may never understand everything, but one can get some pretty good indications that allow rational conclusions to be drawn.

Therefore, science is usually considered by Western society as one of the highest forms of mental activity -- one with truth as its goal. Heidegger notes that, '…science, as a theory of the real, …stakes everything on grasping the real purely. It does not encroach upon the real in order to change it. Pure science, we proclaim, is disinterested" (Heidegger**, Technology** 167). In an absolute sense, truth and neutrality in science are limited to the facts of nature that are there for observation via our senses. In a less absolute sense, truth in science is limited to that which is directly observed and sensed by the observer. Even here any expression of absolute truthfulness is limited by the time and space relationships between the observer and that which is being observed, and also by the restrictions inherent in the use of language to express the observation. Anything beyond this is, in effect, a *belief* rather than absolute, true knowledge. In brief, it is impossible to separate fact in nature from one's own interpretation of it (Fischer 5-7).

Today, it is clear that the biases, interpretations, and economic interests reinforce the non-neutrality of science and technology. Just as technology is driven by desires and goals, science is clouded by biases and economic imperatives. In a society where one's livelihood via either corporate employment, government grants, or academic research publication requirements is literally what feeds scientists and their families, what institutional support is needed so scientists will be more apt to

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make ethical decisions and be rewarded rather than punished for whistle-blowing? Whistle blowers, such as David Parnas, who saw the inherent danger in the objective of the Strategic Defense Initiative (SDI), seemed constantly challenged by peers who went along with the doomed SDI research, as part of the funding game, even though they knew the system could not work. Rationalizations, such as the government is going to spend the money anyway, we can use the funding to advance the state of computer science, and we can redefine the problem, seemed to be the norm (Parnas 46-52). When institutions and the scientists are bound to make decisions based on personal economics, what can institutions or professional societies do to eliminate this conflict of interest between business objectives and scientific integrity?

The fluid nature of scientific theories, the internally policed dogma of a paradigmatic worldview, and the inherent subjectivity of scientific assessments only serve to weaken the idealized arguments of neutral scientists. Of much more damage, however, is the recent series of revelations of 'junk science' and deliberate fakery within the scientific community. The public has heard or read stories about scientists, even those at prestigious institutions, such as the Lawrence Berkeley Laboratory, who abrogate their professional responsibilities to repeat tests, analyze and validate raw data, and hold their colleagues responsible based on scientific skepticism (Johnson 1-6). There seems to be too much delegation to a narrow set of experts. There is too much polite acceptance of prestigious colleagues' claims without the required skepticism. There seems to definitely be too much of a culture of 'publish first' based on limited data and assume that repeated experiments will prove our projected case true. All of these developments seem to go against the stated tradition of scientific skepticism.

Since the traditional scientific approach developed at a time when wealthy scientists pursued knowledge without so many direct links to commercial institutions and they practiced in a world where instantaneous communications were unavailable, slowing down the rush to profit and rush to publish, is it not reasonable to ask the scientific community to re-evaluate its methods and ethics in light of the new cultural and business realities? Since so many scientists are beholden to commercial or other funding interests and since they have created an almost real-time communicative culture of deference to experts, should the scientific method developed over the past 400 years be revisited in light of the harsh realities of modern society?

In an era when scientific research can be used for both good or evil, as shown by biological research for cures that could also be helpful to bio-terrorists, has the assumption of the neutrality of facts outlived it's usefulness? As science (knowledge) and technology (applications) are increasingly intertwined, must we consider banning certain research, not just restricting the publication of the research? And, if so, who decides? Arguments can be made for continuing the Australian research in mouse pox and genome sequencing of viruses based on convincing agricultural and medical benefits that are possible derivatives of the research (Pollack). Equally strong arguments can be made as to how publication of this research enables terrorists or rogue states to more quickly develop weapons of mass destruction (Pollack). Does this situation help society understand that a certain threshold must exist beyond which it is unsafe to venture in the name of pure research? If we restrict knowledge, what makes us think that others won't eventually make similar discoveries? Is full disclosure safer than restrictions? Does the approach to nuclear weapons limitations provide any guidance to those in biotech? How does one stop Frankenstein?

[ii] **Additional Comments on the Status of Engineers vs. Scientists**

The practice of technology is frequently seen as an art or craft, as distinguished from science, which is seen as precise and based upon established theoretical considerations. As such, scientists also have held certain elitist views and have separated their intellectual pursuits from the 'crass implementation' world of engineers and technicians. As C.P. Snow observed,

> "Pure scientists have by and large been dim-witted about engineers and applied science. They wouldn't recognise that many of the problems were as intellectually exacting as pure problems, and that many of the solutions were as satisfying and beautiful. Their instinct – perhaps sharpened in this country [Britain] by the passion to find a new snobbism wherever possible and to invent one if it doesn't exist – was to take for granted that applied science was an occupation for second-rate minds" (Snow 32).

As Ortega observed, "Poets, philosophers, politicians, founders of religions, discoverers of new values…the engineer is dependent on them all. Which explains why they rank higher than he, a difference which has always existed and against which it would be in vain to protest. Technical achievements are more or less anonymous or, at least, that the glory which generally falls to great men of the former types is rarely enjoyed by technical inventors. Who outside the ranks of professional engineers remembers offhand the illustrious names of its inventors? The engineer cannot take the helm, he cannot rule. His role is magnificent, highly admirable, but irremediably secondary" (Ortega 121-122).

"The artisan's position within the technoeconomic machine is a subordinate one," notes Leroi-Gourhan (Leroi-Gourhan 176). Civilization depends on the artisan, but they rarely get the respect and accolades of the warrior, nobility, or statesman. "Even though the divinization of inventions has led to a veritable cult of technology, the soldier-astronaut who travels in a rocket is perceived as a hero but the engineer who designs one merely as a servant of science – a hand" (Leroi-Gourhan 172). Society has traditionally discriminated against the skillful hand in favor of meditative thought. According to Leroi-Gourhan, "technical activity comes lower down than language and working with the most tangible elements of reality lower down than symbols" (Leroi-Gourhan 172). It is ironic, however, that "symbolic functions enjoy preeminence over technology, although it is the latter that is the driving force behind all progress" (Leroi-Gourhan 184).

Snow attributes "the only qualitative changes in social living that men have ever known" to the "agricultural and the industrial-scientific" revolutions, and the technological advances that enabled them. "For, of course, one truth is straightforward. Industrialisation is the only hope of the poor" (Snow 22-23).

[iii] **Additional Historical Perspectives of the Development of Science and Technology**

BBC reporter and author of **Connections**, James Burke, presented a good summary of the ways in which the popular culture assumes that technologists experience the effects of economics and human values. Burke designates six major initiators of technical innovation. They are: deliberate invention, accidents, spin-offs, war, religion, and the environment.

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First, as one might expect, technical innovation occurs as a result of deliberate attempts to develop it. When inventors like Lewis Howard Latimer and Thomas Edison began work on the incandescent bulb, it was done in response to the inadequacy of the arc light. All the means were available: a vacuum pump to evacuate the bulb, electric current, the filament which the arc light used, and carbon for the filament. With these components the remainder of the required work was the synthesis of technologies toward a definite goal --the light bulb's creation.

A second factor that frequently occurs is that an attempt to find one thing leads to the discovery of another. For example, William Perkin, searching for an artificial form of quinine, used some of the molecular combinations available in coal tar and accidentally found that the black sludge produced by one of his experiments turned out to be the first artificial aniline dye.

Unrelated developments have decisive effects on the primary event. An example of such spin-off developments can be seen by the development of paper. The medieval textile revolution, which was based upon the use of the spinning wheel and the horizontal loom, lowered the price of linen to the point where enough of it became available in rag form to revolutionize the paper industry. Burke discusses other examples of how unforeseen circumstances play a leading role in technical innovation. This includes the stimulation of mining activities for metals to make cannons when Chinese gunpowder was exported to Europe and the development of a barometer as a result of frequent flooding of mines and the failure of pumps.

The fourth and fifth factors are all too familiar: war and religion. The need to find more effective means of defense (or offense) has driven technology from the most ancient of times. The use of the cannon led to defensive architectural developments that made use of astronomical instruments. Ancient Mesopotamian, Egyptian, and Mesoamerican religious beliefs led to great strides in engineering and architecture and the Islamic world fostered advanced astronomy because of the need to pray, feast and fast at specific times.

Finally, physical and climatic conditions play important roles. For example, the extreme changes in Europe's winters in the 12th and 13th centuries provided urgent need for more efficient heating. The chimney filled the need and had a profound effect on the cultural life of that continent.

While Burke's summary provides a layperson with an intriguing examination of the milestones of technology development and the paths chosen, by various societies, perhaps it is more instructive to look closer at the historical linkages between social values and cultural development as drivers of technology and science.

Abstract thinking, our precursor to science, rose from the Mesopotamian practicalities of applied engineering and mathematical astronomy, plus a bit of divination as the bridge to abstract thinking. The remarkably accurate astronomical data, accumulated over many centuries without the telescope or any form of chronometer, is a lasting memorial to the capabilities of the Mesopotamians (Derry 13). They had tables that determined the first and last visibility and the beginning and end of retrograde motion of the planets Venus, Mercury, Saturn, Jupiter, and Mars (Saggs, **Civilization** 239). They determined the exact times and positions of the new moon and full moon. H.W.F. Saggs, notes that, "The Babylonians concerned were employing a sophisticated mathematical astronomy relating planetary and lunar motion which was not surpassed until the coming of Copernicus" (Saggs, **Civilization** 239). Even the skeptical McClellan and Dorn give them credit for using systematic research to solve specific problems in astronomy, such as whether the month has 29 or 30 days, and cite this as theoretical, "…insofar as more attention was paid to the abstract models of mathematical cycles than to what was visibly going on in the heavens" (McClellan 52-53).

Since the rulers of Mesopotamia considered themselves to be agents of the gods whose duties therefore included performance of rituals and ceremonies to ward off evil and gain the good graces of the gods, by the 2nd Millennium BC, the kings commanded that omens correlated to celestial phenomena be observed and recorded (Roaf 74). By the 1st Millennium, the "science" of astrology became very important. Continuous observations date from 747 BC. Signs of the zodiac were named and by 500 BC the Babylonians could predict the movements of the moon and the occurrence of eclipses, solstices, equinoxes, and the cycles of the sun and the moon. They could also predict the movement of heavenly bodies indefinitely into the future (McClellan 52). From 410 BC to 75 AD, horoscopes and almanacs predicting the positions of the sun, moon, planets, and stars were compiled (Roaf 124). According to Roaf, "…the practice of first recording observations and then applying accepted theories in order to predict the outcome is the basis of modern scientific method" (Roaf 124).

Ancient Egypt also provides an early example of how a society's worldview drives engineering and the development of science. While modern philosophers continue to debate whether technology shapes society or whether society shapes technology, the development of engineering and the science over 5,000 years ago in ancient Egypt vividly demonstrates the extent to which technology can have practical social and religious bases. Unlike the Greeks, who later benefited from the advances of Egyptian and Mesopotamian scholars and who developed an abstract theory of knowledge, the Egyptians used knowledge for the practical accomplishment of goals tied to their religious worldview (Assmann). An examination of Egyptian engineering and science, principally during the Old Kingdom (c. 2670-2150 BC) and Middle Kingdom (c. 2040-1650 BC), shows that religion drove the development of, and was reflected by, their monumental architecture. These architectural wonders served as a societal organizing principle and demonstrated the power of the state, which was believed to be run by either an incarnate god on earth or the son of a heavenly god (Morenz). In addition, the supporting sciences, such as mathematics, astronomy, geography, and medicine all had practical purposes in support of the Egyptian religious worldview (Nunn). One also finds that the most accomplished practitioners of engineering and science were accorded high status as priests and established a role model for later cult heroes.

As ancient Egypt shows us, the technology of monumental construction, calculation, record keeping, and organization, and especially what society does with these techniques, is a matter of cultural values and societal choice (Edwards). In the Egyptians' case, the cultural values centered on religion and the societal choice was one of maintaining an idealized world (Redford). Traditionally, technology as a trial-and-error art is thought to have developed separately from science as an abstract discipline throughout most of recorded history. As seen in Egypt, the practical techniques of arithmetic can be used for organizing labor and trade, geometry can be used for construction, and astronomical observation can be used to produce calendars and the determination of ideal planting cycles (Hornung). In this sense, it can be sometimes viewed as *applied science*. Yet, from the ancient Egyptians until modern times, much of *technique* continues to be developed with little or no basic scientific knowledge. As McClellan and Dorn cite, "…in many instances technology directed the development of science, rather than the other way around" (McClellan 2). One can certainly see the links in the case of Egypt, where accounting techniques led to a mathematical system, which when combined with the observational impetus provided by religion, led to documentation of general rules that were precursors to engineering as a profession.

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The roots of Western scientific inquiry can be traced back to the classical philosophies of the Greeks. The Ionian Greeks had an earthy tradition that stressed the enjoyment of life, commercial property, aesthetic refinement, and acceptance of newcomers. This allowed free thought and inquiry to flourish. Pre-Socratic Ionian Greek natural philosophers established nature as a valid subject of inquiry. From its earliest manifestations, the Greek mind had turned to natural philosophy, which was indistinguishable from Greek science. Led by Thales of Miletus, the Greeks saw the formation of the earth by natural processes, no longer through an act of the gods. "The Ionians conceived of nature as a completely self motivating entity," according to science historian, Thomas Goldstein. The workings of the universe occurred as mere extensions of the primordial chaos, automatic functions of its basic elements. Matter possessed its own evolutionary quality. 'Order' and 'law' were mere concepts superimposed by the human mind on the autonomous processes of nature (Goldestein 52). Ionian Greek philosophy and its classical definitions of truth and beauty, exemplified by the Socratic logic of Plato, and the later Hellenic-era metaphysics of Aristotle, laid the foundation for rational scientific inquiry.

It is clear that the development and evolution of advanced mathematics by the priestly classes and the practical applications by the scribes of Mesopotamia and Egypt existed long before the Greeks and has had a considerable influence on a number of societies, including our own. As Hogben notes, "There is no doubt that the raw materials of Greek mathematics were imports." He also cites the influence of the Phoenicians of the Levant on the Greek colony of Miletus, on the father of Greek geometry -- Thales of Miletus (640-546 BC) -- and their influence on the travels of Pythagoras in Egypt and Mesopotamia (Hogben 60-61). One might also surmise that Alexander's conquests of Persia and India provided ample opportunity for his teacher, Aristotle, to 'borrow' the works of Babylonian, Persian, and Indian scholars to further expand and refine Greek philosophy into a rigorous scientific method. So, the Greeks did not monopolize abstract thinking; but they certainly refined it.

By the untimely death of Alexander the Great, the Egypt of the Ptolemies, who themselves ruled as Egyptian Pharaohs of Greek origin, ushered in a Hellenistic age (330 BC – 350 CE) of great technological and scientific activity. With Alexandria as its capital, the Ptolemies were distinguished for city planning, good water supplies, drainage systems, fine government buildings, increasingly comfortable and luxurious houses, labor-saving inventions, and important advances in mathematics, astronomy, and medicine. At Alexandria, a great library brought together all the learning of the known world and its museum functioned as a university. Although Alexander destroyed the military power of Egypt and the Near Eastern empires, the imprint of the older civilizations allowed religion and its associated worldview, as one of the great indigenous forces, to continue to travel from east to west (Derry 16).

As such, Plato's intellectual exercises were an outgrowth of the Greek wealth and their spirit of open questioning. Much of the scientific method owes its approach to the mimetic assumptions of Socrates and Plato, and to the substantial refinements to Plato's metaphysics by Aristotle. Through his words and actions, Plato, via his alter ego Socrates, demonstrated key concepts critical to the future process and ethics of scientific collaboration. Among them include a belief that there is an absolute truth that can be revealed through logical philosophy. He also used binary yes/no logic via cross-examination of hypotheses that sought to disprove falsehoods, and, by a process of elimination, allow one to move closer to the truth. In addition, in a manner that would be important to future holistic approaches to knowledge, Socrates held a conviction that the process of logical inquiry can explain nature in a way that is not necessarily inconsistent with religion.

Just as in modern times, scientific truth evolves based upon new knowledge and an internal competition among ideas within the scientific community. As such the Socratic and Platonic philosophies ultimately gave way to the refinements of Aristotle. Aristotle, the son of a physician and Plato's pupil of twenty years, took his master's basic philosophy, added more structure and advocated verification of intuitive natural laws with objective observation (Loomis vii-xiii). Loomis noted that he reasoned like Plato, from ideal abstract principles, whenever the subject of the reasoning lay outside his field of observation. Both a great thinker and a great scientist, Aristotle set the tone for future scientists by his method of inquiry and an avowed determination to yield to observation as the final arbiter. As a result, an atmosphere of sober empiricism distinguished the Hellenic Greeks from the Ionians, with Aristotle being credited as a great dividing line in Greek philosophical history. Aristotle's pupils and their successors carried on his teachings at the Lyceum for over 800 years, until, like Plato's Academy, it was closed by order of a Christian emperor in Constantinople (Loomis X).

The classic Roman civilization built upon Greek science to develop their mighty empire with its renowned technical prowess. The Romans, being driven by conquest, glory, commerce, and an increasing need to find new resources never really flowered as scientists. Free thought was not the hallmark of Rome. The Roman way of doing things was impressed upon its citizens and conquered states as a matter of standard procedure. The Romans did, however, undertake massive engineering feats such as extended roads, aqueducts and highly structured cities (DeCamp 172-280). Here technology flourished but no new ideas of philosophical importance stand out. Great translators of other works, the Romans were exploiters of resources and fantastic implementers of technology.

This dominance of Greek philosophy and Mesopotamian-Egyptian-Roman technology in the Western psyche should not cause one to overlook the important technologically developed societies of the east. Like the river-based agricultural societies in Mesopotamia and Egypt, the Indian and Chinese societies developed a bureaucratically practical system of applied mathematics. By the first unified empire under Chadragupta Maurya (321-291 BC) and his grandson, Asoka (272-232 BC), the elaborate Indian bureaucratic structure made use of mathematical recipes for practical concerns. Significantly, however, the Indian system developed into one that used nine Arabic numerals plus a zero. The Indians were keen mathematical astronomers and were adept at measurement, algebra, trigonometry, negative numbers, irrational numbers, and the calculation of pi to four decimal places (McClellan 141-146). Examination of Chinese symbolic numerals indicated unique symbols for 1 through 10 and further symbols for powers of 10 (e.g., 100, 1000, …) that seem very similar to our modern Arabic numeral system (McClellan 130). They had a decimal place-value system by the 4th century BC, knew the Pythagorean Theorem by the 3rd century BC, and they used counting rods and the abacus to facilitate arithmetic operations by the 2nd century BC. The Chinese mastered large numbers using a base-10 system, handled squares, cubes, and, like the Babylonians, solved problems by what we today would call quadratic equations. Though by the early current era's seemingly playful exploration of numbers by Zu Chougzhi (429-500 AD), who calculated pi to seven decimal places, Chinese problem texts principally dealt with practical measurements of agricultural fields, cereal exchange rates, construction, and distribution problems (McClellan 130-131).

As Rome crumbled under the weight of countless invasions, the cosmic vision of the Greeks and the technological achievements of the Romans shriveled. With Europe over-run by the Germanic tribes, scientific inquiry was stunted for a millennium. Europe slept in a stupor of ignorance for one thousand years. "To those who lived through the catastrophe, it seemed that the utter breakdown of civilization had come, the ruin of everything humanity had ever tried to create over thousands of years, a verdict from a wrathful heaven," according to Goldstein (Goldstein 55). Europe reacted with a radical readjustment of mind, turning their backs on the world of the senses, which now seemed unworthy of intellectual scrutiny. The end of Roman civilization meant a steadfast attachment by Europeans to the dogma of Christianity. To Europeans it offered the only hope left.

By the late Medieval or early Renaissance period, science and technology experienced a European re-awakening. Leonardo da Vinci was able to develop and apply his genius due to the largesse of his wealthy patrons, who also gave him time to observe and think. Like many of his predecessors, Leonardo spent a period in the mechanistic world of the large workshops (Van Os 244). Unlike the average guild artisan, Leonardo's patron was the Duke of Milan, Ludovicio Moro. The newly enlightened, urban, nouveau riche became important patrons of artists and artisans. The Church also became a powerful patron of the arts. Notably, Leonardo's *Last Supper* was painted for the monastery of Santa Maria delle Grazie (Murray 238). With patrons that allowed this kind of creative freedom and tolerated the extensive time associated with a visionary process, Leonardo moved beyond mere craft to high art (White 309-310). It is only in this enlightened work environment that superior observation skills and a scientific understanding of nature allowed the artisan to emerge as a creative genius.

The Renaissance courts of Italy, private solons, and informal associations of amateurs provided a new social support system for scientists. They also provided a flexibility of research and a seat of change not found in the static university system. They legitimized and defined the role of science and scientists in the 17th century. The patronage system provided financial support, but the patrons also gained influence and enhanced reputations from the scientists they supported (McClellan 226-227). For example, after his publication of *Starry Messenger* (*Sidereus nuncios*), Galileo parleyed his new fame into a move from the University of Padua to a much more prestigious and well-paid position as Chief Mathematician and Philosopher at the Medici court in Florence (McClellan 225). Later, he also became a member of the *Academia dei Lincei* (*Academy of the Lynx-Eyed*), patronized by the Roman aristocrat Federico Cesi. According to McClellan and Dorn, Galileo fashioned himself into a scientific courtier, in competition with the established professors at the university.

Three hundred years later, Albert Einstein's accomplishments arose from an age of intense investigation of nuclear physics. While he is often portrayed as the solitary genius or singularly-focused discoverer of nature's greatest secrets, Einstein's work stood on a solid foundation laid by his predecessors and contemporaries. According to Bernard Cohen, "Einstein himself argued that his intellectual creation should be considered as a part of an evolutionary rather than a revolutionary development in physics" (Cohen 435). For example, in 1887, the American physicist Albert Michelson (1852-1931) failed to detect the motion of the earth relative to the then-supposed stationary ether. The null result of which would eventually be predicted by Einstein's relativity theory. In Germany in 1895, Wilhelm Roentgen (1845-1923) discovered X-rays, a new type of radiation that extended the range of electromagnetic radiation beyond convention theories. J.J. Thomson (1856-1940) demonstrated the particulate nature of cathode rays in 1897. Antoine-Henri Bacquerel (1852-1908) accidentally discovered that uranium ore clouded unexposed photographic plates in 1898. Marie Curie (1867-1934) discovered that heavy elements emitted different types of radiation, including electrons, gamma rays, and alpha rays. In addition, Max Planck (1858-1947) suggested that light or radiation travels in discrete energy packets or quanta and did not exist according to the energy continuum of classical physics. In the early 20th Century, Ernest Rutherford (1871-1937) and Nils Bohr (1885-1962) proposed a model of the atom, which was mostly empty space, that had electrons orbiting a solid nucleus, in the manner that the planets orbit the sun (McClellan 344-347).

This was the world in which the young Einstein inherited. Einstein himself credited Michael Faraday (1791-1867), of whom he kept a portrait of on the wall of his study, with setting the stage for the grand revision of physics that made Einstein's work possible (Boorstin 679-684). After Faraday, the world would no longer be one of Newtonian forces, but one of pervasive fields of force. According to McClellan and Dorn, "Einstein was perfectly positioned to effect a revolution in contemporary physics: he was well educated technically in the central dogmas of the field, yet he was young enough and professionally marginal enough as an outsider not to be locked into established beliefs" (McClellan 345). So, Einstein did not invent the concepts of mass, energy, light, and acceleration, rather, he combined these concepts in a novel way. He looked at the same world as the other physicists, but he saw something quite different (Michkalko 128).

[iv] **The Role of Technologists Influencing Social Change**

Engineers and scientists are becoming more active in the cultural evolution and political decision-making processes of modern society, and one might arguer that they have done so for millennia. Though kings, queens, diplomats, theologians, lawyers, and financiers may have played a more visible role in the affairs of the day, a look behind the scenes shows the clear influence of scientists and engineers, even when they were in service of the former group.

Twenty years ago, the President of the American Association for the Advancement of Science, Anna Harrison, saw a role for scientists as educators of the public and as consultants to special interest groups. In a fashion similar to Bronowski's argument, Harrison stressed the importance of scientists coming out of their labs to participate in the decision-making processes of technical innovation by helping the public decide on socially appropriate courses of action.

Likewise, in 1984, Joel Yellin, then Senior Research Scientist at the Massachusetts Institute of Technology, proposed a system of expert advisors who would help create a deeper emphasis on the principle of public participation in technological decisions. Yellin saw the growing use of experts in government agencies and the delegation of public responsibility to these agency experts as being a serious threat to representative government. In an argument similar to his contemporary, Anna Harrison, Yellin conceded that administrators of agencies such as the Environmental Protection Agency (EPA) have far broader responsibilities than initially envisioned by politicians. They are called upon to assure worker health and safety, to protect and improve air and water quality, and to guarantee the safety of complex engineering systems. They also must predict the long-term consequences of major industrial and government decisions which, increasingly involve technological innovation that results in social changes which surpass the capacity of the general public to absorb these changes, not to mention understand all aspects of the technology (Yellin 126). With Yellin, we saw yet another argument for responsible scientists participating in technical decisions rather than merely allowing the stated neutrality of science to cause an abandonment of this responsibility to professional bureaucrats.

Given the position of Einstein as a public intellectual and acknowledged 'genius' of modern physics, Einstein was able to impact the world through advocacy of a critical public policy, which led to the development by the U.S. of the atomic bomb. Einstein's historic letter to President Franklin

Roosevelt in 1939 warned of the possibility that Germany, already at war in Europe, might develop an atomic bomb. Roosevelt authorized a small exploratory project that grew into the largest research and development initiative in history – the Manhattan Project, which involved 43,000 people working in 37 installations, at a cost of over $2.2 billion (McClellan 360-361). The era of 'technology as applied science' and government-sponsored 'Big Science' was underway.

Technologists have been influencing western society prior to the Enlightenment, back to the Renaissance of the 17th Century, and even into ancient times. The European Scientific Revolution of the 16th and 17th centuries began with Nicolaus Copernicus who overthrew the geocentric view of Ptolemy and The Bible that had been accepted for over a thousand years. After Copernicus, the earth was no longer the center of the universe but merely one of the many planets that circled a minor star in an insignificant galaxy. Radical in its impact, this view of the world robbed humans of their proud position in the center of God's creation. Without dogmatic theological constraints, other scientists such as Johannes Kepler who is credited with the laws of planetary motion, Galileo Galilei the re-discoverer of many of the principles of gravitation and the invention of the telescope, and sir Isaac Newton who combined much of his previous work into the laws of motion each contributed to the Renaissance's spirit of inquiry.

To scientists, Galileo was the foremost leader in advancing experimental science. He impacted the world of science by enabling the understanding of telescopic astronomy, the principles of motion, the mode of relating mathematics to experience, and the science of experimentation. He uncovered laws associated with vector velocities, trajectories of projectiles, inertia, free fall, the gravity of an object on inclined plane, and transformed individual visual experiences into intellectual conclusions (Cohen 135-141). Sir Isaac Newton hailed Galileo as the primary founder of his own rational dynamics and it would take another 50 years after Galileo for Newton's revolution to achieve the potential inherited from Galileo (Cohen 144-145). However, to the non-scientist, Galileo's impact on the societal understanding of humanity's place in the universe is paramount.

Galileo was involved in a dispute in 1613 at the dinner table of the Medicis over the religious implications of Copernicanism and the role of science in support of religion. In *his Letter to the Grand Duchess Christina Concerning the Use of Biblical Quotations in Matters of Science* (1615), Galileo took the position that faith and reason cannot be in contradiction since the Bible is the word of God and nature is the work of God. Galileo could not ignore the facts of observation, but sought to rationalize them with God's plan. However, in instances where there appears to be a contradiction, science supercedes theology in questions concerning nature. As he put it, "the Bible was written to be understood by the common people and can readily be reinterpreted, but nature possesses a reality that cannot be altered." For Galileo, as McClellan and Dorn explain, if scientists demonstrate some truth of nature that seems to contradict statements found in the Bible, theologians must then articulate reinterpretations of the literal sense of Holy Writ (McClellan 228). "Galileo's postulate that science and human study of nature should take priority over traditional theology represents a radical step, much removed from the medieval role of science as handmaiden to theology" (McClellan 228). Centuries later, Albert Einstein would write an introduction to Stillman Drake's translation of Galileo's Dialogue (1953). In it he lauded Galileo's 'leitmotif' or passionate fight against authoritarian dogma and his acceptance of 'experience and careful reflection' as the only 'criteria for truth' (Cohen 439). Galileo was not fully rehabilitated by the Church until the 1990s (McClellan 242).

Oddly, Leonardo da Vinci was perhaps the world's first documented creative genius, however, "He had hardly any influence at all on the science and engineering of his time," notes L. Sprague

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DeCamp (DeCamp 396). "But, of all these gadgets, only a few – the canal lock, and perhaps the screw-cutting machine and the turret windmill – were actually reduced to practice. Sometimes the idea was not workable," says DeCamp. For example, Leonardo's flying machines relied on human muscle, the mass of which was shown by Borelli in 1680 to be no where near the proportion to weight needed to fly like birds. His battle cars were too heavy for the human-powered cranks to operate them. (DeCamp 402). While Leonardo's ideas drew upon extensions of his observation of the natural world, he did not have the formal intellectual training in physical sciences or mathematics to allow his sketches to become real. While his career as an engineer is debatable, his impact on art is unmistakable. Leonardo's career shows how painters influenced by the scientific methods of the High Renaissance gave art greater realism, action, and emotion. In the process, the painter was elevated from a cog in the mechanistic wheel of workshop production to one of creative genius, free to portray realistic scenes as the mind's eye saw it (Frere 10-27).

In Ancient Egypt, one also finds that the most accomplished practitioners of engineering and science were accorded high status as priests and established a role model for later cult heroes. One such person was Imhotep. Other than kings, he is the earliest historical personage supported by tangible proof of his existence. We know of Imhotep through the discovery in 1926 of his name and titles on the base of a statue of King Djoser who reigned at the beginning of Dynasty III (c. 2654-2635 BC). His name recurs on temples, in books, and through the Greek translations of writings that refer to him. One Greek translation notes, "The entire Greek language will relate thy tale and every Greek will worship Imouthes [Imhotep], son of Ptah" (Morenz 250). Also, the St. Petersburg Pushkin Museum has a votive statuette of Imhotep among it collection (Strouhal 245). In addition, we know of amulets from Dynasty XXVI that commemorate Imhotep's deification (Redford 16).

Tradition revered Imhotep as a great architect, physician, royal scribe, and sage. Imhotep achieved such great importance that in later years he was revered as the 'patron saint' of scribes (Hornung 16). As his name implies – 'He who cometh in peace' -- Imhotep was the author of the earliest work of wisdom literature, what one might think of as works on ethics, or 'instructions in wisdom' and 'directives for life' (Morenz 111). The advice given by the senior officials who wrote the surviving five complete and seven partial texts was meant to ensure personal success in concert with the needs of the state and the norms of ancient Egyptian society. These treatises cover truth-telling, fair dealing, rules for a well-ordered life, justice, wisdom, obedience, restraint, and humanity. They generally took the form of verses addressed by a father to his son or a king to an heir. These books were used as teaching texts in the schools for scribes and, at least in the cases of Imhotep and Prince Hordjedef, the authors of these ancient works were held in such high esteem that they were deified (Strouhal 31). Among his titles were those of High Priest of Heliopolis, Chief of the Observers, and Grand Vizier. As a vizier (tjaty), to whom the king would delegate his own priestly functions to officials, Imhotep would have been responsible for management of the state-run economy, administrative functions of the state, and the judicial system. Dating back to the Dynasty II, the Vizierate alone was responsible to the king for proper order in the land (Hornung 21). Imhotep was also the royal chamberlain and court physician to Djoser and in later years he was worshiped as a god of healing (Nunn 10). Sir William Osler refers to Imhotep as, "…the first figure of a physician to stand out clearly from the mists of antiquity" (Jackson 13). He was worshiped as a medical demi-god from 2850 to 525 BC and as a full deity from 525 BC to 550 CE (Jackson 14). As such, the Egyptians placed him as one of only three mortals with the healing powers of the gods Amun, Thoth, Min, Horus, Isis, and Serapsis (Strouhal 251). His image graced the Temple of Imhotep, perhaps one of the first hospitals (Jackson 13). The Greeks came to identify him with their own Asclepius (Hornung 16). Asclepius was mentioned as a wise physician in Homer's Iliad and later, like Imhotep, was promoted to godhood (De Camp 23).

Imhotep is the most ancient engineer whom we know by name and inventor of the pyramid, which among the Seven Wonders of the Ancient World, only the pyramids survive to this day (De Camp 19). In addition, as head architect, Imhotep had to survey the site, calculate and decide on the type and quality of materials to be used, the quantities required, arrange for it to be hewn in the appropriate quarry, arrange for transportation of the materials to the building site, estimate the size and qualifications of the labor force, and manage junior scribes who would make arrangements for housing, feeding, and equipping the workers (Strouhal 170). The architect would also employ astronomers to lay down the north-south axis, which in the case of the Step Pyramid, was only off by three degrees (Strouhal 170).

As the greatest architect of the ancient world, Imhotep authored a book on the traditional schemes for temple construction. It was found in a temple library and was said to be the model for the Ptolemaic temple at Edfu. This temple was, "one of the best preserved monuments in antiquity," according to Morenz. The temple at Dendra, also of the Ptolemaic period, was based on this ancient tradition as well (Morenz 85). These temples refer to an adherence to Imhotep's plans in wording that is similar to Holy Scripture – 'without taking [anything] away from it or adding to it …' (Morenz 85).

When one looks at the impact of ancient engineering, one recognizes that the Egyptian pyramids were symbolic as well as literal exercises in state building (McClellan 45). The massive public expenditure entailed in the development of the pyramids was not solely for the glorification of a king, but rather for the welfare of the state, according to Erik Hornung. Since the Egyptians believed that the king's creative powers held together the very order of the world and had to be preserved even beyond death, the construction of a pyramid was a communal religious effort on the part of Old Kingdom Egyptians. These people were not 'free' in the modern sense of the word, but rather were in various ways bound to and dependent upon the king and other divine powers (Hornung 24). According to Hornung, "The clear structure, the firm order, and the tight organization of the state, which made it possible for all its energies to be concentrated on a single cultic task, found symbolic expression in the form of the pyramid" (Hornung 24).

Archaeologist Michael Hoffman of the University of Virginia observes, "The impact of contrived and monumental architecture – the ways it manipulated space and scale – certainly were linked to the social function of the royal mortuary cult itself. As Egypt consolidated from local chieftainships into regional kingdoms, into the world's first national state, it developed the royal tomb as its flag: a symbol of political integration, under god" (Hoffman 336). Not only were the pyramids symbolic, they served a practical purpose. Pyramid building, certainly in the Old and Middle Kingdoms, served as a dominant activity around which Egyptian society was organized. Egyptologist Mark Lehner of Harvard asks the question 'how the pyramids built Egypt' might be more interesting than 'how the pyramids were built' (Shaw 45). Likewise, Assmann refers to Egypt as a case of ethnogenesis. As Assmann explains, "The old Kingdom is not only the period in which pyramids are built, but also the time that was defined and indeed 'created' by the pyramids – as planning time, building time, cult time, and eternal time" (Assmann 53). It was a time when collective construction of gigantic structures caused laborers from all over the country to speak the same language in order to plan, agree, and live together (Assmann 53). In this sense, Egypt as a culture and as a nation was created.

However, one must also take a look at the role of 'public relations' and 'spin' from the ancient times. Though archaeologists can verify Imhotep's existence, and his obvious magnificent works of stone, the sheer range of expertise attributed to Imhotep may have grown as his legend became cult. The worship of Imhotep from the New Kingdom (c. 1550-1070 BC) into the Greco-Roman period resulted in him being given divine lineage, as the son of Khereduankh, his real mother, and the god Ptah (Redford 70). Not unlike the legends of medieval saints of the Catholic Church, a truly great man may have been given attributes beyond reasonable human capabilities. Because, if the legends are true, Imhotep stands as a truly unique historical multi-genius, exceeding both Aristotle, who wrote on a wide array of subjects from mathematics, to zoology, to ethics, and Leonardo da Vinci, who was both a great artist, scientist, and inventor.

Few people in the history of the world have set the standard for excellence in multiple disciplines. Hippocrates and Galen discerned the causes of disease as biological, rather than spiritual, but they did not simultaneously run the economy of an empire. Newton, Galileo, and Copernicus introduced the world to revolutionary laws of physics and astronomy, but they did not simultaneously practice medicine. Even in modern times Albert Einstein set the standard for physicists and Thomas Edison for inventors, but neither wrote wisdom literature or philosophy. Modern Nobel Laureates are renowned for their excellence in a single domain, including great works of literature, but they are not simultaneously architects of monumental stone works meant to last forever. If one is to believe the legend, none of these great personages of history mastered the scope of disciplines and the depth of expertise as Imhotep, the first 'Renaissance Man.'

One explanation for the extent of Imhotep's skill set might be the general practice in the Old Kingdom of bestowing honorific titles on members of the royal court. Some titles that began as a mark of function became marks of rank within the hierarchy. H.W.F. Saggs cites Klaus Baer's findings of some individuals having as many as 200 titles, a sign that the ancients were obsessed with considerations of rank in relation to the king (Saggs 27). When it came to rank, the most important officer of the state was the Vizier. The earliest viziers were royal princes, a relic from when the king kept all authority within his circle of kinsmen. By Dynasty V, viziers no longer had to be princes by birth, but they had to be men of considerable ability, since his task was to oversee the whole administration and be second to the king in status, and in some cases, of greater importance in practice (Saggs 28). So, Imhotep as a vizier would have been considered at the very height of power, prestige, influence, and control of Djoser's kingdom.

Another explanation may lie in the motivation of the Ptolemies. Ptolemy V Epihanes, the Greek pharaoh, in an effort to cope with a famine and the revolt of King Ergamenes of Meroe, sought to associate himself with the founder of the Memphite Dynasty – Djoser – to attain legitimacy in the eyes of the Egyptians (Grimal 64-65). This motivation to discover, cultivate, embellish if necessary, and propagate Third Dynasty heroes by the Ptolemies may also have contributed to the growth of the Imhotep legend. As Nicolas Grimal of the Sorbonne reminds us, "Imhotep the courtier is now better known than Djoser the king, and it was Imhotep, rather than Djoser, who later became the object of a popular cult. In fact, the cult of Imhotep was spread from Alexandria to Meroe (via a temple of Imhotep at Philae), and even survived pharaonic civilization itself by finding a place in Arab tradition, especially at Saqqara, where his tomb is supposed to be located. Djoser on the other hand, was not deified, and he only achieved immortality through his pyramid" (Grimal 65-66).

Yet another explanation lies in the profitability of cults. "The driving force behind these enormous cults was that they paid," according to Redford. "They were expensive to run, but they attracted worshipers and pilgrims in the thousands, in some cases from outside Egypt, as can be seen from hieroglyphic dedications on bronze votive statues." This is a pattern of religious exploitation that European Christians should be well familiar with, since the sale of relics and benefices was so common in the medieval period that Giovanni Boccaccio and Geoffrey Chaucer lampooned it in the **Decameron** and the **Canterbury Tales**, respectively.

Whatever the reasons behind his popularity -- whether it is as crass as the profit motive, a public relations move by the Ptolemies, a veneration of great leaders of the skilled architectural and engineering trades, or whether he is the impetus for wisdom in the manner that Benjamin Franklin became in 18th century America -- it is clear that the collective cultural mind of the Egyptians was so impressed by the innovative and inspiring work of Imhotep, that 5,000 years later, we still speak of him. He is an iconic symbol of the values of ancient Egypt: skill in service of the king (god), wisdom, literacy, healing, and the ability to transcend time through immortal acts of monumental creation and through legendary good works.

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