Classical Aesthetic Philosophies Frame the Scientific Search for Truth

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The inquiry of truth, which is the love-making, or wooing of it,
the knowledge of truth, which is the presence of it,
and the belief of truth, which is the enjoying of it,
is the sovereign good of human nature.

- Francis Bacon, from *Of 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. Albert Einstein noted, "As far as the laws of mathematics refer to reality, they are not certain, and as far as they are certain, they do not refer to reality" (Cole 147). 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.[1] It is also clear that, within

[1] Whether philosophical worldviews guide scientific inquiry, or whether scientific discoveries catalyze new worldviews is beyond the scope of this essay. 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 scientific search for truth. See Alfred North Whitehead's 1925 Lowell Lecture entitled *Science and Philosophy* for a more detailed discussion (Whitehead 173-196).

the scientific community, classical aesthetics frame the goals and provide the philosophical outlook that guides the search.

But just what do we mean by the word 'science'?[2] For our purposes, let us define *science* as the body of knowledge obtained by methods of observation. It is derived from the Latin word *scientia*, which simply means knowledge, and the German word *wisenschaft*, which means systematic, organized knowledge. Thus, science, to the extent that it is equivalent to wisenschaft, consists not of isolated bits of knowledge, but only of that knowledge which has been systematically assembled and put together in some sort of organized manner (Fischer 5-7). The 20th-century German philosopher Martin Heidegger defines science as the 'theory of the real' (Heidegger, Question Concerning Technology 157). In particular, the science with which we are concerned is a body of knowledge that derives its facts from observations, connects these facts with theories and then tests or modifies these theories as they succeed or fail in predicting or explaining new observations. In this sense, science has a relatively recent history, perhaps four centuries (Platt). However, the roots of scientific inquiry can be traced back to the classical philosophies of the Greeks.

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.[3] 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.[i] 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.[4]

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[2] Numerous definitions and descriptions of science have been written, none of which have been able to succinctly encompass all of the characteristics of these terms. The "man in the street," according to J.B. Conant, "considers science to be the activity of people who work in laboratories and whose discoveries have made possible modern industry and medicine" (Conant). This statement, although it may appear to be true to many laypersons, is quite shallow as a meaningful description of what science is. For example, many people who clearly qualify as scientists do not have any association with laboratories and their discoveries do not have any direct applicability in either modern industry or medicine. As important as contributions to these areas have been, this concept illustrates the need to develop working definitions with significant key words so we may clarify just what concepts science employs.

[3] Thales of Miletus, Anaximander, Pythagoras, Socrates, and Plato developed many of their ideas using earlier ancient works as their base (Goldstein 48-64).

[4] It was Pythagoras who is credited with the introduction of the vision of an intrinsic natural order and Plato adopted this vision (Goldstein 52).

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, <u>Cosmic Connection</u> 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 you send someone a message in code, but they have no way to decode it, your message has no more information than total nonsense[5] (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. In the *Allegory of the Cave*, in which the cave represents the realm of belief or faith, and the light represents the realm of truth and knowledge, Plato's mimetic philosophy of natural order holds that the ability to attain true knowledge is accomplished through a difficult path of acquisition (Adams 11). The path that Plato recommends is a journey within the mind. 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). The Marquis de Laplace noted that, "... nearly all our knowledge is

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[5] The universe is teeming with signals that we cannot identify, much less decode.

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. The ascension out of the cave, from belief to knowledge, is a painful journey, but once positive movement is made, it can be seen to be a move in the right direction toward reality. When one is out of the cave and one's eyes adjust to the light, there is yet another truth -- namely that the light is actually produced by the sun. 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.

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). Unlike Plato, Aristotle did not believe in a world of ephemeral appearances of changeless ideas. Loomis notes that Aristotle argued that, "...the world really is, has been, and will continue to be, regardless of human eyes and imaginings" (Loomis xvii-xviii). Hazard Adams notes that Aristotle believed that reality was the process by which form manifests itself through the concrete and by which the concrete takes on meaning working in accordance with ordered principles. Aristotle believed that change was a fundamental process of nature, a creative force with a conscious direction toward perfection (Adams 49). However, like Plato, Aristotle thought it necessary to, first of all, understand and explain the workings of the human mind and to show what kinds of reasoning were valid and could be relied upon to provide knowledge with surety.

In his *Organon*, Aristotle made clear the processes of logical, reasoned thinking and for proving the correctness of its conclusions. He made plain the steps by which a science or body of knowledge may be firmly built up from its starting point in certain fundamental axioms or obvious statements, perceived intuitively to be true. Every science, as Aristotle pointed out, must begin with a few general truths. They cannot be logically proved, but our minds by simple intuition accept them as obviously true. Without such assumptions as foundations, we could never start to build anything (Loomis, xi-xxxviii). Louise Loomis, editor of a 1940's translation of Aristotle's *Metaphysics*, 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 being a great dividing line in Greek 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).[ii]

Greek science, by the sheer process of speculation, argument, intuition, plus a dash of empirical reasoning, had moved, within the space of two generations, from the early mythical notions to a point that is surprisingly close to modern concepts (Goldstein 52). Having channeled the power of Greek philosophical thought into a logical system of scientific classification, Aristotle came to exercise an enormous influence over European science for the next two thousand years (Loomis, xi-xxxviii). When Europe awakened from the feudal Dark Ages and the Medieval suffocation of theocracy[iii] to an enlightened approach to knowledge[6] that included the works of Francis Bacon, Sir Isaac Newton, and Nicolaus Copernicus, it embraced the process of observation, generalization, explanation, and prediction that was fully rooted in an earthy materialism, indicative of the age. This view of knowledge became pervasive, changing assumptions not only in science but also in the entire social fabric of Europe. Europe 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, Question Concerning 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.[7] Just as unknowable

[6] Two aspects of these scientists' work stand as foundations of modern science. They include the empirical approach based upon objective, rational observation, and the use of mathematics to describe nature. The two criteria for the dynamic entity of scientific truth, either one of which is generally sufficient to cause persons to accept a principle, are first, that it can be checked by observation in a manner in which its consequences lead to its support rather than to contradictions; and second, it can be derived from intelligible principles (Fischer, 49). These principles laid the groundwork for modern scientific methods of inquiry and were forcefully argued by Rene' Descartes, the philosopher, and Francis Bacon, the theologian (Capra 15-120). This new approach also included the process of generalization, explanation, and prediction, or what can be thought of in modern terms as the *hypothesis*, *theory*, and *law*.

A *hypothesis* is a tentative assumption made in order to test its scientific consequences, but which as yet has received little verification or confirmation. A *theory* is a plausible, scientifically acceptable statement of a general principle and is used to explain phenomena. A *law* is a statement of an orderliness or interrelationship of phenomena that, as far as is known, is invariable under the stated conditions (Fischer 47). It should be stressed that the term law is used differently in reference to scientific knowledge than to other areas of everyday life. A scientific law is descriptive rather than prescriptive. It is a statement used to describe regularities found in nature, and is not a statement of what should happen. It is not correct to consider that natural objects obey the laws of nature; rather, the laws of nature describe the observed behavior of natural objects. In contrast, the laws of a human government are prescriptive in that they prescribe how people should behave.

Another guiding principle of science is its supranationality -- its inherent right to transcend national boundaries and allow scientists throughout the world to verify experimental results, challenge, theories, and allow technology to leverage new scientific discoveries.

[7] Sagan explained that the one thousand trillion sodium and chlorine atoms in a grain of salt would overwhelm our ability to understand salt if we were forced to know about every atom. This is because the human brain has a limit of approximately ten trillion neurons and dendrites, the connections between neurons.

are phenomena on the cosmic scale of the universe (Sagan, Broca's Brain 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, Question Concerning Technology 167). However, science is based upon a search for the truth in a society that bends the truth to suit its needs. 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. 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).

As discussed, science has many facets. In essence it seeks to be pure neutral knowledge extracted painfully from nature through systematic means for dissemination to all humanity. However, much of the relevance of science to society arises by way of *technology*.[8] 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

[8] The origin of the word *technology* gives valuable insight into 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. The practice of technology frequently is that of an art or craft, as distinguished from science, which is precise and is based upon established theoretical considerations. 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.

will itself also be directed toward getting everything under control"[9] (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. Suffice it to say for our use that technology is science plus purpose. 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).

There are intimate relationships between science and technology; yet science is not technology and technology is not science.[iv] Technology relies very heavily upon basic scientific knowledge in addition to existing technologies. There is also a strong influence in the reverse direction. Modern science relies to a large extent upon current technology as well as prior scientific knowledge. Science and technology reinforce each other by complex interactions. Each one, science or technology, can build upon itself or upon a linkage from one to the other.[10] Indeed, science is not technology and technology is not science, but they are firmly interrelated. One could not exist in modern society without the other.

The study of the history and evolution of aesthetics helps one understand that every society determines reality, truth, beauty, and values in accordance with its own worldview and its evolutionary point in time. Likewise, cultural development has been facilitated by evolving, sometimes revolutionary, paradigms.[11] The worldviews held by individuals or by groups are very influential in determining behavior, as well as in determining motivations, attitudes and actions. Scientists and engineers, being fully human, also experience the effects of paradigms. They and their findings are influenced by the mainstream of social thought framed by current technology and prevalent belief systems. By using knowledge of the universe, creativity, and a scientific approach to problem solving, scientists develop new paradigms.[12] 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

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[9] 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, Question Concerning Technology xxix).

[10] Fischer notes that, "Technology is dependent on science for knowledge of the properties of materials and energy and for predicting the behavior of natural forces. "Science is equally dependent upon technology for its tools and instruments, for preparation of materials, for the storage and dissemination of information, and for the stimulation of further research" (Fischer, 78).

[11] Kuhn described a *paradigm* as a way of seeing the world and practicing science in it. The characteristics of a new paradigm include new scientific achievements sufficiently unprecedented to attract an enduring group of adherents away from competing modes of scientific activity and, at the same time, sufficiently open-ended to leave all sorts of problems for the new group of practitioners to solve.

[12] 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 of how to evaluate evidence and come to agreement, or at least temporary agreement, until it is overruled by new insights and information. Cole describes scientific truth as "...less a collection of facts than a running argument" (Cole 127).

objective coherence of the theory…that normative coherence itself is thereby changed from time to time" (Heidegger, Question Concerning Technology 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 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).

Similar to the evolution of metaphysics and critical aesthetics among philosophers, the process that causes scientists to accept new evidence and change schools of thought was thoroughly examined in 1962 by MIT professor Thomas Kuhn, a science historian and philosopher (Kuhn 1-181). Kuhn noted that paradigm development goes through several predictable structural stages from 'normal science' to new paradigm acceptance. Normal science looks somewhat like aesthetic theories based on 17th Century 'Neoclassicism,' in which nature has structure and follows rules.[13] As Alexander Pope (1688-1744) suggested, there is an unchanging 'methodized' nature of structure, genre, harmony, and symmetry, which was the standard for developing and judging artistic forms (Adams 273-274). It is somewhat like John Dryden's (1631-1700) 17th-century acceptance of rules of time, place, and action to the aesthetics of poetry and rests on Immanuel Kant's (1724-1804) 18th-century treatment of *apriori* assumptions to his systems-like theory of aesthetics in a 'phenomenal' world of sensory data (Adams 213-240, 374-386). Likewise, by accepting Newtonian physics as a framework of inviolate rules, this freedom allowed members of the scientific community to concentrate exclusively upon the subtlest and most esoteric of the phenomena that concerned it. Inevitably this increased the effectiveness and efficiency with which the group as a whole solved new problems.

However, there are always competing schools of thought, each of which constantly questions the very foundations of the others. It is these competing schools that provide science with a self-correcting mechanism that ensures that the foundations of normal science will not go unchallenged (Kuhn 163). The overthrow of scientific paradigms look somewhat like 19th-century Expressive Theories of aesthetics, involving creativity and imagination, where, as William Wordsworth (1770-1850) suggested to his contemporaries, intuition and feeling become the basis of imagination that gives one the power to grasp nature (Adams 436-446). In a similar fashion, scientific revolutions are inaugurated by a growing, often intuitive sense, restricted to a narrow subdivision of creative minorities within the scientific community, that an existing paradigm has ceased to function adequately in the explanation of an aspect of nature for which that paradigm itself had previously led

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[13] Normal science as defined by Kuhn means the body of research firmly based upon one or more past scientific achievements that some particular scientific community acknowledges for a time as supplying the foundation for its further practice (Kuhn 163). The findings of such achievements are the bases for all underlying scientific assumptions and free the scientific community from constantly re-examining its first principles.

the way.[14] So as the crisis, that common awareness that something has gone wrong, shakes the very foundations of established thought, it generates a scientific revolution.

Just as in politics, scientific revolutions seem revolutionary only to those whose paradigms are affected by them.[15] Those scientists whose paradigms are threatened typically react with resistance. Only when the number of instances that refute the old paradigm grows beyond supportable structures of the establishment, does a new paradigm arise.[16] The decision to reject a paradigm is always simultaneously a decision to accept another. The judgment leading to that decision involves the comparison of both paradigms with nature and with each other.[17]

Kuhn continues by challenging those who claim that when paradigms change, the world itself changes. Rather, led by a new paradigm, scientists actually adopt new instruments and look in new places. Even more importantly, scientists see new and different things when looking with familiar instruments in places they have looked before. Just as it was seen by the 1920s Russian Formalists, such as Viktor Shklovsky, where art and literature was thought to defamiliarize the familiar, allowing one to see new aspects of the familiar objects and situations, scientific paradigm shift is almost as if the scientific community has been suddenly transported out of Plato's cave into the sunlight where familiar objects are seen in a different light and are joined by unfamiliar ones as well (Rivkin 20-21). Of course, there is no geographical transplantation. Outside the laboratory, life

[14] This sense of crisis drives a re-evaluation of the existing view and need not be generated by the work of the community that experiences the crisis. For instance, new instruments such as the electron microscope or new laws like Maxwell's wave theories may develop in one specialty and their assimilation may create a crisis in another (Kuhn 163-166).

[15] To outsiders scientific revolutions may seem to be normal parts of the developmental process, almost invisible. Astronomers, for example, could accept X-rays as a mere addition to knowledge since their paradigms were unaffected by the existence of the new radiation. But for the Kelvins, Crookes and Roentgens, whose research dealt with radiation theory and cathode ray tubes, the emergence of X-rays necessarily, violated one paradigm as it created another. From their perspective, these rays could only have been discovered by something going wrong with normal science.

[16] When it repudiates a past paradigm, a scientific community simultaneously renounces as a fit subject of inquiry, the past paradigm's experiments and subsequent textbooks. Scientific education makes use of no equivalent of the art museum or the library of classics, according to Kuhn. The result is sometimes a drastic distortion in the scientists' perception of their discipline's past. More than the practitioners of other creative fields, the scientist comes to see his or her discipline as evolving in a straight line to the present paradigm. In essence, the new paradigm is seen as progress and thus no alternative is available to the scientist while remaining in the field. The new paradigm is free to mature until the endless circle of challenge and debate inevitably signals its death.

[17] Kuhn explains that revolutions close with a total victory for one of two opposing camps, with the winner rewriting scientific knowledge. The new structure of the work itself is sufficient and it becomes the new set of *apriori* assumptions for future scientific work. Will the victorious group ever say that the result of its victory has been something less than progress? That would be admitting that they are wrong and the old paradigm holders are right. To the victors the outcome of a revolution must be defined as progress and they are uniquely positioned to make certain that future members of their community see past history in the same way because the new paradigm holders are the ones that get their work published (Kuhn 166).

continues as before. But, paradigm shifts cause scientists to see the world differently and they, in effect, are responding to a different world. It then becomes only a matter of time before their paradigms become popularized in a community of technologists and the social fabric begins to be re-woven as a result.

Throughout history, many classic philosophers believed that the search for truth and beauty was also a search for the reflection of God.[v] The concept of faith, without concrete proof, is a very difficult assumption for the scientific community to accept.[18] To scientists, the idea that religion is a body of belief, immune to criticism, fixed forever by some founder, is a prescription for the long-term decay of religion, especially in light of new discoveries. However, the scientific community is not innocent of the charge of intellectual tyranny either. As Plato would have it, art is good only if it is subservient to logic. As such, Western science has traditionally rejected the value to the human spirit of faith, emotion, intuition, hope, and general use of the emotional part of the brain. 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*.[19]

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. Heisenberg notes that physics is bent on, "...being able to write one single fundamental equation from which the properties of all elementary particles, and therewith the behavior of all matter whatever, follow" (Heidegger, Question Concerning Technology 172). "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). 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

[18] In fact, Christian theology and secular science have been antagonistically and emotionally opposed throughout much of Western history. The conflict between knowledge-based science and belief-based religion confront our intellect, challenge our deeply ingrained value system, and tear our social fabric. Although each has its own dogma of fundamentalism or scientism, respectively, both serve important social roles in times of crisis. This conflict between diametrically opposed views of the world has been, and continues to be, a major obstacle to holistic human progress.

[19] 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).

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 causes and cures.[20] However, Aristotle warns of the need for careful application of logic.[21] In all syllogistic or deductive reasoning, one must make sure that the *apriori* proposition is comprehensive enough to cover every case. If A is only sometimes B, then C, though included in A, may not be B. He also reminds us that, with inductive reasoning, one must be constantly on guard not to draw conclusions too hastily. Unless the number of instances on which we ground our generalization is large enough to be thoroughly representative, there may be instances we have overlooked (Loomis xiv-xv).

Likewise, scientific reduction of causes and effects to pure mechanistic explanations is contrary to human experience and will also likely be rejected. "… certain characteristics of living systems, such as their adaptive and self-regulating features, cannot be explained by physical and chemical principles alone, but have to be accounted for by reference to new factors of a kind not known to the physical science, namely entelchies or vital forces," cites philosopher of science Carl Hempel (Hempel 101). K.C. Cole observes that, "The universe is full of things that cannot be understood – ever – simply by understanding smaller and more fundamental parts" (Cole 62). 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 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).

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[20] 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).

[21] Aristotle's own reliance on logic shows the modern practitioner its limitations and biases. Aristotle could not agree with the followers of Pythagoras, who took the earth to be itself one of the stars circling around a fire at the center of things and creating day and night by its own turning on its axis. He declared their reasoning as not from facts to theory, but one that forced the facts into their preconceived theory. He believed that the center spot had to be the most precious location in the universe and that is why the earth had to be there (Loomis xxiv).

As the scientific community entered the 20th Century and faced discoveries that confounded Newtonian physics, the Nietzschean concept of relevance came into play. Friedrich Nietzsche (1844-1900) reminded us that truth is, "...an infinitely complex dome of ideas on a movable foundation as if it were on running water." Nietzsche continued, "Truths are illusions of which one has forgotten that they are illusions; ...a sum of human relations which became poetically and rhetorically intensified, metamorphosed, adorned, and after long usage seems to a nation fixed, canonic, and binding" (Adams 636-637). This was the state of Newtonian science at the turn of the 20th Century, as well. It no longer explained new discoveries because scientists became too comfortable with their mutually agreed frame of reference, or what Kuhn called 'normal science.'

As an example, consider the breakthrough thinking that was required in the early 20th Century. One of the most important implications of Einstein's General Theory of Relativity is the concept of reference frames. As Nietzsche described, reference frames can be considered simply as a certain point of view. So, in order to understand the relationship between what one sees and what is going on, one needs to add, or subtract, the influence of one's own reference frame. Consider how a shadow in Plato's cave is a two-dimensional slice of a three-dimensional object. The Three-dimensional object casting the shadow remains invariant as the shadow moves and changes form based on the light falling on the object and the background on which it falls. However, everything we see and measure is under the influence of a reference frame. This shift in perspective allows relationships to become clear. It allows us to see relationships between common objects that obey Newtonian physics and extrapolate those relationships to the orbits of the planets. Conversely, failure to take into account one's reference frame can lead to what Plato called 'shadows' (Cole 192-195). As Plato warned us, when we take our reference frame for granted, we mistake it for reality.

Therefore, logic is a useful tool but it has its limits. Reference frames help us understand that there is a duality in nature. "The opposite of truth is not heresy," as Oppenheimer reminded us. It may be a different kind of truth. Each added view adds insight, as long as the viewer understands the kind of frame that influences the perspective. Physicists Neils Bohr and Christopher Morley cautioned us with the truism, "The opposite of a shallow truth is false; the opposite of a deep truth is also true" (Cole 202). Logician Keith Devlin argues for a softer mathematics that incorporates metaphors as well as formal reasoning. To really understand what it means to think rationally, mathematical logic will likely need to join forces with psychology, sociology, biology, and even poetry (Cole 157-164).

As we enter the 21st Century, the search for simplicity has recently become the metric for truth. Scientists have come to believe that the simpler model is the more likely to be truthful and beautiful. Simplicity takes the form of invariants, those aspects of nature that are truly fundamental. Invariants are defined by symmetries, which in turn define which properties of nature are conserved (Cole 11). "These are the selfsame symmetries that appeal to the senses in art and music and natural forms like snowflakes and galaxies. The fundamental truths are based on symmetry, and there's a deep kind of beauty in that," observes Cole. Elements of Aquinas' trinity of wholeness, proportion, and brilliance can be found in this new Aristotelian metaphysical model (Adams 116-119). It also has elements of Neoclassicism's economic, clear, easy, mathematical plainness.

This search for simplicity and invariants comes at a time when physicists are encountering the strange new world of subatomic particles and interstellar phenomena that defy Aristotelian logic, Euclidean geometry, and Cartesian coordinates. The world of the very large and the world of the very small seem to show scientists that there is not just one right answer for every question. It turns out that the paradoxes of certain phenomena reveal that logic can lead to contradictory conclusions, point in different directions at once, and violate Aristotle's belief that one cannot be logical and contradictory at once. Modern mathematicians have introduced us to the multi-valued, somewhat ambiguous logical construct called 'fuzzy logic.' Unlike the two-valued logic of Aristotle, with its binary yes/no or true/false clarity, fuzzy logic provides a sliding scale of gray between the extremes of black/white logic (Cole 158-171).

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.

We have become quite adept at conquering tangibles with technology. From medical science to space travel, from instantaneous communications to automated warfare, Western science and technology have consistently provided utility. However, when we turn to the world of the intangibles, technology and science face definite limitations. Social problems transcend mathematical descriptions and involve emotions that cannot be touched, measured or successfully manipulated. Theological questions transcend our three physical dimensions of space and our one dimension of time. What exists beyond those dimensions can only be entertained as speculation or believed through blind faith. 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 and science cannot define God.

A workable holistic approach for modern society is the reconciliation of the emotional, artistic, and religious schools of thought with the scientific community 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.[22] Since phenomena outside of the physical realm of experience are, by definition, foreign to science and native to

[22] The complementary nature of science and religion is not a merely a recent 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).

religion and art, one's feeling, intuition, and connectedness can certainly assist in answering complex questions. Art and religion could tell one where to look, and science could determine how the process occurred. Science's focus on the physical realm of cause, effect, and cure, plus its values of truth, objectivity, dissent, independence, respect, and supranationality could help solve many of the most pressing social problems. Art and religion, focusing on the non-physical realm of could help refine universal meaning, personal morals, interpersonal relationships, and societal value. When scientists start appreciating artists and listening to theologians and mystics, and this latter group starts, not only listening, but also understanding and practicing science, society may be on its way to viewing these ultimate questions in a holistic fashion.

Just imagine a concept of creation that took place anciently, with the process being started by the loving, all-powerful universal 'Source,' in an Aristotelian sense. Under such a paradigm, the physical laws with which we are well familiar would be mere representations of a multifaceted being of which we are an integral part. Genesis then becomes allegorical, and we are continually in a process of biological and mental evolution to become more closely associated with the Source, who is revealed in the harmony of all creatures and not in the trivialities of individual actions.

Suppose science and aesthetics could agree upon a scenario like this one? How fascinating! How innately truthful! How beautiful!

End Notes

[i] Our concept of science and technology has a relatively modern European flair. However, both science and technology existed with different underlying assumptions before the Renaissance, before the Roman Empire, before the Greeks conquered the known world, and even before the great flowering of Egypt. Both concepts and their applications may be directly traced back to the cradle of civilization. As noted by historian Chancellor Williams, ancient cultures that occupied the fertile crescent of the Nile Valley prior to Egypt's greatness was the exclusive province of Kushites, Nubians, Shebans, Mesopotamians, and Thebans, which we now refer to collectively as Ethiopians (Williams 34-35). These ancient people were accomplished agriculturalists and were very religious. Indeed, religion to the Ethiopians was far more than ritual reflecting beliefs, but a reality reflected in their way of life. Religion from the earliest times became the dynamic force in the development of all the major aspects of their civilization.

Their belief in immortality was a simple matter of course and beyond the realm of debate. This belief was the great inspiration for ancient technology. The Ethiopians built, on a grand scale, structures that were meant to stand forever. Actually, it was necessity that gave birth to mathematics and astronomy. Building the Ethiopian pyramids and the most elaborate system of temples the world had known required the development of engineering (Williams 38).

Therefore, we see that Ethiopian scientific and technical development was driven by religious beliefs. This contrasts to the modern Western view of technology, which is embedded with drivers for a more-and-better world. Both schools of thought stress the products of technology but the motivations are quite different.

Many of the ancient temples were dedicated to reflective thinking and discovery -- what we might call colleges. These temple-centered colleges fostered free discourse and viewed science as purely a process of thought. Scholars from foreign lands came to study, and from here religious ideas and their architectural designs spread abroad. Since the Ethiopian Empire at that time included what we now call ancient Egypt, it was natural that these facets of the Upper Nile culture should spread to the lower Nile and the northernmost part of the continent. The early Greeks were heavily influenced by these same architectural structures, scientific methods and religious concepts, according to Williams. The Greeks eagerly copied, reshaped and made them into parts of a new Western culture (Williams 38).

[ii] 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. 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.

When the hope given by the Church was no longer needed, new morals and money provided the impetus for Europeans to cast the Church aside in favor of a new age -- the Renaissance. Suddenly, being earthy and gauche was in. Once again Europe entered an age of free inquiry, but this time a novel twist accompanied the new age. The new twist was represented by a view of life advocated by a new breed of wealthy philosopher/scientist.

The European Scientific Revolution of the 16th and 17th Centuries began with Nicolaus Copernicas 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.

[iii] "Medieval mysticism meant accepting the rule of invisible forces...within the Good Lord's mysterious blueprint ...rooted in the beyond, over the tangible, everyday experience," according to science historian Thomas Goldstein (Goldstein 138). While judging religion and the state of scientific knowledge in the hindsight of history is somewhat unfair, it allows one to question whether religious dogma and reliance on faith instead of rational mental faculties slowed the development of the European scientific method and impeded medical progress when its adherents most needed it. Since ancient times, the educated elite knew the power of Aristotle's reasoning, Hippocrates', Herophilus', and Galen's observation and experimentation, and it knew that the Muslim scholars of the 9th -to 14th-century Spain excelled in medicine and chemistry (White 2: 26-51). In spite of this knowledge, medieval society rejected this early scientific approach in favor of faith. In 1270, Thomas Aquinas, writing in his *Summa Contra Gentiles*, cautioned the faithful not to lift the veil from those ultimate mysteries that are destined to be concealed from the human mind.

Referring to Aquinas, Thomas Goldstein notes:

> The greatest rational thinker of the Middle Ages, in other words, privy to the most complete scientific knowledge of his time, was warning his own generation and the generations to come not to overestimate the power of rational thought, but to acknowledge the superior scope of mystic intuition and sheer faith as paths toward understanding (Goldstein 249-250).

For hundreds of years, the medieval Church set up a series of obstacles to scientific inquiry including: attributing disease to demons; sanctioning and profiting from the supposed healing powers of the relics of the Christian martyrs; using the *Apostle's Creed* and its belief in the resurrection of the body to outlaw dissection in medical schools; promoting ideas that abasement adds to the glory of God, that cleanliness was a sign of pride, and that filthiness was a sign of humility. As late as the 18th Century, church leaders were preaching against the 'dangerous and sinful practice' of inoculation (White 2: 27-69). For example, during the 1721 breakout of smallpox in Boston, even though Zabdiel Boylston's inoculation technique was proven to produce a lower mortality rate than inflicted by the natural disease, it was widely opposed by the medical establishment as unsafe, and by the church as an interference with God's will (Tucker 17-18).

Throughout European history, schools of thought contrary to Church teachings were seen as blasphemous, and appropriate punishment was doled out. Prodded by St. Bernard, conservative theologians from Paris, Orleans, and Lyon hounded the masters of Chartres and summoned them to appear before a tribunal to face charges of heresy for teaching a scientific view of the intrinsic creative powers of nature[iii] -- a view that threatened the 700-year-old doctrine of nature as the passive object of God's creation (Goldstein 69-70). This was the mentality that burned at the stake Giordano Bruno in 1600 for uttering and publishing the heresy that there were other worlds and other beings inhabiting them (Sagan, Cosmic Connection 185). Staunch religious dogma was the reason for the Catholic hierarchy's imprisonment of the aged Galileo Galilei for proclaiming that the Earth moves (Drake 330-351). Johannes Kepler, after whom the laws of planetary motion are named, was excommunicated by the Lutheran Church for his uncompromising individualism on matters of doctrine and because of his writing of *The Somnium*, in which he imagined a journey to the moon. In addition, Kepler's mother was dragged away in a laundry chest in the middle of the night to be burned as a witch for giving birth to such a heretic and selling herbs (Sagan, Cosmic Connection 50-71).

[iv] Technology is applied, but not necessarily based upon science. In fact, as California State University's Robert Fischer notes, "To define technology as applied science is to miss much of the significance of the relationship that exists between science and technology" (Fischer 5-7). He defines technology as the totality of the means employed by peoples to provide material objects for human sustenance and comfort.

One connotation of the working definition of technology is that it is a human activity. It is people who use the products of technology. Furthermore, it is people whose livelihood and comfort is the goal of technology, whether this goal is actually accomplished by technology or not. According to Fischer, technology is directed in specific instances toward specific material objects, that is, toward the production of physical objects. This is not to exclude the importance of non-material concepts to human sustenance and comfort, but it is meant to drive home the central theme that technology is driven by physical needs. By definition, technology is not neutral because it is directed toward satisfying a physical need, as determined by a human value system.

Technology is power and one who controls technology controls the power inherent in its application. Technology is defined, to some degree, by our relationship with the environment. It involves our attempt to control and shape the world and to make use of whatever resources are available in that environment (Fischer 76). The basic Western motive for 'bringing about technology' is the desire to obtain more or better material things. "There are of course more immediate and less profound motivations for individuals in either science or technology, such as the desire to get a paycheck and retain one's job," as Fischer notes.

Other points of comparison involve grander motives such as the ancient beliefs of using technology to devote monuments to gods, heroes or esthetics. 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 indicative of the European Renaissance.

[v] Aristotle deduced the existence of God and attempted to explain God's characteristics and our relationship to the Prime Mover. He argued that matter exists in a potential state and has four causes for its existence. These include the material of which something is made, its form or pattern assumed by the material in the object, the agency that produced the object, and the purpose or end for which the object was brought into being. Sooner or later one will come to something for which one knows no reason. As a result, Aristotle deduced that there must be an uncaused first principle from which everything else starts and a supreme and final end for the sake of which everything exists. Unlike a personified Platonic or Christian God, that is believed to be the universal creator, Aristotle's God was the motionless, calm, immortal substance that is pure form and intelligence and that, while itself is unmoved, produces motion by being the object of the world's desire. Lesser beings aspire to this highest and best form. God, however, does not aspire. To Aristotle, God always has been in a state of supreme actuality, serene contemplative thought, that is life at its fullest and most pleasant (Loomis xvi-xx). Later, St. Augustine, a proponent of Platonic metaphysics, would advocate that beauty, truth, and God are indistinguishable (Adams 107-113).

Plato also talks of movement from faith to knowledge. *The Allegory of the Cave* suggests that the best that those who have not experienced knowledge can do is to have faith in those that have been so enlightened. Likewise, St. Augustine (354-430) asked followers of the Christian religion to read the doctrine and, even if they fail to understand it, to have faith in its teachings until truth is divinely revealed. Augustine asserted that, ultimately, vision will replace faith, blessedness will replace hope, and charity will be increased even more (Adams 113).

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