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Strategic T echnology Institute

Classical Socratic Logic Provides the Foundation for the Scientific Search for Truth

By

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Developed in comjunction with the graduate seminar -- *The Trial of Socrates* -- under the direction of Dr. Thomas Sheehan at Stanford University, December 12, 2002.

> *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"*
>
> -- *Aristotle*

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 logical framework of hypothesis testing laid out by Socrates (469-399 BC) and the refinements to his philosophies by his disciple, Plato (427-347 BC), and Plato's student, Aristotle (384-322 BC). Though Socrates opened the door to examination of the inner self, he also set in motion a metaphysics and critical cross-examination of ideas that define a valid approach to seeking knowledge and a scale by which the scientific community still determines truth.

Before closely examining Socratic philosophy and its impact on the scientific method, one must be clear on just what one means by the word 'science'? 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). 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 modern 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.[1] 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.

Though the roots of modern inquiry rests on a framework solidified by the Greeks, it is important to recognize that Thales of Miletus, Anaximander, Pythagoras, Socrates, and Plato developed many of their ideas using earlier ancient works as their base (Goldstein 48-64). Among their influences were Phoenician,[2] Egyptian, and Mesopotamian scholars.

As the archaeologist Sir Leonard Woolley noted,

> "We have outgrown the phase when all the arts were traced to Greece and Greece was thought to have sprung, like Pallas, full-grown from the brain of the Olympian Zeus; we have learnt how the flower of genius drew its sap from Lydians and Hittites, from Phoenicia and Crete, from Babylon and Egypt. But at the roots go farther back: behind all lies Sumer" (Woolley 194).

Mathematician Lancelot Hogben argues that,

> "The veneration of the Greeks by their successors is indeed due to the fact that they were the first to insist explicitly on the need for proof." Though Greek mathematics were imports, "…they had to pass the customs of Greek incredulity," among a society partial to dispute resolution and competition among rival teachers (Hogben 60-61).

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.

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

[2] See Gionanni Garnini's analysis of the history of the Phoenician alphabet and its adaptations by the Greeks in The Phoenicians edited by Sabatino Moscoti (Moscati 101-119).

The French Assyriologist Jean Bottero of the Ecole Pratique des Hautes Etudes argues in favor of abstract Mesopotamian thought as the foundation for Greek pre-Socratic philosophy.[3]

> "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).

Bottero argues that, "… the Greeks did not develop their conceptions of science, which we inherited, out of nothing; in this important point, as well as in others, they owe a debt to the ancient Mesopotamians." What may have passed on to the Greeks, according to Bottero, was this "scientific point of view, scientific treatment, and the scientific spirit" (Bottero 125).

So, the Greeks did not monopolize abstract thinking; but they certainly refined it.[4] Through his words and actions, Socrates demonstrated key concepts critical to the future process and ethics of scientific collaboration.[5] 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.

Socrates believed, and his student Plato expressed, that there is an absolute truth that can be revealed through logical philosophy, rather than the human senses. He believed that there was another world of ideas and truth around us that we could not directly touch with our human

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[3] 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 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).

[4] According to C. M. Bowra, the Greeks raised mathematics beyond the practical applications of the Egyptians. The Greeks triumphed in pure mathematical thinking without reference to practical considerations. Beginning with geometry, Pythagoras and his disciples saw in numbers certain permanent principles that were the keys to most problems. They promoted the thought and practice that most phenomena could be understood if one could discover the mathematical laws that governed them. The mathematical school of thought was then followed by the philosophical school, which sought reality behind phenomena through words, rather than numbers. (Bowra 165-167).

[5] It is important to note that much of what we know about Socrates' approach to philosophy comes from a series of conversations from other writers, notably Plato. Since Plato was a playwright, a student of Socrates, and an ardent admirer of Socrates, the historical accuracy of Socrates' words cannot be verified. For our purposes, we will assume that when Plato attributes certain beliefs and philosophies to Socrates, it may be safe to assume that Plato shares those views and perhaps has embellished them with his own philosophies.

senses. 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). These ideal forms were not limited to physical objects. For example, in *Symposium*, ideals went beyond physical forms and geometric proofs, but included emotional and spiritual concepts, such as love and beauty. Socrates tells how Diotima corrected his understanding of love and elevated his consciousness to a higher form of love.[6] She explained that *eros* was neither beautiful nor ugly and that Socrates was in love with beauty (Symposium 204ab).[7]. The ideal form of love must be looked at from the perspective of the beloved, not the lover (Symposium 204c). As such, according to Diotima's explanation to Socrates, the ultimate objective of all eros is beauty itself and a desire to give birth in beauty (Symposium 208c-209e, 210e).

Plato, relaying the point of view of Socrates in his Dialogues, affirmed the belief that real knowledge was unobtainable through the lens of the physical senses.[i] To Plato absolute truth was unattainable because he believed that what we see around us is merely an image.[8] 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 that 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[9] (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. Socrates and Plato were correct -- Humans cannot know all things. Absolute knowledge depends on absolute definitions, which is inaccessible to humans (Stone 39).

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.[10] In the Republic's *Allegory of the Cave*, in which the cave represents the realm of belief or faith, and the light represents the realm of truth and

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[6] Diotima seems to be a contrived woman from Mantinea that Socrates uses as a story-telling device (See Nehamas and Woodruff 45).

[7] This notation refers to the Stephanus numbering scheme used by translators of Plato's works since 1578 (Sterling and Scott 10).

[8] 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 forms that our senses can recognize (Sagan, Cosmic Connection 15-16).

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

[10] 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).

knowledge, Plato's 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. 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 common sense

Socrates believed that the truth of reality is in our souls (Meno 86b). He also believed that knowledge is gained through recollection of universal truth (ideals), rather than through 'learning' (Meno 81d). In *Meno*, he demonstrates the recollection of 'untrained' knowledge of geometric shapes by questioning a slave, who has not been taught geometry (Meno 82c-e). Through Socrates' questions, he first leads the slave to a point where he admits that he does not know the answer and knows he doesn't know the answer (Meno 84bc). According to Socrates, one must reach a state of knowing that one does not know, in order to be open to learning or 'recollecting' (Meno 84c). In this exercise, the slave is seen as actually deducing the answers from common sense responses to Socrates' questions. Socrates states that if you repeatedly ask the same questions in various ways, it will ultimately lead to as accurate knowledge as can be had by humans (Meno 85d).

Plato taught his pupils that a convincing proof required the following elements. First, it is essential to *define* the terms used. Secondly, it is essential to state clearly what we all agree to take for granted, e.g., that a+c = b+c if a=b. Third, it is critical to make clear, and to justify, what procedures one may invoke to define our terms or to dissect figures in order to exhibit relations between their parts. (Hogben 63).

Plato's rigor regarding the definition of terms is shown best by an example from *Meno*, in which the dialogue examines the definition of virtue. Though there are many virtues, Plato, through Socrates, seeks to show that there must be a core ideal form (*eidos*), which leads to a common definition (Meno 72cd). Socrates questions Meno, and shows that since the essence of several example virtues is the same, there must be a 'same' thing in common among the examples (Meno 73c). Socrates strictly enforces a rule of logic that one cannot include the term to be defined in the definition. He forces Meno to distinguish between 'a virtue' and 'virtue' (Meno 73e). Throughout the dialogue, Socrates and Meno tried similar analogies with colors and shapes (Meno 74bd). They also examined characteristics of virtue in relation to the ability to secure good things in life (and bad) and judge them in relation to 'how' they are acquired, e.g., justly or unjustly. (Meno 78b-e). Throughout the dialogue, Socrates restricts Meno from defining virtue's characteristics or parts as virtue itself, thereby laying down a core principle of Socratic logic (Meno 79bc).

The problem of not clearly defining terms can lead to a circular argument. This is best demonstrated in *Euthyphro*, where Socrates carries on a dialogue to determine the definition of holiness. They start by trying to determine if everything that is holy is also just. If so, he asks if the reverse true, e.g., everything that is just is holy or is holy a part of just (Euthyphro 11e-12a)? The argument continues, citing that if what is holy is a division of just, then we must find out what kind of division it is (Euthyphro 12d). Socrates makes similar analogies with shame and fear (Euthyphro 12b-12c). As the dialogue continues, adjustments to the definition of holy are made; including one where holy is ministry to the gods (Euthyphro 12e-14b), such that those that look after the gods are pious and holy (Euthyphro 12e), whereas, those things that look after men are just (Euthyphro 12e). The problem with this logic is that it violates the concept of the gods as ‘ideal’ forms, and implies that to ‘look after’ means that humans are trying to ‘improve’ the gods. They further refine the definition to mean it as “slaves looking after their masters” (Euthyphro 13de). They try again, this time refining the argument and definition of holy as an art of prayer and sacrifice (Euthyphro 14c-15c). This leads to definitions of ‘sacrifice’ as making a donation to the gods, ‘prayer’as requesting something from them, and therefore, ‘holiness’ would become a skill in trading between gods and men (Euthyphro 14c-e). Socrates and Euthyphro recognized that they engaged in a circular argument that has an unresolved ending (Euthyphro 15bc).

Socrates, and by extension Plato, started with an assumption that he knew nothing for sure. However, he used a 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. *Meno,* again, provides a good example of Socrates’ approach to hypothesis testing. If virtue is knowledge, it is good, beneficial, and can be taught (Meno 89cd). However, Socrates asks who are the teachers of virtue and challenges Antynus as to whether one can have knowledge of good teachers without experiencing them (Meno 92c). The yes/no logic leads Antynus to determine if good men pass on their knowledge of goodness. Socrates gives several examples of good men who had their sons educated, but not taught virtue (Meno 93b-94d). Socrates leads the questioning to the conclusion that, if neither the sophists nor worthy men are teachers of the virtue, nor can there be pupils, therefore it cannot be taught nor is it knowledge (Meno 96bc). This Socratic interrogation, where the respondent is restricted to yes/no answers, proved that since virtue is not taught, it must be some kind of wisdom or divine guidance as a gift from the gods (Meno 99c). The Socratic process of questioning operates somewhat in the manner suggested by Cole, “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).

However, as Socrates and Plato noted, although one might asymptotically approach truth, it is transitory and perfect knowledge is unobtainable. Just as, in modern times, scientific truth evolves based upon new knowledge and an internal competition among ideas within the scientific community, 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). Unlike Plato, Aristotle did not believe in a world of ephemeral appearances of changeless ideas. Louise Loomis, editor of a 1940’s translation of Aristotle's *Metaphysics,* 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). 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). [ii]

Throughout history, many classic philosophers believed that the search for truth was also a search for the reflection of God. Socrates expressed a conviction that the process of logical inquiry can explain nature in a way that is not necessarily inconsistent with religion. From the *Apology*, one sees that Socrates addresses the historical criticism that he had been a natural philosopher who inquires into things below the earth and in the sky. Though Socrates admits that he studied natural philosophy in his youth, he neither refuted it nor saw a conflict with his philosophical and religious beliefs. He stated that, "I take no interest in these things" and in either case, he saw "no conflict between those who inquire about the heavens and a belief in the gods" (Apology 18b-e). In the Republic, Plato talked 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, Aristotle deduced the existence of God and attempted to explain God's characteristics and our relationship to the Prime Mover.[11] 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).

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[11] 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.

The concept of faith, without concrete proof, is a very difficult assumption for the scientific community to accept.[12] 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*.[13] [iii]

Because we have adopted a faith in science, it is clear that modern humanity will reject any non-rational explanation of causes and cures.[14] However, Aristotle warns of the need for careful application of logic.[15] 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

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[12] 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 confronts our intellect, challenges our deeply ingrained value system, and tears 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.

[13] *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).

[14] 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 outlookon life (Durant 47-48).

[15] 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).

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. Socrates reminds us in the *Phaedo* that when it comes to mechanistic cycles and decay of physical forms, it is impossible to learn anything about spiritual life from studying the material aspects of life (Phaedo 97b). 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 and spiritual 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).

As the scientific community entered the 20th Century, it faced discoveries that confounded Newtonian physics, which no longer explained new discoveries from a comfortable frame of reference. So, the concept of relevance came into play.[16] As an example, consider how one of the most important implications of Einstein's General Theory of Relativity is the concept of reference frames, or simply 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, since everything one sees and measure is under the influence of a reference frame, a shift in perspective allows relationships to become clear. It allows one 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 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). 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).

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[16] . 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.

In such a complex unknowable world of the infinitely large and the infinitely small, perhaps there is a role for both non-rational approaches and rational ones.[17] Even Aristotle reminded us that art finishes the job when nature leaves something undone. 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. 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.

It is in the realm of the inner search for spirituality that Socrates has more to say to us than the mere process of scientific inquiry and the correctness of proofs. He can help lead us to a more enlightened resolution of spirituality, which need not be in conflict with science. Consider his beliefs regarding the soul and immortality, as presented in the *Phaedo*. Socrates believed that death is the release of the soul from the body, which is what the philosopher has been trying to accomplish in life (Phaedo 64cd, 67de). He argued that souls are unchanging non-compound ideals that cannot disintegrate and must have existed before birth, in order to have knowledge of ideal forms (Phaedo 73cd, 76cd, 80b). He also believed that the soul is not dependent on the body the way harmony is dependent on the lyre. As an ideal form, the soul is absolute, whereas harmony has degrees (Phaedo 92bc). Though Socrates could not prove life after death, he desperately hoped for it and went to his grave trusting that the process of becoming free of the body deifies the soul.

Perhaps the modern enlightened scientific community could benefit by a more balanced holistic view of knowledge. Such a view would use science to determine those things that are knowable, but would not fear using intuition, trust, and faith to guide the spirit of inquiry. A holistic view might 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 religion could agree upon a scenario like this one? How fascinating! How innately truthful! It makes Socrates' belief in a rewarding afterlife far superior and more motivational than the physical realm we occupy.

As we have seen through an examination of Greek philosophy, how, by the sheer process of Socratic/Platonic speculation, argument, intuition, plus a dash of Aristotelian empirical

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[17] 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). This need to blend disciplines is even more pronounced as we enter the 21st Century, because it is 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.

reasoning, the Greeks moved, within the space of three generations, from the early mythical notions to a point that is surprisingly close to modern scientific 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[iv] to an enlightened approach to knowledge[18] 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. Thanks to Greek philosophy, 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 169). Likewise, the 20th-century German philosopher Martin Heidegger defines science as the 'theory of the real' (Heidegger 157). This view of knowledge became pervasive, changing assumptions not only in science but also in the entire social fabric of Europe.

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[18] 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*. An *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. 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.

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Notes

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[i] 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'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 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*. 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" (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. 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. 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 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. 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 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 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. 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). 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 the way. 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. 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. 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.

Kuhn challenged 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 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.

[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 wa s 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] *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 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 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).

[iv] "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 9^{th} -to 14^{th}-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 -- 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).