Understanding Early Science

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Science [1] is generally regarded as the epitome of objective truth. A flood of books and articles have been written on science and its glories. Sometimes one has to be aware of what is not said!

So many words written and *no definition of science*! Dictionaries do provide definitions that "accommodate" all claimants to the name of science—except the thinkers of the past or the deconstructed future! Confronting false "science" requires a review of science history and then a revision of some cherished early concepts. If a modern secularist does not blush at the tenants of Greek science, neither will he blush at the "findings" of relativity, quantum mechanics or astronomy!

What should science be and do? Ideally, science is objective truth—truth not captive to bias or viewpoint. (The implied corollary is that Religion is subjective opinion!) Be aware that truth can be discovered without the aid of science. Consider the discovery of a cave or a mineral deposit. These discoveries do not require scientific procedure! Are they therefore an illusion? No—these are *facts*.

Science also discovers *facts,* but discovering facts is not science's primary interest! Rather, science wants to organize facts—even facts discovered without the aid of science. Even better, science wants to predict new facts, facts not "seen" without the "aid" of the knowledge that science applies to (simple) facts.

Putting facts into "order" requires a combining thread of causal relationships—but sometimes it may be difficult to tell if the thread is science, philosophy, or religion. Additionally, science must be able to "reach out and touch" distant or otherwise inaccessible "facts." A rock at your feet—or a distant star—or an event of long ago—are all to be comprehensible.

Organizing and predicting can themselves be easily thought to be (complex) facts. Exposing false science requires working through the knots and tangles of tacit threads of understanding woven into science through the centuries, imbedded as to be hardly distinguishable, at the root of which is frequently subjectivity. If this root problem surrounding (complex) facts makes us blush, we can refer to theory, paradigm, or systematic understanding.

Looking once again at the ideal statement of Science, we see that what is really meant is *Science is objective truth*—illuminated by an overarching knowledge about causal relationships applied to all types of facts. Science is not merely a collection of facts.

The pre-Socratics. Greek science begins with the pre-Socratics, prior to 400 B.C., the earth, air, fire and water folks—and the atomists. These were soon followed by two other schools—Pythagoras/Plato and Aristotle. The pre-Socratics, were such as Thales of Miletus, who said that all things are made of water—yet he predicted an eclipse of the sun. Then Anaximander criticized Thales—Anaximander preferred a boundless source of "everything." Anaximenes said that all things are made of air. Heraclitus said that all things come from a strife—an opposition between opposing tendencies—all things are in flux. But he preferred fire as the basics and advocated grasping the "underlying principles" of things – a hint of what science means. Parmenides said that "What is, is." Empedocles said that all things come from "earth, air, fire and water."

The atomists began with Anaxagoras, who said that matter had infinite divisibility. Leucippus said that matter is made of innumerable and indivisible constituent particles. Democritus said reality consists of matter in motion—through an infinite void. Atomism was soon buttressed by Epicurus and Lucretius. Epicurus modified the atomist theory by introducing a random swerve into the motion of the atoms.

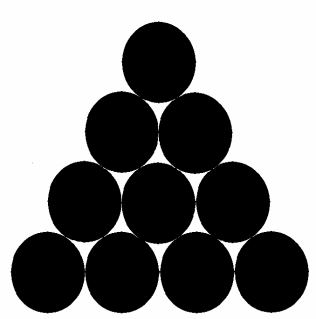
These ideas were not flippant—but the problem with the pre-Socratics is that they lacked a robust "research program." After accepting their "combining thread," what do you do next? How do you increase the store of knowledge using their (complex) facts? There was no easy answer—plus each of these had "schools" associated with them, which heatedly argued with each other. (The "schools" sounded too much like the implied corollary argument that Religion is subjective opinion!) All said they were objective, but with an overabundance of "overarching knowledge?"

On the other hand, the Pythagorean/Platonic and Aristotelean views suggested something to do. The Pythagorean/Platonic view said to study arithmetic and geometry. The Aristotelean view said to observe nature and be logical.

Pythagorean science. The Pythagorean view ultimately failed and was subsumed into the system of Plato, but Pythagoras, (*c* 582 - *c* 500 BC), had the first notable success in finding the "combining thread" of matter and thus unifying thought. His unifying "thread" was a substance—called *number*. Nature was a numerical reality. To Pythagoras, mathematics meant number and arithmetic; even geometry was subordinate to number. Number was his (complex) fact! His science had a twofold creed: *Matter is number and number is self-evident truth.*

(Some of Pythagoras' followers were called *mathematekoi*—those who studied all. *Mathematekoi* has also been translated as "inner light." This hints at the "mind's eye" and the transcendent arithmetical world that figured so prominently in Pythagorean thought. Other students of his were called *akousmatikoi*—the word refers to magic and ritual.)

Pythagoras was pious and moral, devoted to the (philosopher's) gods, and a vegetarian, except for beans. He believed in reincarnation—occurring at 216 year intervals, *i.e.*, 6^3, *e.g.*, 6 x 6 x 6 = 216. He freely referred to his past lives and attributed some of his knowledge to them!



TETRAKTYS

As a proto-atheist, Pythagoras prayed as follows to the number 4 (and its triangular culmination in 10, called *tetraktys*):

> Bless us, divine number, thou who generatest gods and men! Oh holy, holy *tetraktys*, thou that containest the root and the source of the eternally flowing creation! For the divine number begins with the profound pure unity until it comes to the holy four; then it begets the mother of all, the all-bounding, the first-born, the never-swerving, the never-tiring holy ten, the keyholder of all. (*The Main Stream of Mathematics*, Kramer, 1989, page 73.)

Pythagoras was a number-theologian! This seems a strange belief, but various sources attest to his great preoccupation with numerology: equating number, things, the divine.

> This early Pythagorean doctrine is puzzling because to us numbers are abstract ideas, and things are physical objects or substance. But *we have made an abstraction of number which the early Pythagoreans did not make. To them, numbers were points or particles.* (*Mathematics: the Loss of Certainty*, Kline, 1980, page 12. Emphasis added.)

Pythagoras' science was not the abstraction we call mathematics, but a "physics" of the numerical particles of matter. As no one could see these units, his challenge was to show his followers how to use their mind's eye to "objectively" see these units of matter in everything, and the "godly" origin of number.

Each of these physical numbers (units of matter) could not be broken or modified in their individual wholeness. They were like unbreakable, indivisible marbles whose unchanging wholeness meant one number was as good as any other—a sort of early *cosmological principle*. Our earth-bound observations of the sky can thus be *extrapolated* to reveal the structure of inaccessible nature. With number having such precise and simple wholeness and "physicality," (the universal yardstick), grandiose extrapolation merely "assented" to arithmetical truth, like 1 + 1 = 2; certainly it was not an act of faith.

This concept of physical number was so strong that a "proper" scientist did not count as we do: "one, two, three...." No! No! He said: "One apple, two apples, three apples...." Numbers were not abstractions as thought today—they were not detachable from things.

Pythagoras was very observant and resourceful. He developed the octave scale in music and discovered the numerical relationship between sound tone and string length, or sound tone and air chamber size. Such relationships confirmed to him that numerical properties exist in nature, and these deeply impressed him. Other

examples were the number of planets (and their "music" [2]) and the rise and fall of fevers.

A crucial consequence of the Pythagorean creed was that mathematical number ruled physical number. *Physics is incarnate mathematics. If matter is simply mathematical, then, as a consequence, mathematical impossibilities limit physical possibilities.* Mathematical laws automatically explain the physical cosmos. Universal Natural Laws were the immediate "fruit" of his scientific "thread" of arithmetic.

Looking once again at the ideal statement of Science, we see that what this really meant to Pythagoras is Science is objective truth—illuminated by an overarching arithmetical "incarnation" as "all" matter. Science is not merely a collection of facts. Arithmetic, as a thread, has properties that may strike many people as not being objective!

Pythagorean number difficulties. To explore Pythagoreanism, we note the reference to 1 + 1 = 2. And what does Pythagorean arithmetic say about 1 – 1 = 0? To them, this is an absurdity! Zero was not a number— remember, "nature abhors the void [3]." Well, what about 1 – 2 = -1? Again, absurd, matter does not have negative properties. Okay, what about 1 + ½ = 1 ½? Again, absurd, fractions would violate the integrity of matter.

First, several comments on zero and negative numbers:

> [Negative numbers] became known in Europe through Arab texts, but most mathematicians of the 16th and 17th centuries did not accept them as numbers or, if they did, would not accept them as roots of equations.... Vieta [1540-1603] discarded negative numbers entirely. Descartes accepted them to an extent. He called negative roots of equations false on the ground that they claim to represent numbers less than nothing.... Pascal [1623-1662] regarded the subtraction of 4 from 0 as pure nonsense. He said in his *Pensees,* "I have known those who could not understand that to take four from zero there remains zero" [e.g., 0 – 4 = 0!].... Lazare Carnot [1753-1823], a well-known French geometer...asserted flatly that the notion of something less than nothing was absurd. (*Mathematics: the Loss of Certainty*, Kline, 1980, pages 114 -115, 154.)

As further evidence of this long-lasting "truth," August DeMorgan, an eminent mathematician, wrote in 1831**:**

> Above all, [the student] must reject the definition still sometimes given of the quantity -a, that it is less than nothing. It is astonishing that the human intellect should ever have tolerated such an absurdity as the idea of a quantity less than nothing. (*Studies and Difficulties of Mathematics*, DeMorgan, 1831, 1943, page 72.)

Next, a word on fractions. Because *one* (the profound pure unit or monad) was the foundation of "science," fractions long met with "cultic" disapproval:

> Official Greek mathematics before Archimedes [287-212 BC] does not have any fractions at all. *This was not because they were not known, but rather because one did not wish to know them.*[4] For, according to Plato, the unit was indivisible and, in Plato's own words, "the experts in this study" were absolutely opposed to dividing the

> unit.... Instead of operating with fractions, they operated with ratios of integers.... The reason why fractions were eliminated from the theory is the *theoretical indivisibility of unity***.** (*Science Awakening 1*, van der Waerden, 1980, page 49, 115. Second emphasis in original.)

Their treatment of π illustrates their belief. Instead of saying that π was approximately 3.14159, they said that π was bounded by the ratio of the integers 223/71 and 22/7 [3.140845 and 3.142856]. While their ratios "looked" like fractions, they were never converted to decimal form or even reduced to 3 10/71 or 3 1/7.

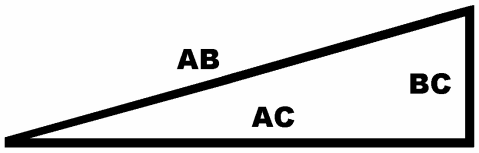
Plato emphasized that Pythagorean science did not allow fractions by stating that attempts to divide and create a fraction would, in turn, be countered by multiplying, to restore wholeness:

> Should someone attempt to partition such a unit, so Plato himself says (Republic 525 E), *all the expert mathematicians* "would laugh at him and would not allow it, but whenever you were turning it into small change, they would multiply it, taking care lest the one should ever appear not as one, but as many parts." (*Greek Mathematical Thought and the Origin of Algebra*, Klein, 1968, page 39. Emphasis added.)

Aristotle summarized the Pythagorean mathematical belief as follows:

> The Pythagoreans first applied themselves to mathematics, a science which they improved; and, penetrated with it, *they fancied that the principles of mathematics were the principles of all things.* (*The Great Mathematicians*, Turnbull, 1929, pages 10-11. Emphasis added.)

The enduring Pythagorean Theorem of geometry is attributed to the Pythagoreans, but it wrecked their intellectual adventure. The Pythagorean theorem: $AB^2 = AC^2 + BC^2$. (Its origin can be traced to ancient Babylon.)



Therein they encountered another absurd number—*irrational numbers*—when trying to calculate certain square roots of triangular relationships. Using an easier example, 10 divided by 3 equals 3.3333...while 4 divided by 2 equals 2. The first answer yields incalculable points or particles—irrationals.

Technically, irrational numbers are not numbers. At least one property of a number is that it can be written down—concisely. For example, 3.333…is not concise. The "..." indicates an endless series of numerals. Also, 10 / 3 is not a number, but a ratio indicating an operation to be performed.

Lacking "physical" existence, irrationals were abhorred—they broke the implicit *continuum* of (whole) numbers. With fractions already banned, irrational numbers would scandalize mathematical law. It would be over 2,000 years before "creative" solutions to this dilemma were developed. Such a pseudo-number

(along with zero, fractions and negative numbers) was not of the same caliber as the profound, pure, indivisible units. In sum, they were *unlawful*! [5]

Matter, that solid weighty material of which stuff is made, could not derive from such numerical indefiniteness! Even worse, the *Tetraktys* became "undivine" in such a fragmented number world. Further, the paradoxes of motion [6] propounded by Zeno of Elea pointedly criticized Pythagorean physical number. Zeno's "paradox of infinity" showed Pythagorean number concepts to be full of irrationals. It rendered motion absurd—as a physical mathematical object!

Pythagorean science failed! Its (complex) fact is not objective truth. Science is not merely a collection of facts, but neither is matter arithmetical!

Plato's innovation. Turmoil prevailed for some time in the wake of the Pythagorean failure. Plato (427?-347 BC) restored calm among thinkers. He championed the founding of mathematics upon the geometric tools of Eudoxus [7] (408-355 B.C.), not upon arithmetic. By comparing lengths instead of calculating distances, geometry avoided irrationals. Arithmetic became a derivative of geometry and was not used on problems that produced irrationals.

> The resolution of the problem [of the irrational]...was to think of all magnitudes geometrically.... When 1 and $\sqrt{2}$ are treated as lengths, that is, line segments, the distinction between 1 and $\sqrt{2}$ is obliterated.... The classical Greeks solved [quadratic] equations geometrically so that the roots appeared as line segments and again the need to use irrational numbers was avoided.... Only geometry could handle incommensurable ratios. (*Mathematics: the Loss of Certainty*, Kline, 1980, page 105.)

Arithmetic—number—was downgraded to be a servant of geometry. The scandal of irrational numbers was not so much solved as swept under the carpet.

Plato's science. Plato's science also had a twofold creed: *matter is geometrical, and geometry is self-evident truth.* With this great universal "thread," facts were to be systematized. "Physical" geometry, in turn, was buttressed by the concurrently formalized deductive proof [8]. Deductive proof and geometry reinforced the practice of "objective" extrapolation on a grandiose scale. Geometric thinking became synonymous with knowledge. Geometrically formulated arguments impelled "assent" to truth; it was not an act of belief in dogma. This (complex) fact opened the door to *monotruth—the priceless single answer*.

Only three (observable) dimensions exist: Euclidean geometry lists them as length, width, and height. From these, area and volume are geometrically derived. Since no geometric figure can be drawn with four or more dimensions, there could be no equations containing the fourth or higher powers.

> The classical Greeks regarded the product of more than three numbers as meaningless because the product had no geometrical significance. (*The Main Stream of Mathematics*, Kraemer, 1988, page 106.)

> All references to a geometry of more than three dimensions before [AD] 1827 are in the form of single sentences pointing out that we cannot go beyond a certain point in some process because there is no space of more than three dimensions, or mentioning something that would be true if there were such a space. (*A Sourcebook of Mathematics*, Smith, 1929, page 524.)

For over two thousand years this physical geometry influenced what thinkers "saw"—such as in astronomy! (And thinkers, in turn, told other people what to "see.")

Plato did use number in his writings [9], but only either-or constructs. There are no intermediate positions (fractions), only brave-coward; smart-dumb; hot-cold, *etc*. Accordingly, his ideas become even more dubious when noting the absence of graduated scales, *i.e*., the absence of fractions.

Plato's hidden (complex) fact. A study of Plato cannot avoid his concepts of forms, ideas, and reason. According to his hints, the pure geometric (and arithmetical) forms existed in...in...in *heaven*. "Immanent" forms were earthly manifestations of this heavenly geometry. For Plato, *reason was divine, a communication from heaven, with the message written in geometry*!

To illustrate how this communication occurred required two steps. In his *Phaedrus*, Plato presents the case of a charioteer and his two horses:

> When the soul comes into sight of a fair and beloved object, the wild horse rushes forward to satisfy his base lust, dragging along his mate...and the driver. At first the driver and the better horse resist ineffectually; but of a sudden there comes to the driver *a remembrance of the pure external beauty he has beheld in a previous existence with the gods*, and, as it were, smitten by the vision, he himself is thrown backwards... (*Platonism*, More, 1969, pages 129-130. Emphasis added.)

From this mistaking of conscience for reincarnation, several have commented upon the next step:

> In a general way we may say this: that the conception of ideas runs parallel in Plato's

> mind with the mythology of a vaguely personal deity. (*Platonism*, More, 1969, page 226.)
>
> Plato justified acceptance of the axioms [of geometry] by his theory of recollection or *anamnesis*.... Humans had experience as souls in another world before coming to earth, and the soul had but to be *stimulated to recall its prior existence* in order to know that the axioms of geometry were truths. (*Mathematics: the Loss of Certainty*, Kline, 1980, page 20. Emphasis added.)

Geometric truths were, indeed, "manna from heaven," communicated through *anamnesis* [10] (remembrance? or mental "transport?"). While *anamnesis* is not an "out of body experience," it certainly was a trip for the "mind's eye."

Plato promoted the so-called Socratic method [11] to prove that others could also recall geometric truths, with training. These "recollections," he claimed, proved that reason discovered pre-existing knowledge, not invented understanding.

Looking once again at the ideal statement of Science, we see that what this really meant to Plato is Science is objective truth—illuminated by an overarching (Euclidean) "geometrical" incarnation as "all" matter. Science is not merely a collection of facts. Geometry, like its predecessor, as a thread, has properties that may strike some as not being objective!

As a further example of geometric causality, Plato explains body growth as follows:

> When the frame of the whole creature is young and the triangles of its constituent bodies are still as it were fresh from the workshop, their joints are firmly locked together.... Accordingly, since any triangles composing the meat and drink ... are older and weaker than its own, with its new-made triangles, it gets the better of them and cuts them up, and so causes the animal to wax large. (*A History of Mathematics*, Boyer, 1968, page 97.)

All these fit Plato's creedal statement. When well-reasoned Greeks said, "Everything is mathematical," they really meant it! It was with extreme seriousness that the sign over the entrance to Plato's academy read: *Let no one destitute of geometry enter my doors.*

For people brought up among pagan sacrifices, oracles, and a chaotic polytheism, these "truths—and the ability of *anamnesis* to reacquaint seekers with the geometric heaven of their "pre-mortal" past—could bring on ecstasy and inspire missionary zeal.

They began to see *geometry in nature*. Like the Pythagoreans before them, they found examples of mathematics (geometry) in nature [12]. *People still do!* (Euclidean) geometry did—and still does—model many features of everyday experience. But how shall we interpret this modeling...or extend its applicability? We will return to this.

The impact on astronomy. Greek "science" drew a sharp distinction between astronomy and physics, and was preoccupied with finding causes—understood as the reduction of phenomena to geometry. When looking at the starry vault overhead, they could see (roughly) circular motion:

> Plato lays down the principle that the heavenly bodies' motion is circular, uniform and constantly regular. Thereupon he sets the mathematicians the following problem: What circular motions, uniform and perfectly regular, are to be admitted as hypotheses so that it might be possible to save the appearances presented by the planets. (*To Save the Phenomena*, Duhem, 1969, page 5.)

Circular motion did not need a physical cause [13]. For this reason, Plato sharply criticized the prevailing opinion regarding the planets:

> The fact is, my friends, that the belief that sun, moon, and other heavenly bodies are 'wandering stars' [14] of any sort is not true. (*Plato: The Collected Dialogues,* Plato, 1989, pages 1391 - 1392.)

The observational discovery that planetary motion can be (approximately) systematized with geometry "confirmed" their science. Astronomy exhibited Platonic form made concrete in circular motion. This was not well-reasoned storytelling or mere "saving the appearances." *It was objective truth, based on geometrical incarnation!* Therein geometrically processed thought triumphed – and beckoned toward a lot of accompanying baggage that could only be seen with the mind's eye.

Ptolemy of Alexandria, Egypt, (*fl.*, AD 127-151) finally succeeded in describing the motion of the planets with the circles of geometry. Ptolemy fulfilled Plato's mandate by adding "equants" to the circular motions—this led to the famous (or infamous) epicycles. As modern critics have had to concede, it was their "damnable excellence" that they succeeded in what they were supposed to do. Ptolemaic astronomy gave the "line-of-sight" direction of the planets. It gave an inconsistent value for the distance to the planets. But "line-of-sight" direction was a valuable aid to navigation.

Ptolemy (or Plato) may have been cautious about the planets because of their inaccessibility, saying that man can only save the appearances. It was not required to ask if such an inaccessible geometrical system was "really real."

Greek science claimed as one of its crowning achievements the conversion of the planets from wanderers into orderly bodies. In other words, astronomy captivated them and highlighted the desire to reach beyond "accessible" (simple) facts. Can science truthfully provide such universal reach—such a grasp of causality so as to justify this grandiose enlargement of knowledge? Why not accept that astronomy is not science—but saving the appearances? Why *must* science give a truthful answer that is beyond its competence? This realistic caution is a respect for atheorism! Maybe astronomy will be science later, but it certainly isn't at the time of the Greeks.

(It is hard to be objective about science operating beyond the experimental

domain.) It would be about two-thousand years before shortcomings with Euclidean geometry became apparent.

Aristotle's science. Turning next to Aristotle, (384-322 BC), he was the most famous pupil of Plato, but he criticized Plato. Aristotle thought that truth came via our senses. The basics of arithmetic and geometry can be learned from playing with pebbles and drawing in the sand. Once these are mastered, the rest of arithmetic and geometry can be developed via human thought. He considered mathematics to be an invention of the mind, therefore subordinate to physical investigation and logical categories.

Aristotle thus downplayed the "cosmic" pretensions of mathematics. He was very observant—it is said that his eyesight must have been remarkably keen to have seen some of the details that he reported. Aristotle emphasized physical investigation of the "here and now." It was proto-empiricism. He wrote on subjects as diverse as biology and physics—and was the father of logic and dialectical argument.

Looking once again at the ideal statement of Science, we see that what this really meant to Aristotle is *Science is objective truth*—illuminated by Aristotelean logic. Science is not merely a collection of facts.

To contrast the two: Plato was mathematically deductive—starting on a cosmic scale; Aristotle was logically deductive—starting from the "here and now." As Aristotle logically extrapolated to the "unmoved prime mover," his system could not be meshed with the geometric outlook of the mind's eye. He undermined the Platonic system. Aristotle's written legacy is much larger than Plato's and was captivating due to its logical cohesiveness. Plato's written legacy was captivating due to its geometrical (and moral and political) cohesiveness.

Advent of true materialism. Meanwhile, Aristotle's criticism or the "certainty" of rigorous geometric proof led many to view geometry as an unabashedly materialistic concept. Geometry began to be seen as "reflecting nature's inherent geometric necessity," without requiring *anamnesis* as the conduit for "manna from heaven." The deductions could be developed without resorting to Plato's geometric heaven, particularly with the publication of increasing numbers of geometry works. Also, after contemplating the perfection of the circle, general acceptance of an infinite cosmos occurred—in spite of Zeno's paradoxes. Mathematics supposedly emancipated reason from polytheism, but Greek thinkers forgot that they clung to mathematical subjectivity. Plato was "promoted" to a figurehead status.

Emancipation from Plato's *anamnesis* required that reason be viewed as self-evident. Despite a flurry of fine words, mathematics and reason are undefined concepts. Reason cannot prove reason—using itself to prove itself is a circular argument. Plato had avoided this circular argument by his *anamnesis*, but most of his successors abandoned it. These later Greek thinkers believed reason pointed to geometry and geometry pointed back to reason. This, however, remained a

circular argument, if one cared to notice, so it was an act of faith to give "assent" to it!
Materialistic thinkers of the day said that science (falsely so-called) was objective truth. But that was shorthand to express, or hide, the real truth: *reason and objective truth and mathematics and grandiose extrapolation and monotruth and infinity and atheism are inseparable.*

Looking once again at the ideal statement of Science, we see that what this really meant to materialists is Science is objective truth—illuminated by a materialistic (Euclidean) "geometry" incarnate as "all" matter—and apprehended by human reason. Science is not merely a collection of facts.

Neo-Platonism. Within centuries, neo-Platonism arose. It developed (reintroduced?) the magic and demons encountered in Pythagorean and some Platonic thought.

Did the pre-Socratics disappear? The earth, air, fire and water folks are honored in the annals of science, but too little is actually available from them to give them higher credence. For atomists, their time had also passed—or would come again. At the least, the name, atom, was to be revived to do yeoman's duty as the atom—as in atomic bomb!

Challenge to the Christian church. The writings of the early church fathers give important witness to the status of these various groups. Gnosticism, in the Fathers' writings, was a Pythagorean and Platonic infatuation. Aristotle was little discussed—I suppose his disdain for the appeal to cosmic ideas meant he was of less threat to Christianity. Atomism also remained—ideas can wax and wane in influence.

> Whatever the allegations of the Greek natural scientists, none of their theses have survived or proved firm, as everything they created was invariably destroyed by their successors; consequently, it is superfluous to contradict them. They destroyed each other. And because they were ignorant of God, they could not agree that an omniscient cause directed the creation of the world. And yet they chose as firm ground this very uncertainty about the origin of things; each constructed his conclusions for himself (St. Basil, AD 330-379).

It should not surprise you that the well-reasoned mindset of science, falsely so-called, in "fulfilling" the lure of objective truth, rejected the Gospel. Acts chapter 17 narrates St. Paul's encounter with such rationalists (and pagans) in Athens. Such folk considered the following Biblical truths to be heretical and unscientific: The proclamation that God had *ex nihilo* created the cosmos; was interested in the cosmos; had visited the earth via His Spirit; had perforated the cosmos by sending His Son to earth; allowed Him to die and then raised Him from the dead [15].

Platonic "Genesis." Plato saw "God" eternally in heaven, non-communicative, and attended by lesser souls who also never descended. The descended masters were definitely lower class, but still exalted. As Plato stated:

> Now, when all of [the class of lesser gods], both those who visibly appear in their revolutions as well as those other gods who are of a more retiring nature, had come into being, the creator of the universe addressed them in these words.... Three tribes of mortal beings remain to be created.... [I]f they were created by me and received life at my hands, they would be on an equality with the gods. In order then that they may be mortal, and that this universe may be truly universal, do ye, according to your natures, betake yourselves to the formation of animals, imitating the power which was shown by me in creating you....

Plato then elaborates on the reincarnational ladder:

> If [the implanted souls in mortals] conquered these [feelings and passions] they would live righteously, and if they were conquered by them, unrighteously. He who lived well during his appointed time was to return and dwell in his native star.... But if he failed in attaining this, at the second birth, he would pass into a woman, and if, when in that state of mind, he did not desist from evil, he would continually be changed into some brute who resembled him in the evil nature which he had acquired....

Plato next reveals the mathematical decay that intervened in "history:"

> And [the lesser gods] did in fact at that time create a very great and mighty movement; uniting with the ever-flowing stream in stirring up and violently shaking the courses of the soul...and they so disturbed the nature of the other or diverse that the three double intervals (that is, between 1, 2, 4, 8) and the three triple intervals (that is, between 1, 3, 9, 27), together with the mean terms and connecting links which are expressed by the ratios 3:2 and 4:3 and of 9:8—these, although they cannot be wholly undone except by him who united them, were twisted by them in all sorts of ways, and the circles were broken.... (*Plato: The Collected Dialogues*, Plato, 1989, pages 1171-1172.)

This is not paganism, but the sacred mathematical subjectivity of the science-of-the-day. It presented its own special cultural barriers.

Christian response. Recall the admonition in 1 Timothy 6:20: "...*avoiding science, falsely so-called*" (KJV). Colossians 2:8 further admonishes: "*Beware lest any man spoil you through philosophy and vain deceit, after the tradition of men, after the rudiments of the world, and not after Christ*" (KJV).

Paradoxically, when thinkers "infatuated with mathematics and logic" contacted the unfamiliar theism of Christianity (monotheism), they were dumbfounded when some Christians (perhaps unwisely) quoted Plato, "God eternally geometricizes!" Applied to Genesis, this meant that order (geometric and logical patterns) evidenced God's design. The cosmos, as God's *poema*, was a stable creation; it was not chaotic, unsystematic or eternal.

Mastering (Euclidean) geometry was thus akin to "thinking God's thoughts after Him." This throttled the atheistic thrust by pointing out that the emerging truths within the "book of nature" bear the imprint of the long-standing truth revealed in Scripture. Both witnessed to the orderly design created by the transcendent God of Scripture.

"Universal" statements could avoid being dismissed as intellectual adventure only if validated by experience or infallible report. Man's reason cannot provide this

validation, having no foundation independent from the selfsame creation. *Only God can validate a cosmic perspective.* Scripture gives His transcendent Revelation, which rebukes the well-reasoned for their extrapolative infatuation.

Such Biblical insight united the faith and reason of men of good will—particularly those converted from science, falsely so-called. The orderly playing field was to yield its secrets without recourse to godlessness, materialism, or meaninglessness. Science flourished in the Christian perforated cosmos of design. Transcendent Revelation's report extends to where objective extrapolation cannot follow, yet mathematicians, observers, philosophers and thinkers found creation's stability and order conducive to their efforts to systematize the accessible. Monotheism provided the anchor, and truth proceeded therefrom.

Looking once again at the ideal statement of Science, we see that what this really meant to Christians is Science is objective truth—illuminated by Biblical Revelation that overspreads creation. (Analytical methods were not specified.) Science is not merely a collection of facts.

Clamoring for attention! But meanwhile, schools of conflicting science dotted the Mediterranean world. "Lovers of truth" were fragmented...polytruth was everywhere! Christian apologists had to address these ideas! In *The Hortatory Address to the Greeks*, the author says:

> You see, then, the confusion of those who are considered by you to have been wise men, whom you assert to be your teachers of religion.... How then, ye men of Greece, can it be safe for those who desire to be saved, to fancy that they can learn the true religion from these philosophers, who were neither able so to convince themselves as to prevent sectarian wrangling with one another, and not to appear definitely opposed to one another's opinions (*The Ante-Nicean Fathers*, Roberts and Donaldson, 1886, 1989, Vol. 1, page 275).

Tertullian, in *On Prescription Against Heretics*, makes his famous comment about Athens and Jerusalem:

> These are "the doctrines" of men and "of demons" produced for itching ears of the spirit of this world's wisdom.... Indeed *heresies are themselves instigated from philosophy*.... The same subject-matter is discussed over and over again by the heretics and the philosophers; the same arguments are involved.... From all these, when the apostle would restrain us, he expressly names philosophy as that which he would have us be on our guard against. [St. Paul] had been at Athens, and had in his interviews (with its philosophers) become acquainted with that human wisdom which pretends to know the truth, whilst it only corrupts it, and is itself divided into its own manifold heresies, by the variety of its mutually repugnant sects. *What indeed has Athens to do with Jerusalem? What concord is there between the Academy and the Church?...* Away with all attempts to produce a mottled Christianity of Stoic, Platonic and dialectic composition! (*The Ante-Nicean Fathers*, Roberts and Donaldson, 1886, 1989, Vol. III, page 246. Emphasis added.)

Scientists and philosophers inspired theologians and vice versa. Their false grasping of the mantle of objective truth was followed by a desire to "improve" or "explain" Scriptural Revelation [16].

Gnosticism. Gnosticism was an eclectic movement that "mixed" Greek ideas with other ideas stirring in the Mediterranean world. Gnosticism reeked of the science of the day! Before giving a quote on gnosticism, consider what was their objective. *It was to reconcile religion and science*.

Gnosticism's challenge to Christianity was the changes it attempted to make to Christianity in order to accommodate Greek "science" and its gods. This Gnostic outlook is commonly called *dualism*: evil matter contrasted with good spirit. Yet, this outlook is far easier to understand as *subordination to the cosmic science of the day. It was making the best of the great reincarnational trek***.** (Starting in a preexistent heavenly perfection, in mental oblivion, finding oneself in the earthly prison on a dungheap, with brief flashes of *anamnesis* for the gnostic few, who then use mathematical and magical "equipment" to safely navigate a return voyage to the higher stars...then back again!) It really was a dualism between the few who were enlightened gnostics and the remaining ignorant lower life forms.

Reaction to Gnosticism. No wonder gnostics had to rewrite the Bible—their "take" on (complex) facts was alien to the Word of God. Gnostics edited and clipped the Bible in order to arrive at an acceptable residue. Gnosticism's appeal: it was the religion compatible with the science of the day.

A selection from *Against Heresies* of Irenaeus, (*ca.* AD 182-188), highlights the sources of gnostic inspiration:

> ... 2. And not only are they convicted of bringing forward, as if their own [original ideas], those things which are to be found among the comic poets, but *they also bring together the things which have been said by all those who were ignorant of God, and who are termed philosophers; and sewing together, as it were, a motley garment* out of a heap of miserable rags, they have, by their subtle manner of expression, furnished themselves with a cloak which is really not their own....
> 3. Again, adopting the [ideas of] shade and vacuity from Democritus and Epicurus, they have fitted these to their own views.... In like manner, these men call those things which are within the Pleroma real existences, just as those philosophers did the atoms; while they maintain that those which are without the Pleroma have no true existence, even as those did respecting the vacuum…. Again, when they maintain that these things [below] are images of those which have a true existence [above], they again most manifestly rehearse the doctrine of Democritus and Plato....
> 4. This opinion, too, that they hold that the Creator formed the world out of previously existing matter, both Anaxagoras, Empedocles, and Plato expressed before them... That God is the slave of this necessity, so that He cannot impart immortality to what is mortal, or bestow incorruption on what is corruptible, but every one passes into a substance similar in nature to itself, both those who are named Stoics from the portico and indeed all that are ignorant of God, poets and historians alike, make the same affirmation.... [17]
> 5.... They also strive to transfer to [the treatment of matters of] faith that *hairsplitting and subtle mode of handling questions which is, in fact, a copying of Aristotle.*
> 6. Again, as to the desire they exhibit to refer this whole universe to numbers, they have learned it from the *Pythagoreans*.... They affirm that from these first principles all things have been made.... These things the heretics repeat, word for word.... he simply sets forth the Tetrad of Pythagoras as the originating principle and mother of all things.

7. .... *Thus, then, by a complete perversion of language, they style ignorance of the truth knowledge: and Paul well says [of them, that {they make use of} "novelties of words of false knowledge."* .... (*The Ante-Nicean Fathers*, Roberts and Donaldson, 1886, 1989, Volume I, pages 376 - 378. Emphasis added.)

Reaction to Atomism. Hippolytus of Portus, around 230 A.D. composed, *The Refutation of All Heresies*. In it we find the following statement about atomism:

Epicurus, however, advanced an opinion almost contrary to all. He supposed, as originating principles of all things, atoms and vacuity. He considered vacuity as the place that would contain the things that will exist, and atoms the matter out of which all things could be formed; and that from the concourse of atoms both the Deity derived existence, and all the elements, and all things inherent in them, as well as animals and other (creatures); so that nothing was generated or existed, unless it be from atoms. And he affirmed that these atoms were composed of extremely small particles, in which there could not exist either a point or a sign, or any division; wherefore also he called them atoms. Acknowledging the Deity to be eternal and incorruptible, he says that God has providential care for nothing, and that there is no such thing as providence or fate, but that all things are made by chance. (*The Ante-Nicean Fathers*, Roberts and Donaldson, 1886, 1989, Volume V, page 21.)

It has been said that atomists were shunned by their compatriots. Next, in the *Recognitions of Clement,* which may have been written before AD 200, or it may be a later work attributed to Clement, is another critique of atomism:

"But you will say, according to the opinion of Epicurus, that successions of atoms coming in a ceaseless course, and mixing with one another, and conglomerating through unlimited and endless periods of time, are made solid bodies…. For they say that those corpuscles, which they call atoms, are of different qualities: that some are moist, and therefore heavy, and tending downwards; others dry and earthy, and therefore still heavy; but others fiery, and therefore always pushing upwards; others cold and inert, and always remaining in the middle. Since then some, as being fiery, always tend upward, and others, as being moist and dry, always downwards, and others keep a middle and unequal course, how could they meet together and form body?

…. And this also I ask: If this expanse of heaven which we see constructed by the gradual concurrence of atoms, how did it not collapse while it was in construction?… And so I go on asking, until the answer comes to nothing and vacuity! (*The Ante-Nicean Fathers*, Roberts and Donaldson, 1886, 1989, Book VIII, Page 170.)

Thus, Christian criticism of Greek "science" existed, yet some early Christian thinkers considered the science of the day to be complimentary to Genesis—but to be read with caution. While we today may think it obvious that they should have avoided this viewpoint, remember the strength of the science of the day. Also, we should think again about today's struggle against the "objective truthfulness" of such adventures as the "big bang."

In one respect the early church Fathers had it "easy"—there were so many schools of Greek philosophy. Obviously, they all could not be true.

What are we to make of Greek "science?" That is, looking once again at the ideal statement of Science, we see that what this really meant to:

The *pre-Socratics* is Science is objective truth—illuminated by the knowledge of earth, air, fire and water—or thereabouts;

The *Atomists* is Science is objective truth—illuminated by the knowledge of atoms;

The *Pythagoreans* is Science is objective truth—illuminated by number;

The *Platonists* is Science is objective truth—illuminated by geometry;

The *Aristotelean* is Science is objective truth—illuminated by logic;

The *Materialists* is Science is objective truth—illuminated by geometry and reason;

The *Neo-Platonists* is Science is objective truth—illuminated by mathematics and the esoteric;

The *Gnostics* is Science is objective truth—illuminated by science and the esoteric;

The Christians is Science is objective truth—illuminated by Biblical Revelation that overspreads creation.

Reflections on the search for truth. The schools of Greek science sounded too much like the corollary argument that religion is subjective! Yes, science is not merely a collection of facts. The "causal [18]" threads are where the treasure is! In each school of science, subjectivity is in the thread of "illumination," taking science beyond the collection of (simple) facts. Indeed, it may be said that science can not keep the two types of facts untangled—the (simple) facts that can be touched or even discovered without the aid of science—and then the (complex) facts, those that are only "seen" with the illumination of overarching knowledge. To transcend (simple) facts requires an objective foundation. The Greeks failed to provide this foundation—(complex) "facts" proved to be ethereal!

The true nature of mathematics remains obscure. It could be a tool of God, even though an unseen concept. And, pagans and Aristotle had their useful proto-empiricism, which used mathematics for practical purposes.

Geometry is required in activities such as construction, surveying and navigation. Circles are circles—they convey no extrapolated knowledge about the cosmos. The cosmos might be orderly due to mathematical essence or created design! Arithmetic was useful—but number has to apply to the broad gamut from bankruptcy (negative accounts) through to all positive values. The cosmos still reveals God's handiwork—created, orderly and finite.

Considering this history, some may yet impatiently ask for the "overarching knowledge to apply to all facts" that others write about. Beyond mathematics,

observation and logic as tools to investigate the accessible, "overarching knowledge" is hard to distill into coherence. These are valuable contributions of the Greeks, but they do not weaken the validity of the Biblical account of origins.

We cannot laugh at those Greek scientists and mathematicians, in spite of their manifest subjectivity as they grasped for the Universal. Some of them developed useful mathematical "tools" and "rafts" of data. Euclid's *Geometry*, Archimedes' work on statics, Ptolemy's work on geography, the work on conic sections, the calculation of the diameter of the earth and the sun, are only a few. These tools apply to both abstractions and mundane problem solving.

(Those today who make grandiose claims for Euclidean geometry as a Universal Natural Law contradict our present-day enthusiasm for non-Euclidean geometry. And we must wonder if "mathematical disasters" lie in the distant future.)

To say that the usefulness of mathematics is a sign of God's design is not to deny our investigative desires. It is the solution to the broad aspects of the puzzle, not the stymieing of the search for knowledge. Some may object that this is "limiting" reason. Rather, such people advocate a subjective "cosmic" reason. Their uncritical emphasis on free and autonomous reason is a blindness in the mind's eye. Such reason has a long history of being unreasonable. Universal Natural Laws have been repeatedly postulated, and just as repeatedly, proven wrong.

Therefore, no scientific tool or fact has been advanced that renders objective the related concepts of atheism, materialism, and meaninglessness. It is unwise to accept the associated collections of "theory dependent facts" as objective. No wonder philosophers of science can only say: *"Well, I have written a large book on science, but in a matter of a few words, I cannot say what science is."* As said at the beginning of this paper, if a modern secularist does not blush at the tenants of Greek science, neither will he blush at the "findings" of relativity, quantum mechanics or astronomy!

Facts and "overarching knowledge" contact each other, but maintain a respectable separation. We must respect this separation and recognize the many fallible bridges thinkers have constructed in vain to grasp the universal. To the chagrin of "scientists," a rock at their feet—or a distant star—or an event long ago—are explained by many "overarching knowledge" systems; but where is truth?

Uncertainty continues until today! Yet unbelief in well-reasoned thought structures (which are unwisely called science) may still seem hard to accept. Nonetheless, thinkers continue to be puzzled by many fundamental things. Comments from several contemporary thinkers may be helpful to us.

Roger Penrose, the eminent British mathematician, values his ancient heritage:

> Whenever the mind perceives a mathematical idea, it makes contact with Plato's world of mathematical concepts.... Mathematical ideas have an existence of their own, and

> inhabit an ideal Platonic world, which is accessible via the intellect only.... [E]ach [mathematician] is directly in contact with the same externally existing Platonic world! (*The Emperor's New Mind*, Penrose, 1989, page 428.)

Penrose even commented upon mathematical truths that are noncomputable.

Paul Feyerabend sarcastically comments on the present state of mathematics:

> The case of mathematics is especially interesting. It was here that abstract thought first produced results and it was from here that the paradigm of true, pure and objective knowledge spread to other areas. But the many approaches mathematics now contains shows no tendency to coalesce into a single theory.... *Today mathematics is less restrained and more pluralistic than any other intellectual discipline.* (*Farewell to Reason*, Feyerabend, 1987, page 72. Emphasis added.)

Morris Kline has a final caution also:

> The efforts to eliminate possible contradictions and establish the consistency of mathematical structures have thus far failed.... Disagreement now extends even to the methods of reasoning.... The claim therefore to impeccable reasoning must be abandoned.... *The recent research on foundations has broken through frontiers only to encounter a wilderness.* (*Mathematics: the Loss of Certainty*, Kline, 1980, page 276. Emphasis added.)

The Bible warns us not to be tossed too and fro by the winds of human wisdom. (I Timothy 6:20.) The early church Fathers still offer useful insights. Irenaeus, (*ca*. AD 200), for example, said:

> Is it a meaningless and accidental thing, that the positions of names, and the election of apostles, and the working of the Lord, and the arrangement of created things, are what they are?—we answer them: Certainly not; but with great wisdom and diligence, all things have clearly been made by God, fitted and prepared [for their special purposes];.... [Mankind's attempts at explanation present] an *uncertain* mode of proceeding, on account of their *varied and diverse* systems, and because every sort of hypothesis may at the present day be, in like manner, devised by any one; so that they can derive arguments against the truth from these very theories, inasmuch as they may be *turned in many different directions*.... For system does not spring out of numbers, but numbers from a system; nor does God derive His being from things made, but things made from God. (*The Ante-Nicean Fathers*, Roberts and Donaldson, 1886, 1989, Volume 1, page 396. Emphasis added.)

Such old advice has up-to-date relevance. Extrapolative infatuation does not stand on a firm foundation.

Review and challenge. In ancient Greece, no consensus occurred, but we may "ignore" their disunity and say that their science was gradually "distilled" into the idea that matter is infinite and incarnate mathematics. This (complex) fact created enthusiasm and drove generations of secularists, enabling them to "seem" objective with their grandiose mathematical models that greatly transcended the experimental realm. Many of its micro aspects proved useful to mankind. But this "distilled" legacy of Greek science, in spite of our rigorous computer programs, our psychological analyses, literary criticisms and a fearfully growing self-doubt, remains foundational to the science of our day.

What is science, today, after the passage of another two thousand years? Has subjectivity finally been purged from "science?" *No*—there are more knots and tangles and ramifications woven into science. That story would be another paper but not another conclusion.

As the prophet Isaiah says in (29:9): *Men are drunk, but not with wine.* Perhaps they are (now) drunk with extrapolative infatuation.

References

[1] The material presented in this paper relies on a pending revision to the writer's *Polyscience and Christianity*. Used with permission.

[2] Much later, Johannes Kepler (AD 1571-1630) tried to write the score for this heavenly music!

[3] Some writers think this cliché was aimed at disproving the atomists–and their void. Whatever the case, there was no void until demonstrated in the AD 1700's.

[4] Fractions were freely used by their Babylonian forebearers.

[5] In the *Manual of Harmonics*, by Nicomachus the Pythagorean (AD 100), the translator and commentator, Flora Levin, says that the Pythagoreans discovered the irrational due to a musical problem instead. The midpoint of a musical octave is an irrational number. (A logarithmic number—but that was unknown then.) Nicomachus, as Levin points out, wrote obscurely as he evaded defining this midpoint. He finally confessed that note, interval, and system were musical terms, not mathematical terms, thereby quietly confessing that all was not number.

[6] Paradoxes of motion: Technically, motion is not paradoxical, but some mathematical attempts to model motion lead to paradoxical mathematics. Zeno's examples of a runner traversing a track or the flight of an arrow were mathematically insoluble by a "physical" arithmetic.

[7] Eudoxus: Perhaps the most renowned astronomer and mathematician of his day. Much of the fifth book of Euclid's *Elements* is his work. Eudoxus' "Method of Exhaustion" was the tool that bypassed the irrational.

[8] Deductive Proof: Geometry illustrates this as its few simple rules (axioms) were (supposedly) used to construct the entire edifice of geometry. (However, recent mathematicians have concluded that Euclid's axiomatic structure was flawed. These flaws weren't noticed earlier because Euclid's axioms were such a "clear" intuition.)

[9] Plato was an accomplished mathematician. See the *Manual of Harmonics*, translated by Flora Levin. She points out various examples of his computations regarding musical problems. Another reference is to *Timaeus* 35b-36b, where Plato summarizes a lengthy calculation on the formation of planetary motion—here understood also as the diatonic musical scale, (the harmony of the spheres), including his proof that there is no center to the octave scale in music—his infamous ratio of 256:243 is irrational.

[10] Amnesia is one word derived from *anamnesis*. It is a strong word—to lose your whole personality is so drastic an effect that it is not proper to merely call it a lack of remembrance. *Anamnesis* conveyed the idea of communicating (or connecting to) an important, but missing, part of your existence or of reality.

[11] Socratic Method: A question and answer procedure recommended by Plato that supposedly showed the ability of people to "recollect." See Plato's example in the *Meno.* The example is not rigorous. Bertrand Russell wrote:

"When...in the Meno, [Plato] applies his method to geometrical problems, he has to ask leading questions which any judge would disallow." (*What is Mathematics: Really?,* Hersh, 1987, page 101*.)*

The believability of the process additionally requires belief in prior existence with the gods. (Plato's ideas about reincarnation [prior existence] included sojourns in the "heavens" between trips back to earth.) Therefore, strictly speaking, the Socratic method did not "teach;" it "stimulated" the remembrance (*anamnesis*) of facts brought in from a prior existence in another world.

[12] Some examples are the geometric structure of crystals; the Fibonacci series in such things as sea shells; the honeycomb structure of bee hive cells. It is not surprising that they found geometry in (an orderly) nature. Once you set your mind to exactly determining the trajectory of an object, geometric forms result. This led to detailed study of variants of the circle, such as the work on conic sections.

[13] Ptolemy (*fl*. AD 127-151) or Aristotle are often blamed for the infatuation with the circular motion of geocentric astronomy! However, as seen here, Plato first mandated the circle as the perfect motion of geometry. Fixation with circular motion dominated astronomy for some two thousand years. Circular motion was "perfect;" it implied perpetual motion, and as such, no "gravity" was required to "cause" its movement!

Many centuries later, Kepler illustrates this in that he first tried to fit Tycho Brahe's observational data into circular orbits. He finally gave up and tried the "inelegant" ellipse. But once he had the ellipse, he next needed a cause for the newfound explanation of motion. It was no longer sufficient to say that it moves because of geometry.

[14] *Planet* is a Greek word meaning "the wanderer." Plato objected to this misnomer because a wandering object would not be following a mathematically described path—a materialistic mandate. For Plato, this meant a circular path. In view of atheorism, what would have been the result if Plato had advocated elliptical orbits? (Would such also save the appearances, but without needing epicycles?)

[15] In addition, the Pythagorean / Platonic viewpoint stipulated that "knowledge" was the key to salvation. Christianity says that a repentant, cleansed heart is the criteria of salvation. Also, Christianity stresses that salvation is open to both men *and* women—of all strata of life! "Scientists of the day" considered that to be contrary to sound reason. They *reasonably* excluded women because of their need to be reincarnated into the higher life form of animal man! This wasn't a sexist statement, because plain, ignorant animal man also had to be reincarnated as gnostic man!

[16] The intent here is not to use these writers to castigate modern inquiry. After all, they themselves sometimes showed the influence of various "sciences of the day" or "common knowledge." The intent is to show the long dispute with grandiose speculations. Only then can we avoid false relations between Athens and Jerusalem—between science, intellectual adventure, and Christianity. The concern continues today.

[17] [Note in reference material]. Our author's demonstration of the essential harmony of Gnosticism with the old mythologies, and the philosophies of the heathen, explains the hold it seems to have gained among nominal converts to Christianity, and also the necessity for a painstaking refutation of what seem to us mere absurdities. The great merit of Irenaeus is thus illustrated: he gave the deathblow to heathenism in extirpating heresy.

[18] Causality: Effects have causes. This does not prove materialism—it could take an infinite regress to "prove" that God cannot be a "first" cause of the cosmos...or up to an infinite journey to prove the cosmos is utterly large and unperforated. The word, *cosmos*, does not imply that a material cause is required to initiate all motion or generate the original matter. The supernatural can create or intervene. This out-of-the-ordinariness identifies a miracle. Further, human thought can initiate local motion in our little spheres of influence. The ahistorical initiation of both of these causal agents is incalculable. The results, though, are calculable.