Galileo and the Church

One century separates the publication of the *Revolutionibus* by Copernicus from the death of Galileo. Within that period, the Scientific Revolution was begun, its Declaration Of Independence from Religion was declared, and its intellectual battle for independence from religion was concluded. The crucial action took place in the 25 year period between Galileo's development of the telescope in 1609 and the abjuration of Copernicanism forced on him by the Roman Inquisition in 1633.

1453	Fall Of Constantinople
1517	Start Of Reformation
1543	Copernicus Published
1545-1563	Council Of Trent
1564	Galileo Born
1609-1610	Telescope, Kepler's Laws *Starry Messenger* Published
1613-1616	Attacks Begin; Letters To Castelli and Grand Duchess; First Inquisition.
1618	Thirty Year War Begins
1623	Barberini Becomes Pope; *The Assayer* Is Published
1632	*Dialogue Concerning The Two Chief Systems Of The World* Published; Second Inquisition
1633	Galileo's Trial, Abjuration, And Sentence.
1638	*Two New Sciences* Published.
1642	Galileo Dies.
1820-1835	Church Recognizes Earth's Motion As True; *Dialogue* Removed From Ban.
1893	Church Officially Rejects Fundamentalism.
1979	Pope Confesses Guilt.

Table 1: Major Dates

Many factors contributed to the Church's decision to subject Galileo to an Inquisition: pressures arising from the Reformation, the Counter Reformation, and the Thirty Year War; the decline in power and consequent political alignment of the Florentine court (Galileo's patron) with Spanish interests against the Pope; the power struggle between Dominicans and Jesuits; Galileo's own combative personality; the sensitivity of Pope Urban VIII to Galileo's perceived slights; the sensitivity, jealousy, defensiveness, and vindictiveness of Aristotelians both in and out of the Church. None of these factors, however, caused the dispute in the first place. That cause was a fundamental disagreement over nature of truth which has not gone away. Things that bother people today concerning scientific claims to truth are virtually the same as those that bothered Church leaders 350 years ago. The record of Galileo's trial lets us examine them with the advantage of hindsight and the perspective of centuries.

The Church burned witches and wizards but no natural philosophers

Christianity like all great religions derives its truths via written and oral traditions which evolve in time, for any system of beliefs which survives long enough to be called ancient must evolve. It must be sophisticated enough to continually re-interpret its basic texts[2]. Moreover, it must provide a range of interpretations to be able to serve the uneducated as well as the educated, the child as well as the adult, and the sinner as well as the saint. A child may need to interpret the "hand of God" literally, but a reasonably mature adult can understand it

to mean something else[4]. Fundamentalism, a single, simple, literal interpretation of Scripture, was never an essential characteristic of Christianity.

Certain basic miracles, especially that of the Resurrection, could not be allegorized by the Church, but a belief in miracles by itself did (and does) not make the Church an enemy of science. In fact reason was needed by the Church to demonstrate to pagans whom they wished to convert that apparently miraculous events not described in Scripture were not due to sources of power independent of the Christian God. This was especially true when those powers could be identified as pagan gods or the demons into which they had been transformed by the Church. That reason depended on the existence of natural law, and that is what science seeks to establish. The comprehensibility of the world requires that natural law be obeyed at least almost all the time.

The Church burned witches and wizards but no natural philosophers. Even philosophers who directly contradicted Church teaching had little to fear. As late as 1440, Nicholas of Cusa had argued—brilliantly, but alas with no factual evidence—that the universe was infinitely large, could have no fixed center, and was populated with an infinite number of worlds; and though this contradicted a literal reading of Scripture, he was made a cardinal. The Church, in any case, did not feel overly threatened by mere speculations of philosophers whose spider-like webs, spun from their own imagination, had neither the backbone of mathematics, nor the flesh of observation.

The Protestant Reformation shook the Church's confidence and ability to absorb new ideas.

One century later however, conditions had changed, and Copernicus dared publish his great opus only from the safety of his deathbed. Yet even then astronomy was not greatly affected. Sensible people still agreed that theories such as heliocentrism, were merely clever calculational techniques, not descriptions of 'truth'. The Church still had no compelling interest in banning a book on a form of astronomy which seemed to merely amount to clever mathematics.

Finally, however, only two years after publication of *De Revolutionibus*, on 8 April 1546, the Council of Trent, that had convened in response to the Protestant Reformation, promulgated Decree 786:

> *Furthermore, to control petulant spirits… in matters of faith and morals pertaining to the edification of Christian doctrine, no one, relying on his own judgment and distorting the Sacred Scriptures according to his own conceptions, shall dare to interpret them contrary to that sense which Holy Mother Church, to whom it belongs to judge of their true sense and meaning, has held and does hold, or even contrary to the unanimous agreement of the Fathers…*

Thus, the Reformation had challenged, and the Council had begun to defend more closely, traditional Church prerogatives, which included the sole authority to interpret Scripture.

The Church questioned the source of Truth.

Complex issues[6] motivated this re-assertion of power. Through the spread of printing, the Scriptures were for the first time available to all believers, and Protestantism held that these new readers, properly illuminated by the Holy Spirit, could interpret Scripture by themselves. But who was properly illuminated?[78].

One way to maintain control was to undermine the Protestants' source of revelation: stand-alone Scripture. The Catholic Church thus began a historical critique of Scriptural text in order to show that the Protestants would be reduced to complete doubt about religion as long as they based their case on their personal reading of it.

Facts depend on interpretation.

Suppose you are given a book called The Bible, but is it? Maybe it contains errors in transcription or translation; and even if not, still, how do you know what the writing means? Ancient Hebrew is still poorly understood; making sense of it relies heavily on scholarship and tradition. The idea that you are reading the original and making up your own mind, that you are an independent agent, is an illusion; in fact you are heavily dependent on authority. If everyone could read a perfect rendition of divinely inspired Scripture the meaning of which was perfectly clear, then there would be no need for a hierarchy to interpret the text. But this is not the case. Thus the need for a tradition of interpretation.

This kind of radical skepticism was extended to include natural philosophy. Galileo talked about the 'Book of Nature' but was that Book, as presented to our senses "The Book"? And how clear was its interpretation? Did that not also need Church guidance?

Another part of the Church's effort to maintain control was the elevation at that time (1567) of Thomas Aquinas to the status of an official Doctor of the Church. The weight of Aristotelian natural philosophy, which he had wedded to Catholic theology three centuries before, was thereby more firmly committed to the support of that theology.

Truth is not merely in outward appearances.

Particularly important was Aquinas' Aristotelian interpretation of the Eucharist. The central question was the miracle of transubstantiation: bread and wine becoming the body and blood of Christ. The Council stated:

> *If any one shall say that, in the Holy sacrament of the Eucharist there remains, together with the Body and Blood of Our Lord Jesus Christ, the substance of the Bread and Wine, and shall deny that wonderful and singular conversion of the whole substance of the Bread into (His) Body and the Wine into (His) Blood, the species* [*i.e.* outward appearance] *only of the Bread and Wine remaining—which conversion the Catholic Church most fittingly calls Transubstantiation—let him be anathema.*

The council's statement is phrased in terms of Aristotelian metaphysics¾the distinction, utilized by Aquinas, between 'substance' (or the 'reality', the 'essence' of a thing), and 'species' (or the 'outward appearance', the 'accident' of a thing[10]). The idea is that the outward appearance of bread and wine remains the same although it actually turns into flesh and blood. The immediate purpose of making Aquinas' view orthodox was to exclude the teachings of Luther who professed uncertainty over the matter and criticized Catholic refusal to discuss it. Besides that, three centuries of similar interpretation had been based on St. Thomas and Aristotle and the Catholic Church naturally felt that it had a great stake in the omniscience of both philosophers.

The philosophic issue is the distinction between outward appearance and inner truth. It is an issue in interpretation of Scripture--its outer versus inner meaning--that was addressed by

Plato in his parable of the cave, and in his theory of Forms. It was to lie at the heart of the dispute between Galileo and the Church.

Science is needed to confirm the miraculous basis of Christianity.

The question of vouchsafing miracles also re-appears here, this time with Protestants in place of Pagans. Perhaps Transubstantiation and in addition, other miracles were being granted to Catholics by divine favor but denied to Protestants? To support such a claim, Catholics had to be able to convincingly identify an event as being a miracle, that is, as being supernatural as opposed to being natural.

Thus, miraculously, Protestantism was an added goad towards an ever more serious study of natural philosophy by the Catholic Church In all these considerations, the presupposition was always the rule of Reason. A miracle was a phenomenon which could only be proven to be indeed miraculous, to be inexplicable by other than supernatural intervention, through the use of reason,.

In summary, at the start of the 17th century, biblical interpretation had become associated with burning theological and social issues, and the Church was vigorously reasserting its authority as the sole interpreter of Scripture. It was also vitally interested in natural philosophy and was prepared to more thoroughly extend its authority to this area. And finally, in conjunction with all this, it felt more strongly than ever committed to defending Aristotelianism.

Fundamentalist Criticism: …the earth's motion was incredible and could not happen, especially since the Holy Scripture was clearly contrary to this claim

Before engaging the deeper meaning of Galileo's trial, it is worth dispensing with the secondary issue of fundamentalism. Galileo's views are clear, and worth repeating in detail.

On Dec. 12, 1613, Father Benedetto Castelli, a former student, current friend, and collaborator of, and successor to, Galileo at the university of Pisa, was invited to dine at the Medicis. Those present included the Grand Duke Cosimo II, his Grand Duchess Maria Maddalena of Austria, the Grand Duke's mother the Grand Dowager Duchess Christina of Lorraine, her confessor, and a fellow professor at the university, Cosimo Boscaglia, who taught Aristotelian philosophy and enjoyed the patronage and friendship of the ducal family. What happened was related in a letter Castelli sent two days later to Galileo[11]:

> *…asked about school by the Grand Duke, I gave him a detailed account and he seemed very satisfied.… asked whether I had a telescope, and I told him Yes and so began to relate the observation of the Medician planets* [moons of Jupiter discovered and so named by Galileo]… .… *Her Most Serene Ladyship* [Cristina]*… began saying to herself*[12] *that they had better be real and not deceptions of the instrument*[13]*. So their Highnesses asked Mr. Boscaglia who answered that truly their existence could not be denied.*
>
> *… before I say what followed, you must know that at the table Boscaglia had been whispering for a long time to the ear of Her Ladyship; he admitted as true all the celestial novelties you have discovered, but he said that the earth's motion was incredible and could not happen, especially since the Holy Scripture was clearly contrary to this claim. …*

At this point … Her Ladyship [Cristina] *began to argue against me by means of the Holy Scripture. I first expressed the appropriate disclaimers, but then I began to play the theologian with such finesse and authority that you would have been especially pleased to hear.… I behaved like a champion, despite the fact that the majesty of their Highnesses was enough to frighten me,… Only Her Ladyship contradicted me, but in such a way that I thought she was doing it in order to hear me. Mr. Boscaglia remained silent.…*

The events surrounding this incident and the increasing attacks upon Galileo since his development of the telescope and publication The Starry Messenger in 1610, made it clear that the faithful Castelli had been set up. He had known he was being drawn into a dangerous discussion of theology, had "expressed the appropriate disclaimers", but then had gone ahead anyway. Prof. Boscalgia said nothing because Her Ladyship, his cats paw, did all that he had hoped for. It was not necessary to win a theological argument, only that natural philosophers be seen as encroaching upon the domain of theologians.

Fundamentalism is an intellectual shambles.

Galileo wrote back one week later. He had since been told more details of the meeting, and after complimenting and reassuring his nervous follower, he made the following comments. They explain the separate domains of science and religion, and the case against fundamentalism. Key portions are indicated in boldface and the whole is summarized at the end.

In regard to the first general point of the Most Serene Ladyship, it seems to me very prudent of her to propose and of you to concede and to agree that the ***Holy Scripture can never lie or err****, and that its declarations are absolutely and inviolably true. I should have added only that,* ***though the Scripture cannot err, nevertheless some of its interpreters and expositors can sometimes err in various ways. One of these would be very serious and very frequent,*** *namely to want to limit oneself always to the literal meaning of the words; for there would thus emerge not only various contradictions but also serious heresies and blasphemies, and it would be necessary to attribute to God feet, hands, and eyes, as well as bodily and human feelings like anger, regret, hate, and sometimes even forgetfulness of things past and ignorance of future ones.* ***Thus in the Scripture one finds many propositions which look different from the truth if one goes by the literal meaning of the words, but which are expressed in this manner to accommodate the incapacity of common people; likewise, for the few who deserve to be separated from the masses, it is necessary that wise interpreters produce their true meaning and indicate the particular reasons why they have been expressed by means of such words.***

Thus, given that in many places the Scripture is not only capable but necessarily in need of interpretations different from the apparent meaning of the words, it seems to me that in disputes about natural phenomena it should be reserved to the last place. For ***the Holy Scripture and nature both equally derive from the divine Word****, the former as the dictation of the Holy Spirit, the latter as the most obedient executrix of God's commands; moreover,* ***in order to adapt itself to the understanding of all people, it was appropriate for the Scripture to say many things which are different from absolute truth, in appearance and in regard to the meaning of the words; on the other hand, nature is inexorable and***

> ***immutable, and she does not care at all whether or not her recondite reasons and modes of operations are revealed to human understanding****, and so she never transgresses the terms of the laws imposed on her; therefore, whatever sensory experience places before our eyes or necessary demonstrations prove to us concerning natural effects should not in any way be called into question on account of scriptural passages whose words appear to have a different meaning, since not every statement of the Scripture is bound to obligations as severely as each effect of nature. Indeed, because of the aim of adapting itself to the capacity of unrefined and undisciplined peoples, the Scripture has not abstained from somewhat concealing its most basic dogmas…*
>
> *Given this, and moreover it being obvious that two truths can never contradict each other,* ***the task of wise interpreters is to strive to find the true meanings of scriptural passages agreeing with those physical conclusions of which we are already certain and sure from clear sensory experience or from necessary demonstrations****. Furthermore, as I already said, though the Scripture was inspired by the Holy Spirit, because of the mentioned reasons many passages admit of interpretations far removed from the literal meaning, and also we* ***cannot assert with certainty that all interpreters speak by divine inspiration; hence, I should think it would be prudent not to allow anyone to oblige scriptural passages to have to maintain the truth of any physical conclusions whose contrary could ever be proved to us by the senses and demonstrative and necessary reasons. Who wants to fix a limit for the human mind? Who wants to assert that everything which is knowable in the world is already known****? Because of this, it would be most advisable not to add anything beyond necessity to the articles concerning salvation and the definition of the Faith, which are firm enough that there is no danger of any valid and effective doctrine ever rising against them.*
>
> *…,* ***I do not think it necessary to believe that the same God who has furnished us with senses, language, and intellect would want to bypass their use and give us by other means the information we can obtain with them****. This applies especially to those sciences about which one can read only very small phrases and scattered conclusions in the Scripture, as is particularly the case for astronomy, of which it contains such a small portion that one does not even find in it the names of all the planets; but if the first sacred writers had been thinking of persuading the people about the arrangement and the movements of the heavenly bodies, they would not have treated them so sparsely…*

His major points in brief are as follows:

1.Scripture is true but interpreters may err[14]. Galileo sets up the analogy between two assumed sources of fact: scripture and phenomena. Both are and need to be interpreted. The meaning of Scripture depends on the meaning of its words, and word meanings are notoriously slippery. The meaning of experience is filtered through our sensory apparatus. Both scripture and phenomena must be fitted and are fitted to the templates within us that determine what is information and what is noise. This view is *partially* Sophistic. Does it say (along with Protagors) that *Man is the measure of all things*; and does it say (along with Nietzsche) that *All is interpretation*? Well, yes, but, that depends on what you mean by *all*, by *things*, by *is* ! Man is also the measure of what this words mean

2.It is already well known that Scriptural interpretation is necessary since literal meanings lead to internal inconsistencies and violations of basic religious principles.

3.*In order to adapt itself to the understanding of all people, it was appropriate for the Scripture to say many things which are different from absolute truth, in appearance and in regard to the meaning of the words.* The job of *the wise interpreter* is to explain the true meaning and origin of these inconsistencies. In talking about *absolute truth* Galileo distinguishes his sophistic thinking for the normal kind. Clearly, absolute truth, whatever it is, cannot be subject to interpretation. Absolute truth is itself reached by correct interpretation, by passage—education-- from the cave of ignorance to the light of reality.

4.Both Nature and Scripture ultimately come from God (*equally derive from the divine Word*).

5.Nature is not required, like Scripture, to tailor the truth to fit the mental capacities of all people.

6.Since Nature presents the straight truth concerning physical phenomena while Scripture is not so constrained, lessons learned from Nature via sense and reason must take precedence over Scripture.

7.It is not prudent to base religious belief on statements which may turn out to be demonstrably wrong by a science whose future bounds are unknown to us. Somewhat later in support of this, Galileo quotes St. Augustine as follows [Ref. 5, p. 186]: *whenever the experts of this world can truly demonstrate something about natural phenomena, we should show it not to be contrary to our scriptures.*

8.We do not know if those who argue from Scripture are divinely inspired, but they certainly seem to be unable to understand Science.

9.It seems unreasonable that *the same God who has furnished us with senses, language, and intellect would want to bypass their use* and teach Science in another way, especially through Scripture which barely discusses it.

In addition to these points, Galileo discussed the specific passage in Joshua the interpretation of which had been brought up at the Medicis. This unfortunately was what Galileo's enemies had hoped for because first Castelli and then Galileo had now both done what the Council of Trent had forbidden; they had interpreted Scripture according to a Copernican illumination.

Copies of this letter gradually circulated, one finally finding its way to a Dominican named Lorini, a Florentine professor of ecclesiastical history and member of an anti-Galileo conspiracy which had formed when Galileo had publicly espoused Copernicanism. He sent it via a sympathetic Cardinal to the Congregation of the Holy Office, "by the mercy of God, cardinals of the Holy Roman Church, Inquisitors-General throughout the Christian Commonwealth against heretical pravity"[15]Thus, on February 7, 1615, two years after Castelli's gentle inquisition at the hands of the Medici family, the Roman Inquisition heard of the incident.

The basic argument between the Church and Galileo was about the very nature of truth.

Lorini accompanied the letter with the following comments

> *All our Fathers of this devout convent of St. Mark are of opinion that the letter contains many propositions which appear to be suspicious or presumptuous, as when it asserts* ***that the language of Holy Scripture does not mean what it seems to mean; that in discussions***

> ***about natural phenomena the last and lowest place ought to be given to the authors of the sacred text; that its commentators have very often erred in their interpretation; that the Holy Scriptures should not be mixed up anything except matters of religion . . .; that in Nature philosophical and astronomical evidence is of more value than holy and divine*** *(which passages your Lordship will find underlined by me in the said letter, of which I send an exact copy....*
>
> *… they expounded the Holy Scriptures according to their private lights and in a manner different from that of the common interpretation of the Fathers of the Church; that they strove to defend an opinion which appeared to be quite contrary to the sacred text*[17]*; …* [Ref. 16, p.45]

Lorini doctored his copy of the letter to Castelli sent to the Inquisition so as to make Galileo look bad. Despite this, the Inquisitor assigned to the case found nothing of consequence to censure[18]. In particular, nothing was wrong with Galileo's contentions (1) that *the language of Holy Scripture does not mean what it seems to mean;* or (2) *that in discussions about natural phenomena the last and lowest place ought to be given to the authors of the sacred text* which in effect means that a literal interpretation of Scripture does not take absolute precedence in determining the truth of natural phenomena. The Inquisitor did not question Galileo's denial of this fundamentalist assumption.

Furthermore, in none of the subsequent controversy between Galileo and the higher echelons of the Church was fundamentalism ever the basic issue. The points Galileo made in the letter to Castelli were not questioned. By default, the Church agreed that Scripture did not teach natural philosophy but that instead, natural philosophy, using (God-given) *senses, language, and intellect,* determined the proper interpretation of descriptions of the natural phenomena found in Scripture. And although it took the Church almost three hundred years to do it, they finally explicitly reaffirmed in writing their basically non-fundamentalist tradition[19]. As St. Augustine had said: *whenever the experts of this world can truly demonstrate something about natural phenomena, we should show it not to be contrary to our scriptures.*

Thus despite ambiguities and waverings under fire[20], the Catholic Church, at least as it was defined by its highest leaders and in accord with its highest interests, was not fundamentalist. Its basic argument with Galileo was about far more fundamental issues than simplistic fundamentalism. It was about the very nature of truth.

Cardinal Bellarmine distinguished between scientific and metaphysical truth, only the latter being God's, or absolute, or Real, or…, Truth.

We have an insight into the thinking of the Church's chief theologian during this period. In 1615 a small pro-Copernican book was published by Carmelite Father Foscarini. He had asked for Cardinal Bellarmine's opinion of it, and the answer made the following points (Ref. 16, pp.98-100):

> *1. It seems to me that your Reverence and Signor Galileo act prudently when you content yourselves with speaking hypothetically and not absolutely, as I have always understood that Copernicus spoke. To say that on the supposition of the Earth's movement and the Sun's quiescence all the celestial appearances are explained better than by the theory of*

eccentrics and epicycles is to speak with excellent good sense and to run no risk whatever. Such a manner of speaking is enough for a mathematician. But to want to affirm that the Sun, in very truth, is at the center of the universe and only rotates on its axis without going from east to west, is a very dangerous attitude and one calculated not only to arouse all Scholastic philosophers and theologians but also to injure our holy faith by contradicting the Scriptures.…

3. If there were a real proof that the Sun is in the center of the universe, that the Earth is in the third heaven, and that the Sun does not go round the Earth but the Earth round the Sun, then we should have to proceed with great circumspection in explaining passages of Scripture which appear to teach the contrary, and rather admit that we did not understand them than declare an opinion to be false which is proved to be true. But, as for myself, I shall not believe that there are such proofs until they are shown to me. Nor is it a proof that, if the Sun be supposed at the center of the universe and the Earth in the third heaven, everything works out the same as if it were the other way around. In case of doubt we ought not to abandon the interpretation of the sacred text as given by the holy Fathers.…

The heart of his first argument is: *To say that …. all the celestial appearances are explained better* [by Copernicus than by Ptolemy] *…..is to speak with excellent good sense ….* [and]*…. is enough for a mathematician. But to want to affirm* [this] *in very truth …..is a very dangerous attitude*. Bellarmine is, in effect, distinguishing between scientific and metaphysical truth. The first is that which, on the basis of what has been discussed as reduction, leads to a simpler and wider understanding of phenomena, the second is, as it were, God's, or absolute, or Real, or… Truth.

The second of the arguments quoted concedes that *real proof* of truth is attainable outside Scripture, and admits that scriptural interpretations must be revised when in disagreement with truth. Bellarmine thus shows himself to be a non-fundamentalist (in fact, he had been one of the leaders in the Jesuit's attack on Protestant fundamentalism discussed earlier). But, although he says what it is not, he does not say what real proof is.

Barberini pointed out that God has a choice out of many many ways to explain phenomena.

Sometime during the period (1615-1616) now being discussed, while Barberini, the future pope, was still both a cardinal and a friend of Galileo, they are reported to have discussed Copernicanism. Barberini's views as expressed in their conversation has been imaginatively reconstructed by Santillana from a number of sources (Ref. 16, p.166) as follows.

Let Us grant you that all of your demonstrations are sound and that it is entirely possible for things to stand as you say. But now tell Us, do you really maintain that God could not have wished or known how to move the heavens and the stars in some other way? We suppose you will say 'Yes,' because We do not see how you could answer otherwise. Very well then, if you still want to save your contention, you would have to prove to Us that, if the heavenly movements took place in another manner than the one you suggest, it would imply a logical contradiction at some point, since God in His infinite power can do anything that does not imply a contradiction. Are you prepared to prove as much? No? ***Then you will have to concede to Us that God can, conceivably, have arranged things in an entirely***

different manner, while yet bringing about the effects that we see. And if this possibility exists, which might still preserve in their literal truth the sayings of Scripture, it is not for us mortals to try to force those holy words to mean what to us, from here, may appear to be the situation.

In fact, astronomy, the first of the mathematical sciences, was already known to provide three equivalent ways of looking at the world: that due to Ptolemy, Copernicus and Tycho. Maybe there were even more. In the sense that each agreed with observation, each was true. So in general, how would you ever know whether all versions of truth have been found and which of them, if any, is the one favored by God? Thus Barberini maintained his intellectual right to believe (concerning that miracle in Joshua which since Castelli's meal at the Medici's was still serving as the framework of these discussions) that there was a truth favored by God in which the Sun really had stopped.

The story of this conversation ends with the statement that Galileo finally fell silent. The understanding, at least of the storyteller (Barberini's papal theologian), was that the future Pope had won the argument.

The Aristotelians maintained that number could not fully describe reality.

Elsewhere Bellarmine contended that mathematics is a shaky guide to the truth; it may provide hypotheses but not proofs. The whole tradition of Aristotelian philosophy supported this view and some of its rationale goes as follows:

1.A)Mathematics makes exact statements whereas nothing can be measured exactly. Mathematics distorts the world with this innate and unrealistic idealization.

1.B)Number and quantity are 'accidental' as opposed to an 'essential' property of matter. Thus mathematics is limited to specifying and predicting outward appearances.

1.C)Numbers are ideas abstracted from reality but abstractions are not real.

1.D)Mathematics cannot describe motion and change which is the heart of physics.

The first three are interrelated metaphysical points which will be treated first. In some more detail:

1.A asks what mathematics' perfect circles, perfectly straight and infinitely thin lines, and so on, have to do with a reality which seems to be, instead, a 'more or less' kind of world, a place of fuzzy edges and fuzzy logic? This is perhaps the most commonly expressed worry about the ability of 'pure' mathematics to describe the 'impure' world our senses inform us is out there.

1.B refers to statements such as: the number of sheep in a flock has nothing to do with the essence of being sheep; or, lengths and angles might describe the shape of a stone sculpture, but nothing about stoniness—the essence of being a stone. A more recent versions of this is: number might describe the behavior of all the chemicals which make up the human body, but how can it describe the essence of being human (life, consciousness, emotion, …).

1.C is the idea that the number one does not exist—only one something exists—in external reality.

In contrast to the first three points, the last one (1.D) requires some preliminary explanation. It comes from the difficulty we have in describing the continuum: what is the relation between the real number system, mathematical points and lines, and physical space and time?

Every *direct* distance measurement, from that of a wooden ruler to an atomic wavelength, must always yield a rational number[21]. Similarly, direct measurement of the coordinate distances along axes (Figure 1) as well as the distance to the origin of points with those coordinates will all yield a rational numbers. This seems to imply that every physical distance corresponds to a rational number: that the ratio between the distance between any two points and some unit of distance is of form m/n where m and n are integers. This conclusion was believed by everyone before about the 5th century BCE and is still believed by many today. Nevertheless, it is logically contradictory to maintain all these distances are truly rational.

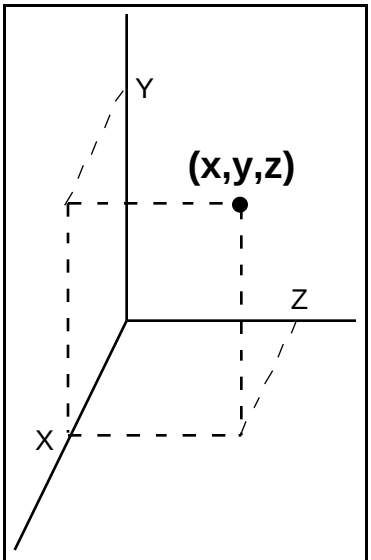

Figure 1: Must x,y, and z be rational numbers? Any direct measurement of them yields a rational number.

The Pythagorean discovery of the non-commensurability of the legs and hypotenuse of an isosceles right triangle destroyed this idea. For the next two thousand years, as long as number meant integers and rationals, this discovery stalled the Pythagorean program for physics. It was still doing so during Galileo's trial, as Bellarmine's first point demonstrates. People near the start of the seventeenth century understood the rational but not the real number system. And in particular, they had not made the connection between the points on a straight line and the real numbers. Thus, for them, number could not exactly describe space.

This left geometry—still logically distinct from arithmetic until Descartes—for the description of space. However physics could not rely on geometry alone because physics described change and hence also involved time and when space and time are mixed, even geometry had problems. These trace back to Zeno of Elea (*circa* fifth century BCE) who presented them in the form of four paradoxes which purported to show that motion is impossible[23]. All have a similar character, and the first, called the *Dichotomy*, will be enough for our purposes. As quoted by Aristotle it says:

> *There is no motion because that which is moved must arrive at the middle [of its course] before it arrives at the end.*

Replacing the end by the middle, the same thing must be said about arriving at the point midway to the middle. This can be repeated forever: each middle becomes an end which is preceded by another middle. If the process never ends, how can something in motion ever arrive at its endpoint, and thereby end the process?

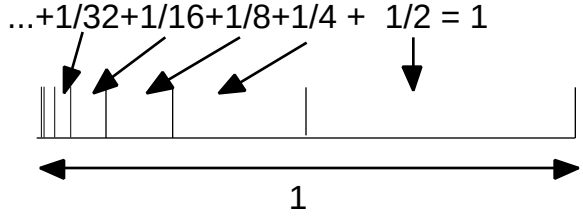

Figure 2: Zeno's Dichotomy

The usual response is that the series of times taken to travel between 'middles', say at constant speed, adds up to a finite sum proportional to (1/2 + 1/4 + 1/8 + …= 1) so the moving object gets to its end in a finite time. This is true but does not answer the question. It tells us how long the arrow would take to get to the end,

if it could, but does not explain how it can. How can an endless process actually end. There is an inconsistency in the way we talk about space, time and motion revealed by the paradox which needs to be clarified[25].

It is not necessary to know whether or not Cardinal Bellarmine understood the problems of non-commensurability and dichotomy in any depth. It is sufficient that he judged that various experts who did understand them were not the obstructionist fools which simplistic histories have made them out to be. Mathematics, as then understood seemed to be quite possibly not up to the job of describing space and motion let alone questions affecting both ultimate truth and reputation of Christianity.

Summary Claim of the Church: The Truth of revelation is beyond that of Science, and there is a Reality that lies beyond the descriptive potential of Mathematics.

Galileo and the Church were not arguing over the possibility of miracles; both agreed that they occur.

Neither were they arguing over fundamentalism. Although fundamentalists could be found throughout the Church hierarchy, its authoritative heads were free of it because of both religious tradition and the then current fight against Protestant predilections towards it. Galileo's arguments on this point, as expressed in his letter to Castelli, were never seriously disputed.

Neither was freedom of speech or of inquiry central to these discussions. Although here again the hierarchy's actions were not blameless, neither were they very different from modern practice in free societies.

Neither did they argue over the data. Galileo did engage in important scientific disputes with natural philosophers as part of the normal course of doing science (and these comprise the great bulk of his writings), but Bellarmine and Barberini were not competent or interested in such technicalities. They were willing to grant both the observations, and the efficacy of Copernicanism in describing them.

Similarly, although much has been made of the fact that early telescopes were hard to use and could give untrustworthy results, this also was not important. If the testimony of the telescope had been seriously suspect, Galileo's influence would have rapidly vanished. He would have posed no threat and no trial would have occurred.

What were the core issues. They depend on with whom one argued, Barberini or Bellarmine. The former denied our ability to discover Truth except through revelation; thus science could not discover it. The latter, on the other hand, allowed that science could discover Truth but would not recognize the authority of mathematics to describe it much less provide the criteria (the mathematical simplicity of Copernicanism) for it. These core issues remain unsettled to this day.

No one doubts the pragmatic value of scientific truth.

There is a pragmatic meaning to truth which not in dispute. People have always given such a sense to the word; they take to be true whatever they perceive as useful to be so taken--whatever works. Since Galileo the area in which science has gained (what William James called[26] in a definition of pragmatism) a *cash value in experiential terms* has continually expanded. Today, certainly in this sense, we know that to say something is *scientifically true* is to award it top honors for reliability and utility, and hence, for truth.

At that time, Bellarmine did not think that Copernicanism had proved itself pragmatic. Although it agreed with astronomical data, so did the Ptolemaic theory. Although it was mathematically simpler, that just made it useful for mathematicians. It did not agree with the generally accepted physics of the day. And it violated the cosmology that had been developed over the centuries to support Christian tradition and morality. He could reasonably argue that, in net, it was not yet true.

Galileo, who was also a pragmatist, nevertheless insisted to the contrary, that Copernicanism was true. He concluded this from an understanding of physics that was deeper than that of his opponents, the Scholastic followers of Aristotelian, upon whose expert views Bellarmine necessarily depended. Evidence of this depth appears throughout his writings in which he exposes their inconsistencies, vagaries, and factual errors. Even taking into account that it is Galileo their opponent who is describing them, and created the modern viewpoint from which we are seeing them, they perform surprisingly poorly in these accounts. Why did these Aristotelians, successful and presumably intelligent men of their time, put on such a hapless performance?

Aristotelian opponents of Galileo were not even wrong.

Their views strikes us today as *not even wrong*--not even to the point, from another, an intellectually foreign, world. Their physical reasoning rarely went beyond verbal classification, referring to things which liked to rise, or liked to fall, things which were pure or impure, and so on. They were not prepared to proceed beyond this: to give any other than verbal, qualitative explanations based on classification. Classification is a process that characterizes the first stage of knowledge in any field, and remains characteristic of it as long as the field resists deeper analyses. It is the process by which we create and given names to sets of objects sharing certain properties. By doing this we identify those properties deemed essential to understanding behavior preparatory to then classifying behavior patterns in terms of them.

The property of being heavy is shared by all members of the set of heavy things. It is understood through muscular sensation. If a thing is heavy, we can predict something about how it will feel to hold it. But then we can also predict that it is likely to fall. By establishing a connection between muscular sensation and possible movement, heaviness aids in data reduction. We need not create and carry along in memory another classification of objects: those with a "tendency to fall". Heaviness *predicts* this other property.

This kind of tool has been discussed before under the topics of ideals and of abstractions: heaviness does not exist in the phenomenal world, the world of Becoming, but is an idea abstracted from it. It is a Platonic ideal; it exists in the world of Being. Ideals/abstractions discussed previously included 'one' and 'sheep'.

The destruction of the Aristotelian worldview required a massive conflagration which required the fuel of technological development, the match of individual genius, and a vision of maximally reduced natural law.

Most sciences have gotten beyond this stage of analysis and reduction only within the last century. Astronomy, through the use of mathematics, was the first study to do so. There were very few other naturally occurring systems here on Earth that were *not* too complex to be similarly analyzed. Because they were so rare, it took rebellious genius to sense that this approach could extend beyond astronomy. It also took time for mathematics to develop to

where it could be used in these new situations. It took time to realize that systems could be made (unnaturally) available to analysis through the technique of experimentation. Part of that time was required for examples of early pioneers to accumulate; part, to develop technical abilities in manufacture; part, to develop social conditions in which to learned men devoted themselves to experimentation. When that time came, and the fuel was in place, the spark of just a few set off the intellectual conflagration that is modern science, and with it, the modern world.

Abstraction, classification, naming, *etc.*, define one level of understanding, and along with it, one level of pragmatic truth. Galileo was one of the few who recognized the possibility of a deeper, essentially mathematical, level of truth. In his Dialog Concerning Two World Systems, the character representing Galileo asks that representing Aristotelian philosophy (Simplicio) to describe *by what cause heavy bodies are conducted downward*. The reply is that *anyone knows that it is gravity*, to which Galileo's character rejoins, *You are mistaken, Signor Simplicio, you ought have said: anyone knows that it is called gravity.* We have named a cause and can classify phenomena as being due to it, but that does not mean we know anything about it.

With the example set by the development of the Copernican system, Astronomy provided the example of how to proceed beyond this intellectual dead end. Astronomy did much more than classify heavenly bodies and their orbits. It measured precise trajectories, and this knowledge revealed the higher simplicity (= higher in the ladder of forms) of the Copernican system. Thus a precise measurement of the trajectory of projectiles might lead to similar insights, similar higher simplicities, which of course it did. Knowing that projectile trajectories were of constant downward acceleration and constant horizontal velocity still did not teach us the *cause* of either that acceleration or velocity--the causes are still just given names like gravity and inertia-- but nevertheless we did learn a lot. We learned useful, pragmatic truths at higher, more abstract, levels: concepts such as velocity and acceleration which precisely connect large varieties of phenomena and thereby provided greater amounts of reduction.

Galileo did not to make Science into a religion.

The discussion of pragmatic truth addresses only the objections of Bellarmine. In that context, events have shown Galileo to be correct: Copernicanism was the truth. But the objection of Barberini concerning a level of truth that remains hidden from scientific inquiry--a God's truth--is unaffected by this. Such truth is paradoxical. On the one hand, being hidden from science implies that it concerns facts that have no effect on phenomena, for if they did, they would no longer be hidden. On the other hand, through their influence on human behavior, they do effect phenomena. Thus beliefs affect behavior irrespective of their truth. Furthermore, hidden truth can never be tested and therefore, never proven nor disproven.

The classic definition of being real is being able to influence phenomena. If spiritual beliefs/truths can indirectly even indirectly effect phenomena, they are real even though the things about which they purport to be true may not be real (by the same definition)! All this emphasizes the fact that what is real and true is not as unambiguous as it is sometimes made out to be, and that talk about the existence of a 'spiritual' truths needs to be rather carefully addressed.

When Galileo heard Barberini's argument he is said to have offered no response. This can be interpreted in more than one way and Galileo may have been even wiser than commonly thought.

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[1]Fishbane, Michael, *Biblical Interpretation In Ancient Israel,* (OUP, Oxford, 1985).

[2] Michael Fishbane begins Ref.1 as follows:

> *One of the most remarkable features of the great world religions is the emergence to independent dignity of traditions and commentaries which supplement the original authoritative teachings—be these latter the product of divine revelation or human wisdom.*

Judaism's emphasis on this need is so great that the student and the scholar, not the pious, is

> *…its central religious type, and God himself [serves as the] prototype. …the early rabbis actually portrayed their God [allegorically] as a scholar of his own Torah, and as subordinate to the decisions made by the disciples of the wise! [Ref. 1, p.3]*

[3]Maimonides , *A Maimonides Reader*, Isadore Twersky ed., (Behrman House, West Orange, 1972).

[4] Maimonides expands on this as follows [Ref. 3, p.44]:

> *…what is the meaning of the following expressions found in the Torah: "Beneath His Feet" (Ex. 24:10); "Written with the finger of God (ibid. 31:18); "The hand of God" (ibid. 9:3); "The eyes of God" (Gen. 38:7); "The ears of God" (Num. 11:1); and similar phrases? All these expressions are adapted to the mental capacity of the majority of mankind who have a clear perception of physical bodies only. The Torah speaks in the language of men. All these phrases are metaphorical, like the sentence "If I whet my glittering sword" (Deut. 32:41). Has God then a sword and does He slay with a sword? The term is used allegorically and all these phrases are to be understood in a similar sense. …*
>
> *…But God's essence as it really is, the human mind does not understand and is incapable of grasping or investigating. And this is expressed in the scriptural text "Can you, by searching, find out God? Can you find out the Almighty to perfection?" (Job 11:7)*
>
> *…the expressions in the Pentateuch and books of the Prophets …are all of them metaphorical and rhetorical, as for example, "He that sits in the heavens shall laugh" (Ps. 2:4), "They have provoked Me to anger with their vanities" (Deut. 32:21), "As the Lord rejoiced" (ibid. 28:63), etc. To all these phrases, applies the saying "The Torah speaks in the language of men." So too, it is said "Do they provoke Me to anger?" (Jer. 7:19); and yet it is said "I am the Lord, I change not" (Mal. 3:6). If God were sometimes angry and some times rejoiced, He would be changing. All these states exist in physical beings that are of obscure and mean condition, dwelling in houses of clay, whose foundation is in the dust. Infinitely blessed and exalted above all this, is God, blessed be He.*

[5]Fantoli, Annibale, *Galileo*, G.V.Coyne trans., (Vatican Observatory Publications, 1994)

[6]Dear, Peter, "The Church And The New Philosophy", in, *Science Culture And Popular Belief in Renaissance Europe,* Stephen Pomphrey, Poalo Rossi, Maurice Slawinski, eds. (Manchester U.P., Manchester, 1991)

[7] The Catholic and Protestant establishments alike had problems more down to earth than those of mere astronomy which could stem from false illumination. In 17th century England for example, there were Puritans, Baptists and then a number of smaller groups—a religious 'left', which included the Familists, Muggletonians, Behemists, Fifth Monarchy Men, Levellers, Diggers, Anabaptists, Ranters, Seekers, and Friends. All had social, political, economic and moral ideas which they perceived to be closely related to, if not derived from, their interpretations of Scripture. On the far left were the 'New Left' of that era: the Seekers espoused prostitution and drunkenness, the Ranters (it was said) held orgies, and the Diggers called for an end to class rule, private property, and wage labor. Even towards the 'right', the Puritans came to revolutionary enough conclusions to fight a civil war with the adherents of the established church. Scripture had a wide range of interpretations and a breach in control over it threatened not only Catholicism, but also many established social norms.

[8]Kubrin, David, "Newton Inside Out" in ,*The Analytic Spirit*, Harry Woolf, ed. (Cornell U. P., Cornell,1981).

[9]Popkin, Richard H., "Scepticism and the Study of History", in , *Physics, Logic and History*, W. Yourgrau and A.D.Breck, eds. (Plenum, New York, 1970).

[10] Aristotle gives two kinds of examples: (1) a musical man might be pale but paleness is not an essential attribute of musicality, it is an accident of circumstance; (2) A triangle has the property that the sum of its angles add up to two right angles—always true but the 'essence' of being a triangle is having three sides from which the other property follows (as secondary). This is also called an accident even though plane geometry proved it always to be true. If we should find a triangle whose angles did not add to two right angles, it would be a miracle of the same type as Transubstantiation.

[11]Finocchario, Maurice A., *The Galileo Affair,* (U. Cal Press, Berkeley, 1989).
[12] The vision of Alice's Red Queen muttering "Off with his head!" somehow comes to mind.
[13]People had been looking through spherically shaped glass for a long time and spurious optical effects were well known. A comment about them by Plutarch (first century CE) was known.
[14]This of course was just the problem with the Protestants as viewed by the Catholics, and vice versa.
[15]See footnote of Ref.16, p. 29.
[16]Santillana, Giorgio De , *The Crime Of Galileo,* (University Of Chicago Press, Chicago, 1955).
[17] The letter continues as follows:

> *that they spoke in slighting terms of the ancient Fathers and of St. Thomas Aquinas; that they were treading underfoot the entire philosophy of Aristotle which has been of such service to Scholastic theology; and, in fine, that to show their cleverness they were airing and scattering broadcast in our steadfastly Catholic city a thousand saucy and irreverent surmises; when, I say, I became aware of all this, I made up my mind to acquaint your Lordship with the state of affairs, that you in your holy zeal for the Faith may, in conjunction with your most illustrious colleagues, provide such remedies as will appear advisable….*
>
> *I, who hold that those who call themselves Galileists are orderly men and good Christians all, but a little overwise and conceited in their opinions, declare that I am actuated by nothing in this business but zeaI for the sacred cause*

Santillana's comments are worth quoting (Ref. 16, p. 46):

> *Lorini had displayed suitable priestly charity by describing the errant characters as "good Christians all, but a little overwise and conceited in their opinions" (un poco saccenti e duretti nelle loro opinioni). In his heart, however, he felt otherwise; they were black souls who did not deserve justice, let alone mercy, and nothing should be left undone for their destruction. His indomitable zeal thought nothing of boldly forging a couple of heresies in his "exact" copy of the letter at the most opportune spots. Galileo had written: "There are in Scripture words which, taken in the strict literal meaning, look as if they differed from the truth." Lorini wrote in stead: "which are false in the literal meaning." Galileo had written: "Scripture does not refrain from overshadowing [adombrare]l~ its most essential dogmas by attributing to God qualities very far from and contrary to His essence." Lorini changed "overshadowing" into "perverting" (pervertire). The startled Inquisitor was bound to comment: "Such words as 'false' and 'perverting' sound very bad". They were about the only points where he found fault with the text, which otherwise seemed orthodox enough.*

[18] The doctored copy of Galileo's letter made by Lorini was incomplete and the Inquisition tried to get a signed copy. Galileo, suspicious of them, avoided releasing one. But his original was finally inspected by the Archbishop of Pisa, who also found nothing wrong with it
[19] In 1893, from*Providentissimus Deus* written by Pope Leo XIII, as quoted in Ref. 5, p. 479.

> *From the fact that we must take a position of strenuously defending the Sacred Scripture it does not follow that we should maintain equally all of the opinions expressed by individual Fathers and later by their interpreters in the act of declaring its meaning. In fact, in the case of the explanation of Scriptural passages which deal with physical questions, they held to the opinions of their time with the results that they perhaps did not always judge truthfully and stated things which are no longer approved today.*

[20] In a famous certificate issues to Galileo by the Pope's chief theologian Cardinal Bellarmine in 1616 he states that Galileo was told that the Copernican doctrine was "contrary to Holy Scripture and cannot be defended or held". Although certainly sounds fundamentalist, it must be compared with other Bellarmine remarks to be discussed which modify it substantially.
[21] A direct measurement, a comparison with a unit, always yields a number of units (inches,...) plus a fractional part of a unit, or equivalently, a *finite* decimal number since it is an operation taking a finite time. An indirect measurement is one deduced through logic based on direct measurements.
[22]Heath, T.L. , *A History of Greek Mathematics,* (Oxford U.P., Oxford, 1960).
[23] Before discussing them, the proper thing to do would be to decide on a mathematical image of time. For example, do you believe that time is composed of a succession of instants? Assuming you do, does each instant have a next instant? If you believe this, you are already in a lot of trouble as the paradoxes will show.
[24]Crossley, J.N. , *The Emergence Of Number,* (World Scientific, Singapore, 1987).
[25] This 'explanation' in any case was not available at the time Cardinal Bellarmine was writing his letter to Father Foscarini. From Ref.24, p.155 we read how this problem of the infinite troubling Zeno was also related to incommensurability:

At that time there was no occasion to say that every point on the line determined a number. … Stifel [1544] did not believe that all lengths could be measured by numbers and he explicitly stated this for the ratio of a circle to its diameter. His objection to the possibility of finding such a number was that the circle is the infinitely many-sided (regular) polygon and therefore requires an infinite calculation. Such a calculation was impossible to effect in a finite time. Therefore, he argued, there is no such number.

[26] James, William, *Pragmatism's Conception of Truth*, The Nature of Truth, Michael P. Lynch ed. (MIT 2001)