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Galileo's Leap into the Future

by

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Dedicated to
Courtney Sale Ross and Anders Holst

Abstract. Certainly one of the larger bifurcations of world cultural history must be the shift from medieval to modern science. According to many historians, the hinge point of that shift was Galileo's early works, beginning about 1611 CE: certainly an outstanding bolt from the blue. In this paper we dig up the roots of Galileo's leap into the future, and offer a theory of the yin-yang type, based on the ancient conflict between Plato and Aristotle.

SUMMARY

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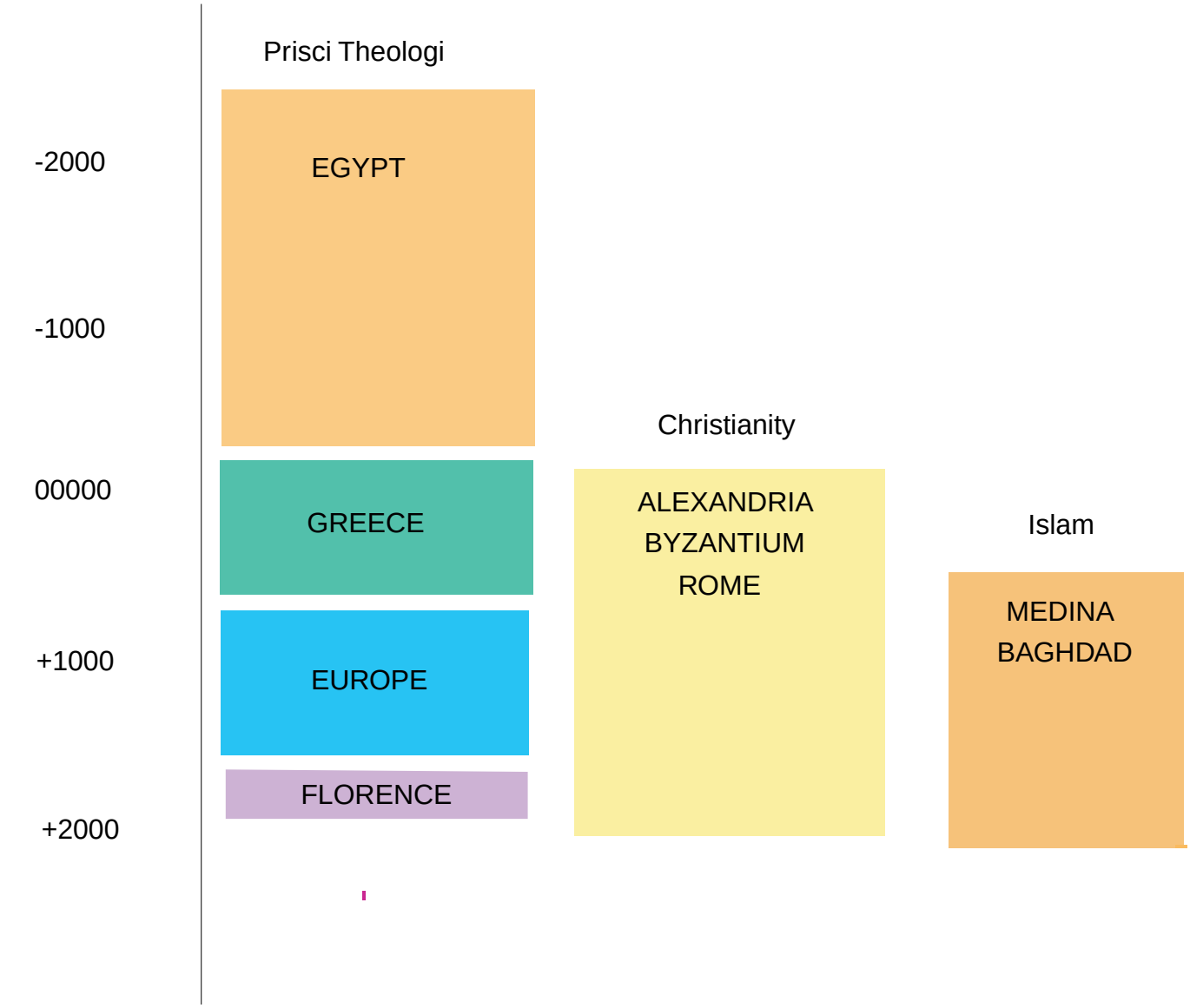
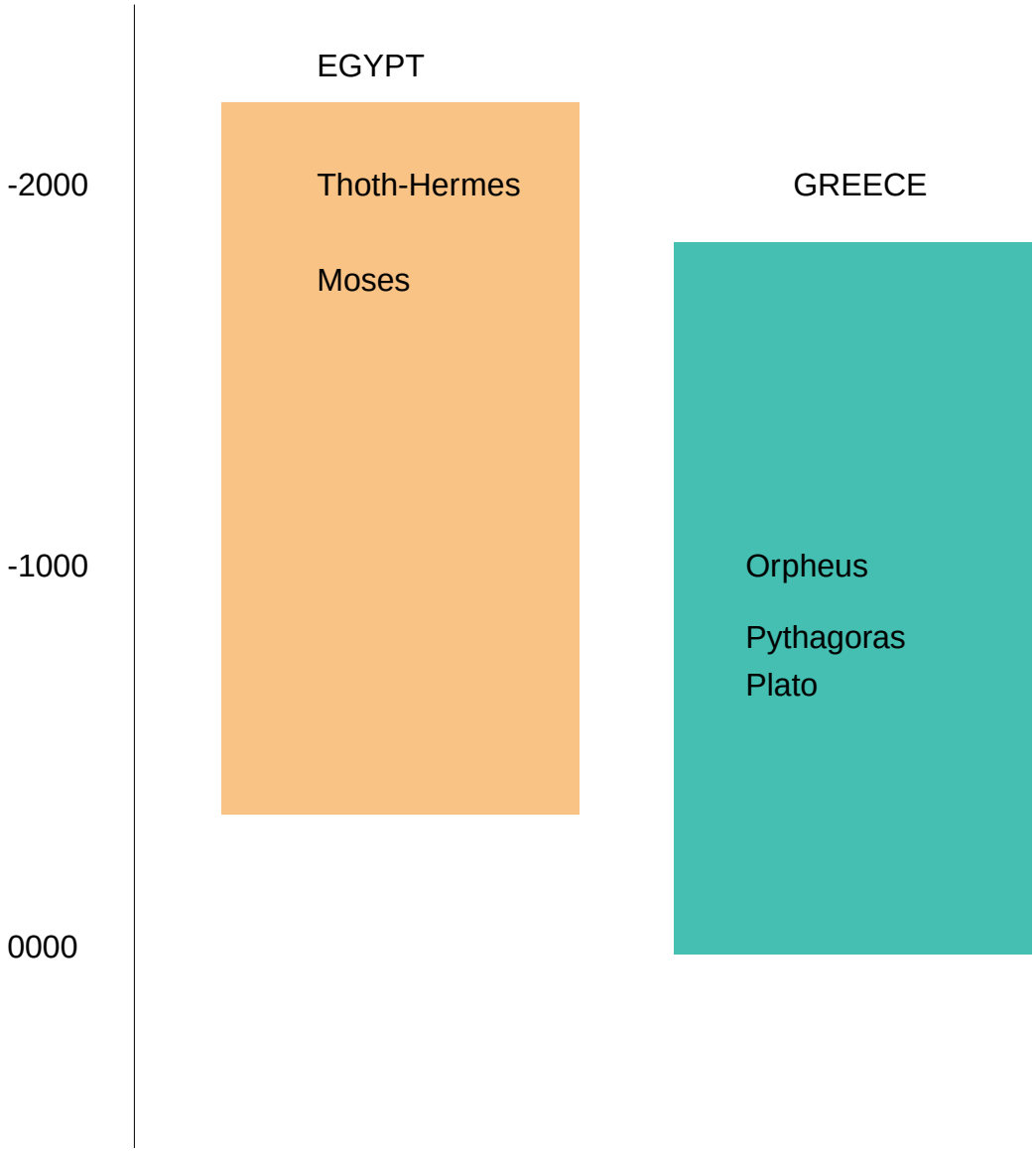


Figure 1. Histomap of 5000 years of philosophy.



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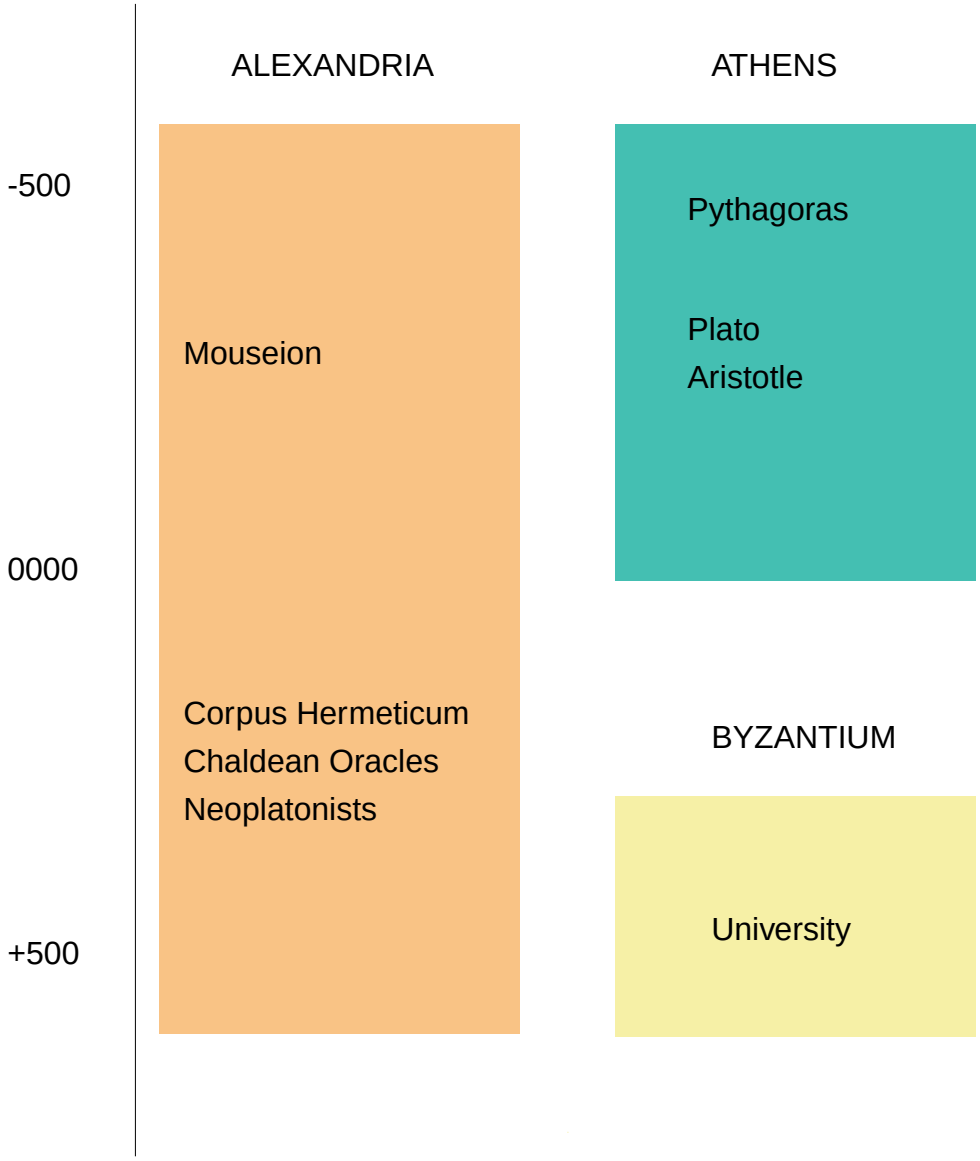

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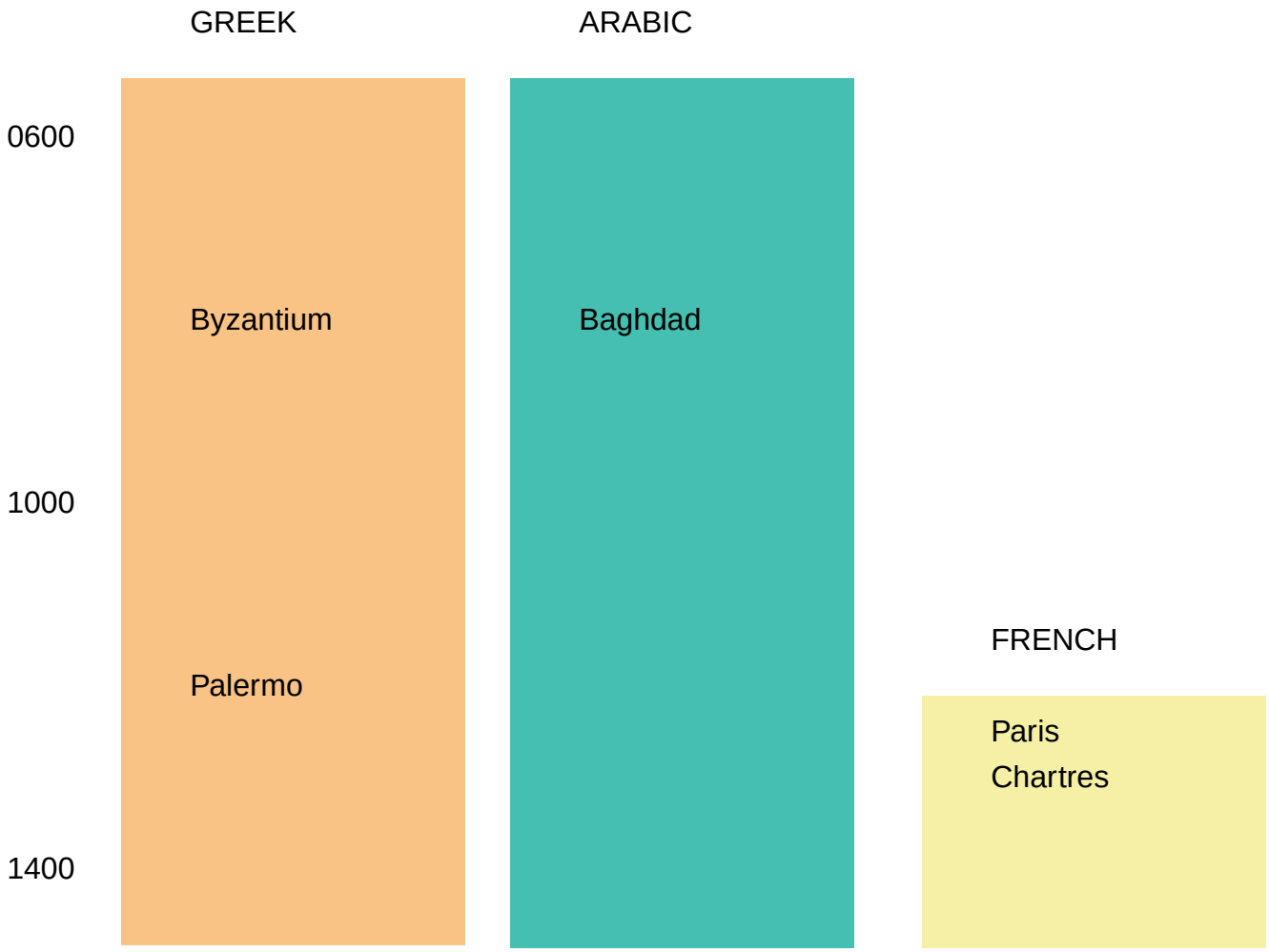

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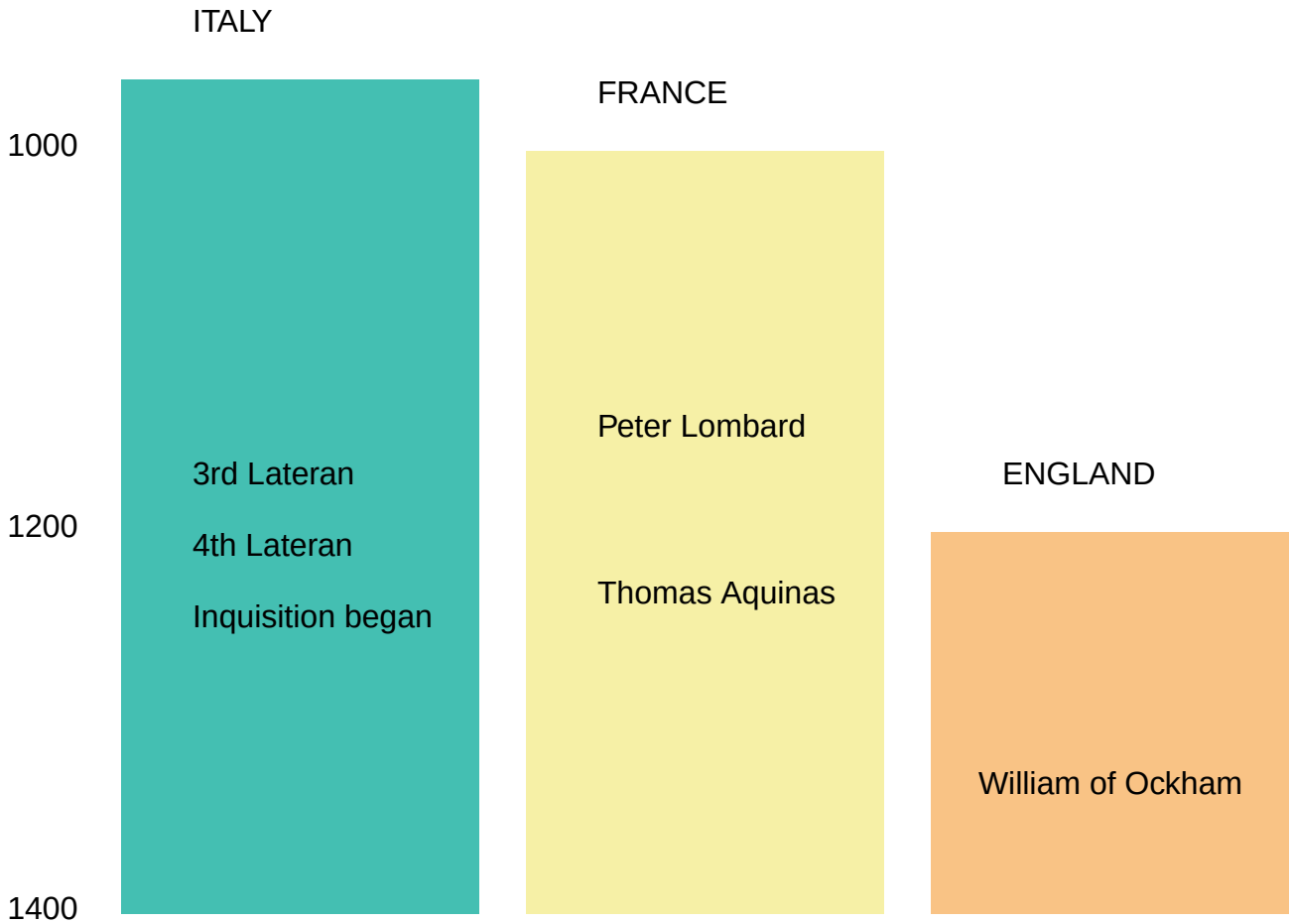

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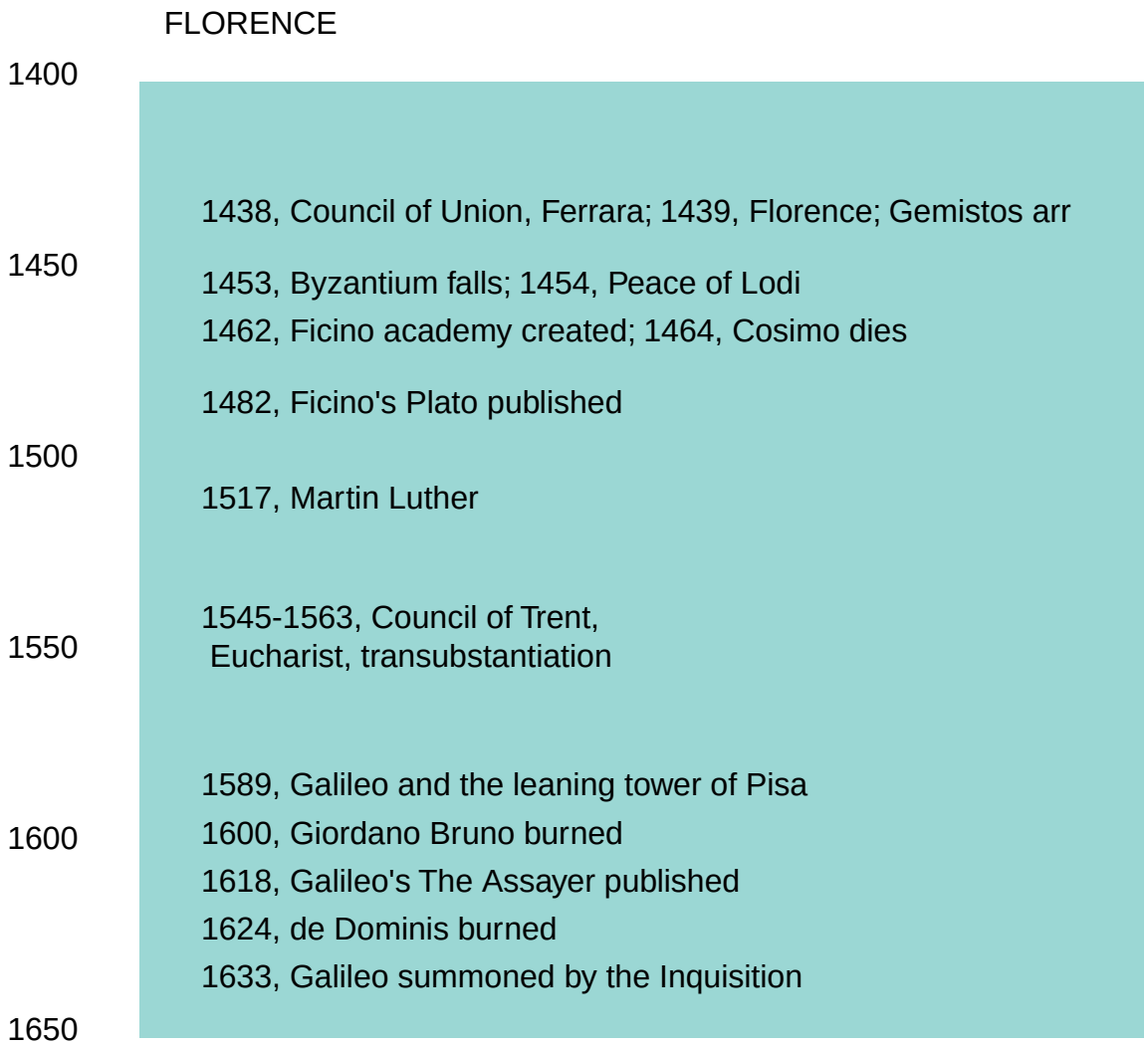

Figure 6. Histomap of the Florentine Renaissance.

1. Introduction

We view the creation of modern science by Galileo in 17th century Florence as a catastrophic bifurcation in the dynamics of world cultural history. In this view, the bifurcation parameter is the balance of two poles, fundamentally manifest in all cultural ecologies generally. In our context, we identify them with the Hermetic (ie, Pythagorean, Platonic, and Neoplatonic) on the one hand, and the rational (ie, Ionic, Aristotelian) on the other. Our story on Galileo's leap into the future relies on a number of ideas from various times and places, not all of which may be familiar. Thus, we begin with a few sidebars, arranged more-or-less in chronological order. Histomaps are included for navigation purposes, beginning with Figure 1, the big picture. You may skip all the side-bars by going directly to Section 7.

2. Ancient: 3000 - 300 BCE

Here is a fast forward of the first 2700 years of our story. Our main goal is to introduce the conflict between Plato and Aristotle, in the context of ancient thought.

2.1 Prisci theologi

There was a myth, from ancient times to the 17th century, of the *prisci theologi* (sing., *prisca theologia*). According to this myth, civilization — theology, philosophy, mathematics, writing, and the like — were brought to humankind by a series of sages, the *prisci theologi*: Thoth/Hermes, Orpheus, Pythagoras, Plato, and occasionally others. [Copenhaver, p. xlviii] After capsules of these four figures, we come to the yin/yang of Plato and Aristotle.

2.2. Thoth-Hermes

Note. This section is condensed from [Mead, 1992, pp. 33-56].

Names: Thoth, pronounced, Te-how-ti. Greek form of the Egyptian Teh, alias Tehu (ibis), Tehut, or Tehuti. Ibis-headed moon god. The Ancient Greek Hermes, Hermes Trismegistus, Thrice-greatest Hermes, the first Hermes. Attributes: Master of Wisdom and Truth. Lord of the Moon. Master builder of temples and monuments. Representative of reason in the world. Initiator of universal order, rules, and laws. God of writing, arts, sciences, medicine, and magic. Inventor of hieroglyphics. Patron of all libraries and scribes. Lord of rebirth. Speaks the Divine Word, or Logos. The teacher of Osiris and Isis. The measurer of times and seasons. The highest idea of deity in Ancient Egypt. His spouse, Nehe-maut or Maat, is associated with truth and righteousness. Thoth and Maat are companions of the sun god Ra in the Book of the Dead.

2.3. Orpheus

This section is condensed from [Guthrie, 1993, Ch. III].

Orpheus, born around 1000 BCE in Thrace or Macedonia. According to legend, the son of Kalliope (one of the Muses) and Apollo, or perhaps, Oiagros, a river god. Sailed with Jason and the Argonauts searching for the Golden Fleece, protected them from the Siren with his magic song. Charmed animals with his lyre. Tried to rescue his lover, Euridice, from Hades. Expounded the religion of Dionysos. Killed by the Maenads.

2.4. Pythagoras

This section is condensed from Joscelyn Godwin's Foreword and David Fideler's Introduction to [Guthrie, 1987, pp. 11-15, 19-49], and [Cornford, 1932/1992].

Pythagoras of Samos, born ca 570 BCE. Travelled and studied in Egypt and Babylon. Initiate and reformer of Orphism, which became the most important religion of ancient Greece. Synthesized spiritual and natural philosophy into the framework for classical Greek culture, including the metaphysical and sacred aspect of Number, the One (monad, unity) and its emanations. Introduced the terms philosophy and cosmos. Created a school around 520 BCE in Croton (southern Italy) featuring communal living, gender equality, vegetarianism, mystery initiations, Orphic poetry, harmonics, music therapy and the monochord, geometry, arithmology, and cosmology. The school was destroyed by a popular revolt around 500 BCE. Among the important followers were Philolaus (b. 474 BCE) and Archytas of Tarentum, an important influence on Plato. The Pythagorean doctrine is based on these three principles:

1. Ideas: material objects are attracted to absolute forms, which have an existence of their own. Mathematics is the study of these forms.
2. Transmigration: an animal has an immortal soul, which reincarnates after death, until a state of perfection is attained.
3. Ideas and souls are related by harmony.

2.5. Plato

This section is condensed from [Cornford, 1932].

Ficino regarded the divine Plato (427-347 BCE) among the greatest of the prisci theologi. Socrates (479-399 BCE) was the agent of a major shift in which philosophy turned from nature to human life. Plato, his disciple, had the genius to grasp Socrates' meaning, and to present it brilliantly it in a series of ten dialogues. In 387 BCE, Plato created his school in Academia, a suburb of Athens. Around 390 B.C.E, Plato visited Western Greece (Southern Italy and Sicily), encountered Pythagorean communities, met Archytas of Tarentum, the great Pythagorean, and adopted Pythagoreanism as a second influence. Platonism consists in the joining of these two streams. He expanded the teaching of Socrates, on the perfection of the soul, to a complete system of nature. In this system, things like morals and justice were based on absolute ideals. Wisdom consists of knowledge of these ideals, and philosophy is the search for wisdom. In 14 more dialogues, Plato presented this unified system. Regarding the metaphysics of matter, Plato subscribed to a Pythagorean form of atomism, in which the elements are regular polyhedra. [Lloyd, 1970; p. 74]

(ca 340 BCE?) returned to Athens to create the Lyceum (Greek, Lukeion) in competition with the Platonic Academy. After a few years, following the death of Alexander the Great (323 BCE), Aristotle was forced to leave Athens, and died within a year.

The majority of Aristotles's writings, from about 40 years of philosophical work, have been lost. This may be a factor in the apparent divergence of his ideas from those of Plato. The surviving works are summaries of academic lectures devoted to logic, metaphysics, the sciences, ethics, politics, rhetoric, and poetics. The work on logic was the only text of classical Greek which was carried forward to the monastic schools of Medieval Europe, where he remained the ultimate authority on science and philosophy until Copernicus and Galileo, in the 16th and 17th centuries.

Originally a Platonist, Aristotle eventually renounced Plato's theory of ideal forms, and became antagonistic to the teachings of the Academe. For Plato's archetypal ideas, existing in a world of their own, Aristotle substituted his forms, as ideals carried within material nature, toward which natural forms evolved by desire. This subtle distinction, the essence of Aristotle's dispute with Platonism, was destined to increase over the centuries. Aristotle's philosophy and science also differed from Plato's in an increased reliance on the observation of nature. In physics, Aristotle rejected the atomism of Leucippus and Democritus. [Lloyd, 1970; pp. 45, 102]

In Aristotle's *Metaphysics*, we find his theory of substance. Natural things consist of matter and form. [Book Delta, 4] Accidents (ie, attributes) belong to a thing, but are not in the substance of the thing. [Book Delta, 30] He contrasts this with Plato, who regarded Forms and Mathematical Objects as substances. [Book Z, 2] [Lloyd, 1970; p. 19]

2.7. Review

A histomap of this section is shown in Figure 2. From the point of view of dynamics — the mathematical theories of chaos and bifurcation — we may review the stories told in this section as follows. From the bifurcation between prehistory and history in ancient Egypt, we get Thoth-Hermes, the first of the prisci theologi, and then a theogony of Egyptian gods and goddesses, including the Memphis trinity of Osiris, Isis, and Horus. In a typical transcontinental mythogenesis, Osiris morphs into Orpheus in ancient Greece. Then we have a another bifurcation with Thales of Miletus, and the birth of Ionian science, a materialist antithesis to Orphism. Soon after, we have Pythagoras, with a revival of Orphism, and Plato, with an Athenian outbreak of Pythagoreanism folded into the tradition of Socrates. With Aristotle comes yet another rejection of the Hermetic/Osirian/Orphic/Pythagorean/Platonic and return to Ionian materialism. The demise of Athenian culture then projects this aspect and ancient thought into diaspora, and the further evolution of the Hermetic/Ionian (or Plato/Aristotle) dichotomy moves to Alexandria.

3. Late Antiquity: 300 BCE - 600 CE

In late antiquity, the center of philosophy shifted to Alexandria, with its large population from Greek, Egyptian, Christian, and Jewish cultures. Meanwhile, Greek and Christian cultures evolved separately in Byzantium. The Hellenistic period (323 - 30 BCE) was followed by the Roman period (30 BCE to 642 AD), then Islam arrived.

3.1. Alexandria

This section is condensed from [Parsons, 1952], [Forster, 1968], [Canfora, 1990] and [Lloyd, 1973].

Alexander the Great conquered the world, chose a site in the Nile delta for his capital, and died. After some struggles for succession, Ptolemy I Soter took over Egypt and built a city on the site, Alexandria. The city grew very large; wealth came from selling grain to Rome. Of the four quarters of the city — Greek, Macedonian, Egyptian, and Jewish — the Jewish quarter held the royal palace complex, the Bruchion, within which was the Library — a collection of scrolls created by Ptolemy I Soter — and the Mouseion — a research institute created by Ptolemy II Philadelphus. Demetrius Phalereus, formerly governor of Athens, came to Alexandria (317 BCE) and became the first head of the Mouseion, bringing Aristotle's library with him. The Alexandrian Library encompassed at least 300,000 scrolls, including translations of the Old Testament and the writings of Zoroaster, as well as Aristotle's lecture notes. Euclid wrote his *Elements* there, and Eristothenes mapped the world. All ot the scrolls were burned by the conquering Muslim army in 642 AD.

Throughout this time Alexandria was the intellectual capital of an empire: first Macedonian, and then Roman. It coevolved successively with Athens, then with Rome, and then Byzantium. The most important schools of Hellenistic philosophy were the Epicureans and the Stoics. In physics, the Epicureans were atomists following Leucippus and Democritus, while the Stoics subscribed to a continuum theory of matter. Important philosophers of the Roman period included Philo the Jew (30 BCE - 40 CE) in Alexandria, the early Christian Dionysius the Areopagite in Athens, the middle Platonists such as Albinus (b. ca 100 CE), and the Neoplatonists.

3.2. Corpus Hermeticum

This section is condensed from [Copenhaver, 1992].

The *Corpus Hermeticum* is a body of writings compiled in the second century CE, probably in Alexandria. It was important in the early Florentine Renaissance, when it was understood to be the work of Thoth, or Hermes Trismegistus, contemporary of Moses, and the basis of an ancient theology (the prisci theologi) culminating with Plato. This theory was debunked by Isaac Casaubon in 1527. Some idea of the content may be gleaned from the titles.

1. Discourse of Hermes Trismegistus: Poimandres.
2. (untitled)
3. A sacred discourse of Hermes.
4. A discourse of Hermes to Tat: The mixing bowl or the monad.
5. A discourse of Hermes to Tat, his son: That god is invisible and entirely visible.
6. That the good is in god alone and nowhere else.
7. That the greatest evil in mankind is ignorance concerning god.
8. That none of the things that are is destroyed, and they are mistaken who say that changes are deaths and destructions.
9. On understanding and sensation: That the beautiful and good are in god alone and nowhere else.
10. Discourse of Hermes Trismegistus: The key.
11. Mind to Hermes.

12. Discourse of Hermes Trismegistus: On the mind shared in common, to Tat.
13. A secret dialogue of Hermes Trismegistus on the mountain to his son Tat: On being born again, and on the promise to be silent. Singing the secret hymn, Formula IV.
14. From Hermes Trismegistus to Asclepius: Health of mind.
15. (missing)
16. Definitions of Asclepius to King Ammon on god, matter, vice, fate, the sun, intellectual essence, divine essence, mankind, the arrangement of the plenitude, the seven stars, and mankind according to the image.
17. (untitled)
18. On the soul hindered by the body's affections. On praise for the almighty and a royal panegyric.
Asclepius: To me this Asclepius is like the sun. A Holy Book of Hermes Trismegistus addressed to Asclepius.

The 17 discourses amount to 66 pages, and the *Asclepius* 26 pages, in the English version of [Copenhaver, 1992]. Tat is a variant of Thoth.

3.3. Chaldean Oracles

The *Chaldean Oracles* (CO) were written by Julianus the Theurgist around 170 CE, but were long thought to be derived from an original by Zoroaster, based on divine revelation. It is a work of theurgy, that is, ways of calling upon gods (god-working) by means of magical rituals and incantations. Like the *Corpus Hermeticum* (CH) the CO was a basic text for the Neoplatonists. In about 24 pages in the English translation [Stanley, 1989], a scheme of beings is described, having some similarity to the Hebrew Kabbalah. Further, an analysis of the human soul into three parts is given. Hecate is an important figure in the CO, and the word *jinx* is introduced.

3.4. Neoplatonists

Here we follow [O'Brien, 1975] and the Foreword by Ian Mueller in [Morrow, 1992].

The influence of Aristotle outstripped that of Plato, but Platonism continued as an underground current, with occasional surges to the surface. One such surge was the Middle Platonism of the Hellenistic period, another was the Neoplatonist movement of Roman times. The most noted Neoplatonists were Plotinus (204-270) and Porphyry (232-304) in Rome, Iamblichus of Chalcis (260-330) in Syria, and Proclus of Xanthus (d. 485) in Athens.

The first and most important extant Neoplatonist writings we have are Porphyry's edition of Plotinus' treatises. The key doctrine of Plotinian mysticism, the One, seems to derive from Philo the Jew, who had sought a synthesis of Old Testament and Platonic teachings, via Albinus. The mystical journey, according to Plotinus, is the return to the One. This is the first of three hypostases: the One, the Intelligence, and the Soul.

3.5. Byzantium

This section is condensed from [Burckhardt, 1852] and [Diehl, 1957].

In 330 CE, Constantine — the first Roman emperor to convert to Christianity — founded Constantinople, also known as New Rome, and moved his capital there. Here began the heresies — Arianism, Nestorianism, and Monophysitism — which rocked the foundations of Christianity. [Forster, 1968; pp. 80-82] These are beliefs in the sequence and manner of the descent of the Holy Spirit into the baby Jesus which conflicted with the majority opinion of the bishops.

The great cultural bifurcation from Ancient to Medieval occurred here. With the end of the Roman Empire in 476, under the onslaughts of Visigoths, Huns, and Ostragoths, Constantinople stood fast: the Byzantine Empire was born. Justinian of Macedonia (518-565) extended the empire over North Africa, Italy, and Spain. He built the sublime cathedral of Saint Sophia, and closed the pagan academies, including the Platonic Academy of Athens.

Ironically, Byzantium was a bastion of Greek culture, arts, language, and literature. The University of Constantinople, founded in the 5th century by Theodosius II, was an outstanding center of philosophy, science, mathematics, music, medicine, and law. A natural balance of Platonic and Aristotelian philosophy was maintained.

3.6. Review

The philosophic traditions of Plato and Aristotle evolved in Athens, then moved to Alexandria and Byzantium. See Figure 3 for a histomap of this period.

4. Medieval: 600 - 1400

While ancient Greek, late Antique, and early Christian cultures were maintained in Byzantium, Islam burst forth in the Arabian peninsula.

4.1. Early Islam

Condensed from [Nigosian, 1987] and [Gibb, 1962].

Muhammed (570-630) grew up in Mecca. He received a vision of the angel Gabriel in 610, with a call to prophethood. Further messages followed, and were collected posthumously as the Qur'an around 650. To escape a plot on his life, Muhammed fled to Medina in 622. The date of this flight (Hijrah, or in latin, Hegira) is taken as the founding date of Islam. During his lifetime, much of Arabia was more-or-less unified in Islam. Following his death in 632, the early Caliphs (from the Arabic, Khalifa, successor) — Abu Bakr, father-in-law of Muhammed (632-634), 'Umar I, father-in-law of Muhammed (634-644), 'Uthman, son-in-law of Muhammed (644-656), 'Ali, son-in-law of Muhammed (656-661) — consolidated and extended Islam over Syria, Jordan, Israel, Persia, Egypt, Iraq, and part of the Byzantine empire. Ali moved the Caliphate from Medina to Kufa, in Iraq.

The early caliphs were succeeded by the Umayyad dynasty (661-750), which extended Islam to France and to China. The Umayyads moved the Caliphate to Damascus in 661, built the Dome of the Rock in Jerusalem in 691, and maintained hostilities along the border with the Byzantine empire.

When the ‘Abbasids came to power (749-1517) they killed most members of the Umayyad clan. One exception was ‘Abd-ar-Rahman, who escaped to Spain to found the Moors, an autonomous Islamic state until 1031. The Moors were driven from Spain in 1492 by King Ferdinand. The ‘Abbasids moved the Caliphate from Damascus to Baghdad in 762. Harun ar-Rashid, the fifth ‘Abbasid Caliph (786-809), encouraged intellectual activities in Baghdad. The reign of his son al-Ma’mun (813-833) was the golden age of Islam. The Bayt al-Hikmah, or House of Knowledge, emerged as a center for translation and study of Greek, Syrian, Persian, and Sanskrit works.

Islamic scholarship developed with a strong bias toward Aristotle, as his logic was considered essential in debates with Christians and Jews. Platonic and Neoplatonic ideas rose to the surface from time to time — for example, in the Epistles of the Pure Brethren around 900, and in the works of the Sufi mystics, al-Hallaj around 900, al-Ghazzali around 1100, and Ibn al-Arabi around 1200. [Nigosian, 1987, p. 91] [Gibb, 1962, pp. 135-148]

4.2. Medieval Byzantium

After the closing of the Platonic Academy of Athens by Justinian in 529, and the burning of the remains of the Alexandrian Library by the Muslim forces of Amr, the general of Caliph Omar I, and the demise of the Mouseion in 642, only the University of Constantinople remained as a center of Neoplatonism. Leo the Mathematician headed the university around 800, just as the Bayt al Hikmah was being organized in Baghdad. Contacts between Byzantium and Baghdad, with intermediates in the Jewish and Nestorian communities of Antiochus and Edessa, contributed to an influx of Neoplatonism manifest in early Sufism and the Brotherhood of Piety. Around 1000, Michael Psellus created a Platonic Academy in Constantinople. [Diehl, pp. 106, 147, 233, 246, 287.]

4.3. Palermo

From [Grant, 1971].

Contacts between Byzantium and Sicily were ongoing throughout the middle ages. After the conquest of Sicily and Southern Italy by the Normans in the 1091, a golden period of multicultural scholarship flowered in Palermo, especially in the court of Richard II. Important translations of Greek and Arabic texts into Latin were accomplished. In particular, Plato’s *Meno* and *Phaedo* were translated by Henricus Aristippus. [Grant, 1971; pp. 16, 17] Perhaps with the stimulus of visits by Leonardo of Pisa around 1200, mathematics flourished. Euclid and Ptolemy were translated. Michael Scot as a leading scholar at this time.

4.4. Paris and Chartres

Condensed from [Le Goff, 1993].

Translations from Greek and Arabic to Latin, beginning around 1100 CE, nurtured the emergence of intellectual activity in Europe. Oriental philosophy was incorporated into Western Christianity, particularly in Paris and Chartres. A strange group of intellectuals, the goliards, emerged in Paris. Expressing themselves in poetry, they were antipontifical rebels, escapees from the rigid structures of the High Middle Ages. Peter Abelard (1079-1142) was the greatest of the goliard poets, the first great intellectual figure of the twelfth century, the first professor of Europe. After his

famous scandal with Heloise, he wrote his text on theology, which was condemned and burned in 1112. His life was a constant war with the Roman establishment. Although his books were officially burned, several survived, on logic, ethics, and humanism. The goliards were the precursors of the Renaissance humanists.

During the 12th century, Chartres was a great center of learning devoted to naturalism, humanism, macrocosm/microcosm, the quadrivium, Platonism, and all Greco-Arab knowledge.

4.5. Review

In this section, ancient philosophy moved circuitously to Medieval Europe. See Figure 4 for a histomap of this period.

5. The Church: 100-1400

As the story of Galileo's leap is tightly interwoven with the story of Christianity, we must collect together a few threads for later reference.

5.1. Eucharist

Condensed from [Rogers, 1917] and [Davies, 1992; Ch. 17].

Baptism and the Eucharist (communion with transformed bread and wine) were rituals of the Early Christians from the beginning, and these evolved into the sacramental system. The word *sacrament* (mysteries) became attached to these rituals around 200 CE by Tertullian, the first Latin Father. The first treatise devoted to the sacraments of the Church, *Concerning the Mysteries*, was written by Ambrose, the Bishop of Milan, around 400 CE. Shortly after, sacrament was actually defined, by Saint Augustine, as a sacred sign. The list of official sacraments of the church eventually grew to seven, but these two original sacraments retain special importance, and the Eucharist has been the center of controversy for centuries.

Augustine had described the conversion of the bread and wine into the body and blood of Christ as a spiritual transformation. But in 831 CE, Paschasius Radbertus, a monk of Corbet, wrote *Of the Body and Blood of the Lord*, the first book on the Eucharist, in which he deviated from Augustine in making a more literal interpretation, presenting the Eucharist as a material transformation. Paschasius maintained that after the consecration by the words of Christ, his body and his blood were present on the alter. His view was rejected by Ratramnus, another monk of Corbet. And thus was born a controversy which raged for 250 years and climaxed with the condemnation of Berengar of Tours (a pupil of Fulbert of the famous school of Chartres, d. 1088) in 1079. By this time, the material view of Paschasius had become orthodox, while Berengar followed Ratramnus.

Peter Lombard (b. 1100) studied in Bologna and Paris, became Professor of Theology at Notre-Dame, and in 1159, Bishop of Paris. Around 1150 he achieved fame for his *Four Books of Sentences*, which became the basic text for instruction in theology in all schools and universities for centuries. The four books were entitled:

- The Trinity
- The Creation and the Fall
- The Incarnation

- The Sacraments and Eschatology

This last provided the Church with an orthodox system of seven sacraments at last. They are: Baptism, Confirmation, Eucharist, Penance, Extreme Unction, Ordination, and Marriage.

To Thomas Aquinas, the Eucharist was the goal of life for all Christians, the crowning sacrament, and the summit of the spiritual life. Luther attacked Aquinas' views on the Eucharist.

5.2. Inquisition

Condensed from [Shannon, 1983] and [Coulton, 1959].

The pursuit of unity for the sake of social stability is perennial. In the context of Christianity (as in others) was manifest in the suppression of heresies. By the Middle Ages, from 800 CE or so, the unity of the Roman Church prevailed throughout Europe. Jews, Muslims, and pagans were exempt, but avowed Christians had to conform.

During the Crusades to recover the Holy Land from the Muslims (1096-1271), around 1150, two major heresies threatened Christendom: the Albigensians (or Cathars) and the Waldensians. The Albigensians were condemned in the Third Lateran Council of 1179. Pope Innocent III (1198-1216) formalized the prosecution of heretics in 1199, and ordered the Albigensians annihilated in a crusade in 1209.

The Fourth Lateran Council of 1215 was the greatest Council of the Middle Ages. More than a thousand bishops and abbots convened at the Great Council. Seventy decrees, prepared in advance by Innocent III, were approved, including penalties for heresy.

Pope Gregory IX (1227-1241) created the papal Inquisition. He formally excommunicated all heretics in 1231, and appointed Dominicans and Franciscans as Inquisitors in 1233. Pope Innocent IV (1243-1254) justified the use of torture for obtaining confessions and the death penalty for the condemned (burning at the stake was already well established) in 1252.

5.3. Thomas Aquinas

Condensed from [Bourke, 1960] and [Davies, 1992].

The most important philosophers of the European Middle Ages were Thomas of Aquinas (1225-1274), John Duns Scotus (1266-1308), and William of Ockham (1288-1347). Thomas Bradwardine (d. 1349), Nicole Oresme, and John Buridan (1300-1358) were also important, especially in the evolution of the physics of motion prior to Galileo.

Both Aquinas and Scotus agreed that the matter and form of the bread are transformed into the matter and form of Christ's body. To Aquinas, the body of Christ is in heaven, and stays there, while appearing at the same time on many altars. It is not really present on those altars, but appears to be. That is *transubstantiation*. To Scotus, the body of Christ stays in heaven, but also is really present on the altar, as it miraculously may really by in different places at the same time. This is called *consubstantiation*.

Thomas Aquinas came on the scene shortly after Saint Francis, Robert Grosseteste, and Roger Bacon. He was a student of Albert the Great. In 1252 he came to Paris to study, then became a professor. He wrote a great deal, including a commentary on Lombard's *Sentences* in 1256. At this time, Aristotle was being rediscovered, but was regarded with suspicion by the Church officials in Paris.

During the first thousand years of Christianity, Plato had been more influential than Aristotle. In the 1260s, William of Moerbeke translated Aristotle from Greek into Latin. In the 1270s, Siger of Brabant was teaching a radical interpretation of Aristotle based on the Arabic commentaries of Averroes.

Using the translations of William of Moerbeke, Aquinas formulated a Christian interpretation of Aristotle which became the philosophic basis of Christianity. In particular, he used the theory of substance from Aristotle's *Metaphysics* to rationalize the Eucharist.

At the Fourth Lateran Council of 1215, the transubstantiation dogma of the Eucharist had been ordained: The bread and wine upon the alter are transformed in substance into the body and blood of Christ, while their accidents (a category according to Aristotle, accidents refers to the attributes of quantity, relation, place, time, position, state, action, and passion) remain. Aquinas wrote extensively in support of this dogma. He clarified substance and accidents in his *Exposition of Aristotle on the Soul*. [Bourke, 1960; p. 97] He was sainted in 1323.

5.4. William of Ockham

Now we rely upon [Cross, 1999; pp. 139-145]

Ockham, a disciple of Scotus, is important for an understanding of Galileo in several regards: empiricism [Grant, 1971; Ch. III], mechanics [Shapiro, 1957], atomism [Andre Goddu, Ch. 7 in Spade, 1999], and Eucharistic theology [Leff, 1975; p. 596]. Here we will summarize his atomism and Eucharistic theory.

Aristotle had rejected the atomic theory of matter of Democritus (and Plato's Timaeus) in favor of hylomorphism, the theory that objects are compounds of matter and form. Ockham followed Aristotle in hylomorphism, but found it compatible with an atomism. His conception of nature is developed in his theory of the Eucharist, presented in two treatises: *On Christ's Body*, and *On the Sacrament of the Altar*.

The communion ritual is a fundamental sacrament (and dogma) of Catholicism. The bread and wine on the alter are transformed into the body and blood of Christ in a miracle triggered by a priest. The transformed substances, called eucharists, are then taken in holy communion by the participants in the sacred mass. As the substance is converted from bread to Christ's body, its "accidental qualities" or appearances — color, shape, weight, taste, and touch — remain unchanged. This is transubstantiation. According to Aristotle, an accident could not exist separate from its substance. This resulted in a ban on Aristotle's works in Paris from 1210 to 1255. [Grant, 1971; p. 24] Ockham resolved this controversy with his view that God's omnipotence is sufficient to create accidents without substances, and vice versa. [Grant, 1971; p. 133] Ockham was denounced for his views in Avignon in 1324. [Redondi, 1987; pp. 63, 214]

5.5. Review

In this section we have outlined the evolution of the sacrament of the Eucharist, which we will require to understand the crime of Galileo. See Figure 5 for a histomap of this period.

6. Renaissance.: 1400-1650

We now begin a story in three part:

- The Platonic Academy of Ficino in Florence: 1452-1499
- The Council of Trent, and
- The crime of Galileo.

Along the way, we make free use of all the side-bars collected above.

6.1. Gemistos

Condensed from [Woodhouse, 1986].

After the relocation of Aristotle's library to Alexandria around 300 BCE, the Platonic Academy in Athens and the Neoplatonic school in Alexandria operated in parallel for eight centuries, until the closing of the Athens Academy by Justinian in 529 CE. Meanwhile, a secondary center had developed in Byzantium. Following the disruption of the Mouseion by the conquering Persians in 616, and the burning of the Alexandrian library ordered by Caliph Omar I in 642, only Byzantium remained as a stronghold of Greek learning. The center in Byzantium was revived and strengthened around 1100 by Michael Psellus, and some satellite schools evolved from it. For example, George Gemistos (1355-1452) created a Platonic academy in Mistra (near the site of ancient Sparta) around 1410. [Woodhouse, 1986; p. 30]

Byzantine scholars made an enormous contribution to the philosophical foundations of the Florentine Renaissance. First of all, they brought Greek texts with them and taught the Greek language. Manuel Chrysoloras was perhaps the first of these, arriving in 1397, with texts of Homer, Plato, Aristotle, and other classics. The Byzantine scholars brought a new style of teaching. They translated texts from Greek to Latin and supervised other translations. Finally, along with the texts of the philosophers they brought texts of commentators, especially on Aristotle.

George Gemistos was an advanced devotee of Pythagoras, Plato, and the Chaldean Oracles, which he ascribed to Zoroaster. He had been a student of Elisha, a Jewish scholar. [Woodhouse, 1986; pp. 23, 26]

By 1430, the decline of the Byzantine army and growing threats from German and Turkish forces alarmed the academicians in Byzantium, who began looking about for safer storage for the Greek scrolls and codices in their care. The call to a council of bishops in Ferrara set for 1438 provided an opportunity, and Gemistos was chosen to accompany the retinue of the Archpatriarch of Byzantium on the long journey to Italy. The Council was relocated to Florence, and Gemistos arrived there in 1439.

Briefly, he gave lectures to intellectuals and nobles on the essence of Neoplatonic philosophy, and his knowledge and charisma made a huge impression. The tension between Plato and Aristotle, an

important tradition in late Byzantine culture, was introduced in Florence by Gemistos in 1439. He lectured on Plato versus Aristotle, and on the Chaldean Oracles. [Woodhouse, 1986; Chs. 11, 4] This was critical to the break of Renaissance philosophy away from medieval scholasticism.

News of all this soon reached Cosimo de' Medici. who was inspired to acquire a complete library of Greek manuscripts, and sponsor their translation into Latin. He shortly acquired a copy of the Platonic Corpus (24 dialogues) from Gemistos, and a copy of the Corpus Hermeticum, acquired in Macedonia by a monk, Lionardo of Pistoia.

Later, John Argyropoulos of Constantinople (1445-1487) came to Florence to teach Greek, and made a number of important translations. Marsilio Ficino and Angelo Poliziano were among his pupils. [Browning, 1997, p. 114-115]

6.2. Ficino

Condensed from [Field, 1988], [Kristeller, 1964], [Walker, 1958], and [Browning, 1997].

In 1452, Cosimo selected Marsilio Ficino (1433-1499), the young son of his physician, as his translator. Following the Peace of Lodi in 1454, there was an expansion of humanism in Florence.

John Argyropoulos came to Florence from Byzantium, and, with Medici support, became Lecturer in Greek language, literature, and philosophy at the University in 1455. His teaching was aimed primarily at Aristotle's works. [Field, 1988; Part Two] Ficino learned Greek from him in 1456 at the urging of Cristoforo Landino, and in 1462, Ficino translated the Orphic Hymns into Latin. Cosimo gave him the Platonic Corpus to translate, a house in Fiesole, and a stipend. Then Cosimo gave Ficino the *Corpus Hermeticum*, and directed him to translate it first. Dedicated to Cosimo, it was published in April of 1463. The following year, Cosimo died, and was succeeded by his son, Piero, and then by Piero's son, Lorenzo, in 1469. Ficino's commentaries on Plato were published the same year. His patronage continued, but was less reliable.

Apparently Cosimo's choice of Ficino was divinely inspired. For Ficino not only translated the CH and PC, but also absorbed their spirit. His house evolved into a de facto Platonic academy, and he into the leading philosopher of the early Renaissance. Many architects, painters, sculptors, musicians, medical doctors, lawyers, and intellectuals of all kinds were attracted to him. His teaching was accomplished at soirees devoted to good wine and food, as had Pythagoras, Socrates, and Plato in ancient Greece.

In 1492, Lorenzo died, and shortly The Medicis were expelled from Florence, Ficino retired, and the Platonic academy lapsed. Savonarola was hanged and burned in 1498.

6.3. Trent

Condensed from [Bungener, 1855].

The long story of evolution of the Christian faith and establishment experienced a major bifurcation in the 16th century, after a long period of increasing tension regarding the authority of the Pope: the Reformation. Triggered by Martin Luther in 1517, Europe was rent asunder with wars and changes, following which Christianity was divided between Protestants and Catholics. The

Roman establishment reacted with reforms meant to control the damage: the Counter-Reformation. The climax of this reaction was the Council of Trent, the most important council in the history of the Church. Here was established the formal creed of Rome.

First convoked June 2, 1536 by Pope Paul III, to be held at Mantua, May 23, 1537. Postponed to May, 1538 at Vicenza, but not a single bishop appeared. Reconvoked for November 1, 1542 at Trent, postponed again until the end of 1545. Session I began December 13, 1545: 29 prelates were present, Cardinal del Monte presided. Session II opened on January 7, 1546, 43 prelates present. Session III on February 4; session IV on April; V on June 17; VI on January 13, 1547; VII on March 3: 30 canons relating to the sacraments were established. Session VIII, March 7: the council decided to move to Bologna. Session IX, April 2, at Bologna: decided to postpone. Session X, June 2: council split between Trent and Bologna. Due to a quarrel between the pope and the emperor, council was suspended for four years.

In 1549, Pope Paul III died, Cardinal del Monte was elected as Pope Julius III, and the Council of Trent was reconvoked. Session XI, May 10, 1551, at Trent; XII, September 1: the Eucharist was declared as the subject of the next session. Also, a letter from King Henry II of France was read, protesting the council, explaining why no French bishops had been allowed to attend the council, and complaining of the conduct of Julius III. The eight chapters of the decree on the Eucharist was read on September 13. Chapter 4 established the dogma of transubstantiation. This decree was accepted in Session XIII, October 11, 1551. {Bungener, 1855; p. 221]

The Council of Trent continued with the other sacraments in Session XIV, November 25, and XV, January 25, 1552. In Session XVI, May 28, a decree was read suspending the council. After a lapse of ten years, it resumed in 1562. In Session XXI, July 16, 1562, the Holy Eucharist was again the subject, and five articles were proposed. Discussions continued until September 16. Session XXV, December 3, 1563: the last session. The Council of Trent ends, after 18 years.

6.4. Galileo's crime

Condensed from [Ridondi 1999].

In 1564, Galileo was born as Michaelangelo died. By this time, the Platonic Academy of Marsilio Ficino and the Florence of the Medicis was long gone. The Council of Trent, casting the Counter-reformation in stone, had recently concluded. The revolutionary text of Copernicus was about 20 years old. Growing up with Vincenzio Galilei as a father was an ideal training for a revolutionary scientist, as Vincenzio was bold to break with centuries old dogma regarding arithmetic ratios of the intervals of the musical scale, preferring experiments to tradition. After a brief stint as a student at the University of Pisa, Galileo abandoned school for a life of truth-seeking, which led in a circle back to Pisa as a junior professor, and the beginning of our story.

It was here in Pisa, in 1589, that Galileo questioned the mechanical theory of Aristotle, which was based purely on theoretical principles, and showed via experiments that Aristotle was definitely wrong. This brought upon Galileo the hatred of his Aristotelian colleagues, who forced him once again to flee the university, in 1591, this time to the University of Padua.

At this time the Inquisition was in full swing. In a particularly troubling case for Galileo, the philosopher Giordano Bruno was imprisoned, in 1592, interrogated by Galileo's friend, Cardinal Bellarmine, and burned at the stake on Easter Sunday, 1600.

In 1609 came Galileo's improvement of the telescope, and his consequent revolutionary discoveries of the moons of Jupiter, and many other novelties of the solar system. This was contemporaneous with Kepler's discovery of his three laws of planetary motion.

At about this time, Galileo's conflict with the Vatican began to manifest. He was called to Rome by Cardinal Bellarmine in 1616, his works condemned, and he was ordered not to support the Copernican theory on the motion of the earth.

Two years later, Galileo published his first book, *The Assayer.* Although this is only the beginning of a long list of great works on various branches of physics which earned for the Galileo the title of father of modern physics, we may pause here, as this is (according to the analysis of Pietro Ridondi, the crux of the conflict between Galileo and the Church. For 16 years later, when Bellarmine had become Pope, Galileo was summoned before the Inquisition in Rome, threatened with torture, and condemned to life imprisonment, narrowly escaping the stake.

Of course the official reason for Galileo's condemnation was his partiality to Copernicus' theory. But the real reason was a much more serious charge against his book, *The Assayer.* By covering the more serious charge with the lighter Copernican charge, it was possible to offer Galileo a plea bargain, sparing him his life, and sparing the Pope a huge embarrassment.

So, then, what was this greater crime? Recall that the most important sacrament of Catholicism, especially in this time of competition for market share with the rising tide of the Protestant Reformation, is the Eucharist. For this reason it was a primary goal of the Council of Trent. And the Eucharist was rationalized by Aristotle's theory of matter, in which the accidents of the bread and wine could coexist with the matter of the body and blood of Christ, all supported by the universally accepted authority of orthodox science: Aristotle's blessing of the Eucharist. But Galileo's atomism, much like Plato's, explained attributes by the geometric shape of the elements. Thus, the accidents cannot be expected to remain the same when the substance is changed.

6.5. Linceans

Condensed from [de Santillana, 1962] and [Drake, 1980].

The Linceans, or lynx-eyed, after the mythical Lynceus the Argonaut, noted for his keenness of sight. [de Santillana, 1962; p. 20] Also known as the Accademia dei Lyncei, founded in Rome in 1603 by four young men including Prince Federico Cesi (1585-1630). The first scientific academy of lasting significance. Elected Galileo to membership in 1611. Coined the word telescope. [Drake, 1980; p. 49]

The Linceans sponsored the publication of *On the Solar Spots* of Galileo in 1613, which was openly Copernican. [de S. p. 22] Sponsored publication of *The Assayer* in 1623 and dedicated it to Pope Urban Eight. [Drake, 1980; p. 71] Planned to publish *Dialogues* in 1930 but the death of Cesi disorganized the Linceans. [Drake, 1980; p. 75]

6.6. de Dominis

Condensed from [Ridondi, 1987, p. 107-118].

In 1624, along with the publication of *The Assayist*, Galileo and the Italian public were able to observe a unique display of terrorism. Marco Antonio de Dominis, Archbishop of Spalato — a renowned theologian, scientist, and intellectual who had written on mathematics, optics and the tides — was charged by the Inquisition with impenitent heresy. In fact he was devoted to the peaceful reunification of Christianity. With this as motivation, he had travelled secretly to England with a copy of *The History of the Council of Trent*, and converted to Calvinism. In fact, he questioned the most important decision of Trent, the dogma of the transubstantiation of the Eucharist, for this was the key point separating the two branches of Christianity. As he unfortunately died during the interrogation, it was found necessary to burn his dead body at the stake.

6.7 Plato versus Aristotle

Condensed from [Le Goff, 1993].

In ancient Greece, the dichotomy of Plato versus Aristotle was very basic. Plato, top-down, irrational, mystic, a mathematician; Aristotle, bottom-up, rational, materialist, a physicist. Every culture seems to have a similar dichotomy — yin/yang, left/right brain, partnership/dominator — as well described by Riane Eisler, Leonard Shlain, and others. The dichotomy was harmonized by Ammonius Saccas of Alexandria, one of the first Neoplatonists, and teacher of Plotinus in Rome. [Guthrie, 1988; p. 87]

It is fair to describe the fate of Plato as predominantly a repression by the more fortunate Aristotle. This may have been an historical accident, as their established harmony in the ancient world was interrupted by the sudden arrival of the Middle Ages, with the closure of the Alexandrian Library by the conquering Persians in 616 CE, the intermittency of the philosophical tradition in Byzantium up to 1079, and the victory of the Turks in 1453. The path of Plato and Aristotle through Islam to Western Christianity rigidified the imbalance, as Aristotle's logic was an important intellectual tool in the formation of Islam. The resurgence of Plato became an occasional event in history, always repressed again in a backlash. Here is a summary of Platonic Resurgence waves since 400.

420: Saint Augustine
800: The brotherhood of piety, Baghdad
1079: Michael Psellus, Byzantium
1200: Paris and Chartres
1462: Marsilio Ficino, Florence

6.8 Review

In this section we have broken the Florentine Renaissance into three stages: Ficino, Trent, and Galileo. Ficino's wave of Platonic resurgence set the stage for modern science. The backlash of the Council of Trent tried and failed to resist it. The creation of modern science was the real crime of Galileo.

7. Bifurcation theory of Galileo's leap

We propose that the birth of modern science occurred in 1624, with the publication of *The Assayist* by Galileo, and we seek to understand it.

7.1. Bifurcations

Our basic posture here, in the analysis of the birth of modern science, is that of bifurcation theory. Jacob Burckhardt, in 1860, was the first great champion of the catastrophic bifurcation model for the Renaissance, and it has been controversial every since. We will not insist on the correctness of this model; a subtle bifurcation model might suit us equally well. [Abraham, 1994] In fact, we might even analyze the Renaissance as a complex bifurcation event, involving a number of adjacent bifurcations: Platonic resurgence, Reformation, Counter-reformation, Copernican revolution, printing, the telescope and atomism of Galileo.

A specific model for catastrophic bifurcations in the context of the history of science has been put forward by Ludwik Fleck, and expanded by Thomas Kuhn. For Fleck, the Wasserman test for syphilis (and the microbiological theory of disease) was the paradigmatic exemplar, which for Kuhn, it was the Copernican revolution. In this model, the bifurcation parameter was the proportion of the community adhering to the new paradigm, or perhaps, the total number of anomalies, experimental facts in conflict with the old paradigm. This model is a good fit for the exemplars of Fleck and Kuhn, yet is inadequate for the social transformation we are considering: the birth of modern science.

7.2. Modern science

We have seen that the Copernican heresy was a side issue in the condemnation of Galileo by the Church. This was a smoke screen covering the more flagrant case of the atomic heresy, which undermined the Aristotelian explanation of the Eucharist. And this in turn is but a special case of the true crime of Galileo: the creation of modern science. The officials of the Church were correct to fear this and try to suppress it, as time has shown that indeed, modern science has replaced Christianity as the dominant world religion.

> Think of P. Redondi's *Galileo Heretic*, for example, a most daring revision of the story, accomplished on the basis of a hitherto unknown document. From the pretext of the condemnation to the power-politics within the Curia, it revises all but one thing: the uncompromising antagonism between the new science and Jesuit "science", between the science of Galileo and the official science of the church. [Feldhay, 1995; p. 5]

All right then, so what indeed was the trigger for the bifurcation from ancient to modern science?

7.3. Our yin-yang theory

We are proposing here that the balance between Plato and Aristotle may be considered the bifurcation parameter. As we have seen above, this balance has been predominantly an imbalance, with Plato held underground, except for occasional waves of resurgence. One such wave was that of the Florentine Renaissance in the second half of the 15th century, which culminated in the Reforma-

tion, and the bifurcation of Christianity. The repression of this resurgence was the Counter-reformation, which climaxed in the Council of Trent in the mid-16th century. Due to the development of printing and the consequent explosion of literacy, the resurfaced Platonism could not be totally erased. Nor could the weakening and splitting of Aristotle be repaired. For example, Galileo's father was a Pythagorean experimentalist, as was Galileo himself. Galileo's scientific proposals were mostly reiterations of prior proposals of Ockham, Buridan, and others. The weakening of the control of intellectuals by the Church, and the development of printing were among the factors which pushed Galileo over the threshold of bifurcation.

7.4. And the demise of astrology

Condensed from the Epilogue of [Geneva, 1995].

And yes, we forgot to mention the fate of astrology. Reaching the Renaissance from Ptolemy and several other streams (Neoplatonism, India, Persia, Islam, and the Jews) it became a primary symbol system and popular topic of the intellectual elite. Ficino's astrological psychology is still popular today. And Galileo was employed teaching medical students how to cast a horoscope, without which medical treatment was impossible. But the rise of modern was the fall of astrology, which survives today as a so-called pseudo-science.

8. Conclusion.

Forgetting for the moment all the sidebars, our thesis may be summarized very briefly. Although the trial of Galileo has been given an enormous amount of study and historical analysis, we regard it as an epiphenomena of the primary bifurcation due to Galileo: the leap from ancient to modern science. This jump might have occurred earlier or later, triggered by other revolutionary thinkers, but it did not. We have described three reasons:

- The resurgence of Platonism in Florence following the brief visit of George Gemistos in 1439, its following support due to the unique interests of Cosimo and the Turkish defeat of Byzantium in 1453.
- The reformation after Luther in 1517, and the grotesque counter-reformation at the Council of Trent, in which the Church tried and failed to suppress the Platonic tendency.
- The Platonic support of Galileo by his father and by the Linceans.

These factors pushed the Plato/Aristotle balance over the threshold in 1624.

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