Chapter 1
The Insignificance of the Earth

A tale told by an idiot,
full of sound and fury,
signifying nothing

Macbeth, Act V. Scene V.

William Shakespeare (1564–1616)
The Oxford Shakespeare, 1914

Macbeth in Shakespeare's famous soliloquy bemoans the insignificance of a human life, even a royal one. Mankind became aware of the insignificance of the Earth in the vastness of the universe during the late Renaissance, when the learned switched from recovering the lost knowledge of antiquity to branching out on their own. The clash of vastness with the idea that the Earth and nature exist for the special benefit of mankind brought what is now called astrobiology to center stage.

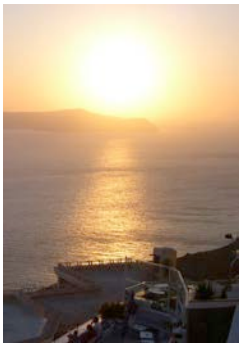
(D1.01 rosemary) I give a brief overview of "Western" history to put the events in the late Renaissance in context. Then as throughout human history, the available technology and science had a strong influence on the prevailing worldview. However, change before 1500 was typically slow and imperceptible over the lifetime of an individual. Like the plant rosemary, modern science took root around 1600 on harsh unkempt soil.

The seeds of science

Prehistory. During the past few million years our species has evolved (see Chapter 9) from one governed by instinct to one dependent on conscious thought and learned knowledge. Archeologists have exhumed a good record of bones. Silent tools and artifacts recount the co-evolution of technology and worldview. Humans 40,000 years ago thought abstractly. Their art adorns caves in Europe. They practiced religion. They carried formidable flint weapons.

Folk science arose in this dimly lit period of prehistory. Our ancestors observed nature, generalized from their observations, and acted to their own benefit on this information. They had good language skills for teaching and learning.

These hunter-gathers were in close contact with nature. They could control many of their activities, when to emerge from the cave, whether to hunt for swans, deer, or nuts, and what weapons to carry. They could not control days and seasons, but could prepare for their regular occurrence. They suffered from rare events, like intense storms, which they could neither control nor predict. It was natural to attribute both the usual and the unusual to the conscious acts of unknown spirits. People had little knowledge of and communication with others living more than a few kilometers away. They took calamity quite personally.



(D1.02) The sky provided a particularly valuable source of information. As discussed in Chapter 2, one tracks hours with the apparent movement of the Sun through the day sky and the stars through the night sky. One tracks seasons with the movement of the Sun across the background of stars, that is, keeping track of which stars are visible just before sunrise and just after sunset. These phenomena are quite regular. The monthly phases of the Moon and its path across starry sky have a high degree of order. The movement of the five naked-eye planets, Mercury, Venus, Mars, Jupiter, and Saturn, is complicated but not erratic.

In general, nature is complicated. The hunter-gathers, like modern scientists, had to generalize from limited information. Often the penalty over over-generalization and trusting instruction is much less than the penalty from refusing to learn from instruction and experience. For example, one could rationally associate violent illness with eating mushrooms. Abstaining from all mushrooms is an effective strategy for the surviving victims, their associates, and their children. There is some penalty; they do miss a few tasty safe morsels. In contrast, under-generalization carries an onerous penalty; gluttonous consumption of all mushrooms in one's path would prove lethal. As a practical matter for the individual's survival, it does not matter whether one regards mushrooms as toxic, accursed, or bewitched. Cost-benefit trade off also exists with animals. A mouse from instinct and experience knows the signs of an approaching cat;

yet its ends up as cat food if it always makes itself 100% sure a cat is actually approaching before fleeing. Mark Twain's cat did not ever jump on a cold stove after jumping on a hot one.

The sky provided so much useful information that it was natural to try to winnow additional omens by observing. This led to astrology. Our words "disaster," "catastrophe," and "ill-starred" have lost much of this connotation. Many other superstitions have some basis from over-generalized and misinterpreted observations. I recall one that persists as an expression because it is no longer taken literally. "Kill a spider and it will rain." It is probably of Native American origin in New England and the northern Midwest. People who are not arachnologists (spider scientists) do not usually go looking for them. Spiders are most evident and liable to be killed during wet periods in the summer of these regions.

(D1.03 wheat) Early Antiquity. Observant hunter-gathers brought parts of nature under control. Herding (about 10,000 B.C.) brought freedom from the vagaries of animal migrations. Alert individuals observed that plants grow from seeds, a fact now thought to urban children in science classes. Agriculture (by 8000 B.C.) supported a large population density in fertile regions. Civilization in the Middle East

took off around 4000 B.C. when sea level and climate stabilized. The first written texts and legends of "Western" history provide insight into ancient thought patterns.

Figure 1: The cordyline palm was domesticated by the Maori of New Zealand about 1000 years ago. Its edible fruit is smaller than that of the date palm, which was an important source of food in the Middle East by 6000 B.C. It was extensively cultivated after 4000 B.C. Its dried fruit "tamar" can be stored until the next harvest. Photo by author.

The tendency to take disaster personally persisted. Odysseus and his crew on an isolated ship viewed their predicament as personal revenge of the god Poseidon. This event is traditionally about 1200 B.C., but the available written versions of Homer's works did not exist into classical Greek times, after 500 B.C. The Hebrew Bible contains other examples, such as the deaths of Nadab and Abihu, allegedly for improperly making an offering.

However, the ancients were not absolute fatalists. Technology continued to improve, with copper tools replacing stones and bronze (an alloy of copper with tin) replacing

copper. Naval architecture improved facilitating the tin trade with Cornwall in the British Isles. Odysseus' crew have probably would have blamed bad construction had their ship sank in Ithaca harbor in calm weather on launching day.

Figure 2: The volcanic island of Thera (also known as Santorini) exploded about 3500 years ago leaving rugged islets. The event wiped out the inhabitants of the island. Tsunamis and falls of volcanic ash devastated much of the eastern Mediterranean. There was trade throughout this region at the time, but a clear historic reference to the event has not been found. The cruise ship (about 200 m long) illustrates the continuing improvement of communications. Photo by Zachary Sleep.

Irrigation developed from observations that plants grow well in desert regions after flooding and from watching the flow of water. It allowed civilization to expand throughout the Middle East. Water management necessitated regional control by complex governments. The bountiful harvests gave rise to raids from nomads, conflicts over fields with neighbors, walled cities, wars, and social stratification. A privileged minority had time on their hands. This led to decadence, organized religions (often deriding decadence), liberal arts, written history, and, for the present discussion, philosophers. Improved communications impersonalized catastrophe. The offenders were a kingdom, a people, or mankind as a whole. Writers in the Hebrew Bible wrestled with the apparent

inequity.

Figure 3: Excavation of the ruins of Har Meggido. Unreinforced stone structures collapsed during earthquakes. Archeologists have found crushed skeletons beneath rubble. Photo by Amos Nur.

Wall cities transformed earthquakes into an impersonal lethal hazard. For example, consider the city of Har Meggido in what is now Israel. It guarded a mountain pass between the Philistine Plain (now the Gaza Strip) and inland cities including Damascus. Control provided defense again the empire in charge of the other side. More remuneratively, the owner could tax caravan traffic. The city, unbeknownst to the ancient inhabitants, lies above an earthquake fault. It is also tens of kilometers from the large fault running from the Gulf of Aqaba in the Red Sea, through the Dead Sea, and the Jordan Valley. Several times in antiquity, an earthquake would topple the walls crushing the garrison. The empire on each side of the city would then send troops. The winner would then rebuilt and placate its deity. The cycle then repeated, but not quite. Building

techniques improved through antiquity with the discovery of the arch and the advent of architects. The connotation of Greek name of this city, Armageddon, has a basis of fact. The Hebrew words “har” and “tel” refer to the low hills formed by the ruins of repeatedly destroyed and rebuilt ancient cities.

Zachariah found moral lessons from an earthquake on the Dead Sea fault. He briefly mentioned what is now called offset on the Dead Sea fault on the Mount of Olives with the correct sense of slip (the west side south relative to the east side) expected from modern science. This event, which also caused damage in Armageddon, had a magnitude around 7.5, a little smaller than the San Francisco earthquake of 1906.

The tendency to moralize after catastrophe persists today. Now as with Zachariah in antiquity, the moralists find the exact lessons that they seek, like blaming Hurricane Katrina on gays. No one to my knowledge took a stance blaming the wrath of the Roman God of Wine Bacchus because of poor patronage of the French Quarter in New Orleans. The rapid reporting of the huge size of this storm and the general knowledge of meteorology would make it difficult to convince anyone that this was personal divine retribution on a bed and breakfast owner in Biloxi who overcharged tourists.

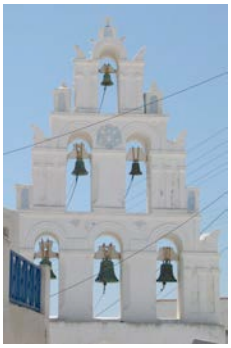
Classical Greek and Roman philosophy. The Greeks inhabited islands in the Aegean Sea and valleys on their mainland. This partial isolation led to a network of city-states with a variety of forms of government, including democracy and tyranny when democracy succumbed to one-man rule. Freethinking led to philosophy as a separate discipline distinct from religion and technology. I discuss the results of Greek astronomy in the next chapter and Greek mathematics in chapter 3. The description of nature

flourished beginning around 500 B.C.

(D1.4) Aristotle (384-322 B.C.) documented what was known at his time. Much of his work survives. His worldview recognized the concept of natural phenomenon. His example, quoted by Charles Darwin (1809-1882), depersonalizes disaster: Rain does not fall with conscious intent to make a farmer's crops grow nor to ruin them during harvest. However, his heavens, especially those past the Moon, were beyond human acknowledge, composed of his fifth element, quintessence, that was found nowhere on the Earth. One could describe the motions of the stars and planets, but not relate them to observable ground-based physics.

The conquest of the Persian Empire by Alexander (356-323 B.C.) spread Greek culture throughout the Middle East. With it came great libraries and centers of learning. Subsequent Roman conquests unified the Mediterranean region. The Romans took great interest in technology. Philosophy continued, but there was no systematic effort to promote science. Pax Romana (Roman Peace, 27 B.C to 180 A.D) marks a period of no serious wars. Roman cities built during that time often lack walls, there was no need for them.

(D1.5) The Roman Empire declined beginning with the death of Marcus Aurelius (121-180 A.D.). The traditional date for the fall of the Western Roman Empire is 476 A.D. The transition into medieval fiefdoms was in fact gradual but punctuated by violence.



(D1.6) Middle Ages. There two diametric popular views about the medieval times: dark-age squalor and fairy-tale castles. Western Europe did in fact lose most of classical book learning. Walled fortifications did reappear. They were small and dank and often doubled as churches. Their sanitation at best involved throwing excrement onto the street or the courtyard. Only the elite enjoyed functional communications. To most, disaster was local and personal. Churchmen range bells and prayed for the end of storms. Steeples with the belfries were the highest objects around, prime targets for lightning. This lethal practice did not end until the late 1700s when Ben Franklin (1706-1790) invented the lightning rod.

The fields of technology involving humble artisans, however, did improve during early medieval times. The horse collar in the 900s made it possible to plow without choking the animal. Plow horses are far more efficient than oxen in the northern climate

zone. Agriculture expanded into northern Europe. Massive horses could carry knights with armor. This enhanced war-making potential and led to advances in metallurgy.

Pope Gregory VII (ca. 1025-1085) marks the transition to late medieval times. Previously, non-Christian beliefs persisted in northern Europe. Kings claimed power over large regions of Europe, but the local lords of castles had day-to-day control over the peasants. The Pope was weak and had little control over the Church away from Rome. He was elected by outcry of the people of Rome after the death of the previous Pope.

Gregory instituted election by the College of Cardinals before becoming Pope himself, but was in fact elected by outcry. Of humble peasant origins, he opposed simony, the sale of Church offices for profit along with other personally decadent practices by the clergy. He also opposed translation of the Bible into common languages with the fear that this would breed heresy. He left a strong papacy in conflict with the crowned heads of Europe at the time of his death in exile.

The Crusades starting in 1096 brought Europe into contact with the Muslim world and the classical works of Greece. Starting in the 1100s, medieval scholastics regarded Aristotle as The Philosopher and his works as dogma. The Black Death (1347-1351) depopulated Europe leaving the survivors in relative prosperity. Necessity began the return of medicine to a practical science-based art from an arcane memorization of trivia, tilling the ground for other sciences.

The Renaissance began as a driven effort to recapture the lost knowledge of antiquity. The effect was lasting. Renewed contact with China brought in the printing press along with gunpowder. Johannes Gutenberg (ca. 1398-1468) effectively adapted the former with moveable Latin typefaces. It no longer required a monastery of monks to reproduce

a book. Our term "clerical error" commemorates the unreliability of the old practice but is now almost equivalent to "typographical error." Common people acquired literacy. University education was a realistic goal for the children of the expanding class of prosperous urban merchants and artisans. It was also within the reach of lower rural gentry.

The 1500s: the rebirth of science

Improved communications turned the 1500s into dangerously interesting times. Power moved away from barons to the kings of centralized nation states. The papacy and the kings contested for power over the local clergy. The general access to education paved paths of upward mobility outside the Church. For example, Shakespeare ventured to London to make his fortune in the liberal arts. Countless others did that in commerce and innovation.

An increasingly educated populace was no longer content to defer matters of state and faith to the clergy and the nobility. In turn, the nobility and clergy guarded their waning influence. The pre-revolution organization of the French government into three estates, clergy, nobility, and common people and the British Parliament into the House of Lords (clergy and nobility) and the House of Commons were attempts to mitigate these conflicts. We still use the term "fourth estate" to refer to the press, which held great power even though it was not an official part of the French government. Cheap handbills, like the present Internet, let anyone of modest means get their ideas out.

(D1.7) The readily available printing press had a profound effect on European religion and then on science. Martin Luther (1483-1546) posted 95 theses by tradition on a church door. They were translated, initially into German from Latin, and printed all over Europe. There had been heresies and antipopes in the past. Protestants struck at the special powers claimed for priests including the sale of indulgences. The Catholic Church effectively reformed on this point and on Luther's other complaints about decadence, but the Reformation quickly got out of Roman control. It was not merely an attempt to direct the papacy or to fix the abuses that had troubled Gregory VII, but one to reform the Church by dispensing with popes. Protestants prayed and interpreted the Bible on their own. To this end, Luther translated the Bible into German. Kings, including Henry VIII (1491-1547), found local control of a reformed church to their advantage. Looting monasteries was lucrative.

Woe to that land that's govern'd by a child!

The Tragedy of King Richard the Third. Act II. Scene III.

William Shakespeare (1564–1616).
The Oxford Shakespeare. 1914.

A patchwork of monarchies and city-states governed Europe in the 1500s. German

states were loosely under the control of the Hapsburg Holy Roman Emperor. The papacy ruled parts of Italy near Rome. City-states, some like Venice partial democracies, ruled much of northern Italy. England, Scotland, France, Portugal, Spain, and united Naples and Sicily were independent kingdoms in 1500.

Hereditary monarchy proved to be an unable system of governance for strong nation states. Kings married their daughters to princes of other kingdoms to cement alliances. Given the low standards of medicine, the ruling king often did not survive long enough to have begotten an adult son at the time of his death. His young child or grandchild might be crowned, leaving relatives quarreling over the rudder of the country. Crowned children were prime targets for assassins as in Shakespeare's *Richard III*. With lack of a male heir, the eldest daughter might rule. In the lack of any close relative, succession passed along the line from a married princess to the king of another country. For example, Phillip II of Spain (1527-1598) was of Hapsburg Austrian origin. He ruled Naples and Sicily, the Netherlands, and Portugal in addition to Spain. He was regent of England during the 1554-1558 reign of Mary Tudor (1516-1558). Her death brought mostly Protestant England and Catholic Spain into direct conflict. Dutch Protestants also revolted against Philip's foreign rule.

The Sortie of Giordano Bruno. Giordano Bruno (1548-1600) was born into this maelstrom in a small Italian town of Nola near Naples. Like many of his day, he entered a monastery to acquire learning and quickly became a star pupil. His independent thinking landed him deep trouble.

In 1576, he slipped out of the Dominican monastery of San Domenico in Naples.

He made it to Rome where he found out he would be indicted. His relative obscurity gave him a chance to escape. Discarding his robes, he slipped north into a sea of religious turmoil. He became an advocate of Copernican theory, believing that the Earth is one of several planets orbiting the Sun. This alone would have been unlikely to bring on serious trouble.

∞ (infinity)

By 1583, Bruno was a recognized man of letters. He enjoyed semiofficial status by staying with the French ambassador in Elizabethan London. London was a hub of enlightenment, an oasis of prosperity from the misery of religious wars on the continent. Practical men realized that tolerance is good for business as long as one did not try to overthrow the state. To boot, Bruno was from Italy, the seat of the rebirth of the arts and sciences. In London, he had his most immediate and lasting influence. He published his salient scientific work, *On the Infinite Universe and Worlds,* in Italian with a fictitious Venetian publisher in 1584. The choice of the language of culture may have helped sales. There may have been intent to obtain some security from the Puritans who would not have read anything in the language of decadence and their censors would not have wasted time looking for a foreign printer. However, it was soon well known that the author was in London.

As the title states, Bruno advocated that the Earth is one of an infinite number of habitable worlds. Unlike the ancient and medieval philosophers, he based his argument on a testable inference (see Chapter 2). The Sun is a star. This simple statement started modern science as what we now call astrobiology. The Church in fact never explicitly banned this concept.

Bruno appreciated vast number of stars can be seen at night and an infinity of more distant stars is invisible. Each star had its own set of planets. He directly challenged the concept that the Earth was specially prepared for mankind. He rejected the concept that natural phenomena occur for our benefit or chastisement. The medieval concept that God does not create in vain still influenced his thinking. His myriad of planets and even their stars were all inhabited. There was nothing special about the Earth.

Bruno's situation worsened in 1585 when his French patron had financial trouble. Bruno returned to France and continued his wanderings through northern Europe. In 1591, he accepted an invitation from a Venetian nobleman, Mocenigo, to teach memory and invention. He regarded Venice, an independent city-state not under the Roman Inquisition, as a safe stop on his early travels. It was a center of commerce, like London; the merchants knew that lethal religious intolerance is very bad for business. He realized that notoriety like insignificance brings some measure of safety. To this point, he had scored a hat trick of excommunications, Calvinist, Lutheran, and Catholic, but not Anglican. Yet he had been allowed to recant and move on.

Disastrously for Bruno, his Italian patron wanted to be taught the black arts, real magic. To make sure that Bruno did not leave and give his supernatural powers to others, Mocenigo threatened him with the Inquisition. Bruno was trapped. He had no real magic to teach. He remained in custody until his death at the stake on February 19, 1600.

A witness account of this event survives to note that heretic was no ordinary Lutheran. The frail nude middle-aged man arrived already on the spit. Chanting monks brought solemnity. Bruno refused his last to recant. The fire ignited. As his last defiant act, he shoved away a crucifix. Blasphemy! The account gives the impression that the flames consumed Bruno's heresy. It could have not been more wrong.

Bruno's teachings. No sixteenth century figure continues to incite such visceral responses. On one hand, Bruno is a father of modern science. A crater on the Moon is named after him. On the other, he is a religious fanatic and mystic who ignorantly forayed into science. He gets only passing mention in the *Oxford Companion to Science*. A *Nova* documentary refers to him as a charlatan. He has been in no way forgiven by the Catholic Church. Just who was Giordano Bruno? What did he profess? What merited his fate?

Giordano Bruno's main interest was philosophy and religion, not science. He was prone to errors when discussing the Copernican theory. He often could not keep his arguments straight. Yet, the leading scientists of the day clearly got the essence of his message whether they were intrigued by it (like William Gilbert of England) or detested it (like Johannes Kepler of Prague.) This is a far better test of lasting contributions than whether moderns find his works easy to read. He certainly did a lot in the 15 years he was at large.

Bruno raised the key issues facing modern astrobiology. In modern terms with a few quotes:

- The Sun is a star. The Earth and the other planets orbit it. The Sun and the other stars shine by their own light. Planets shine by reflected light. The other stars are quite distant. One cannot see planets around them because their faint light is lost in the glare of their stars. "The reason is that we discern only the largest suns, immense bodies. But we do not discern the earths because, being much smaller, they are invisible to us." *On the Infinite Universe and Worlds*. (This is the center of modern astronomy. Equipment to see the very faint light from extrasolar planets

now exists.)

• The universe is infinite with the Sun located in no special place. There is an infinity of stars, each with planets. "There are then innumerable suns, and an infinite number of earths revolve around those suns, just as the seven we can observe revolve around this sun which is close to us." *On the Infinite Universe and Worlds*. (The number of stars is certainly vast, but the structure of the universe is complex. There are hundreds of billions of galaxies each with hundreds of billions of stars in the observable part of the universe. The jury is still out on whether space is infinite in the full mathematical sense and on the fraction of stars with planets.)

• Time is infinite. (The age of the observable part of the universe is vast, but finite 10 to 15 billion years. The best estimate is 13.7 billion years.)

• In general, the same physical laws apply everywhere and there is no special center of the universe. The heavens do change with time; change is just hard to see. "All the stars," says Bruno, "have motion, even those 'fixed' stars of which our sun is one. Nor are the comets in anywise different from other planets but for their apparent difference of position. Whereby their light is sometimes as though exposed to us in a slanting mirror." *De immense*. (Bruno remained a mystic, but he prodded the unification of astronomy with science. The analogy to the mirror for comets is clever, testable, but wrong. Astronomers routinely observe the motion of stars and even the most distant galaxies.)

NASA photo ID AS11-44-6552 **(D1.8)**

• There is relativity in observing. By comparing the mountain he was on with a distant mountain, Bruno noted the nearby mountain would look like the distance one if he switched positions. That is, the Moon would look like the Earth if one was on the Moon and the Earth would then look like the Moon. He even sensed that coordinates are relative to the observer. 'There is no absolute up or down, as Aristotle taught; no absolute position in space; but the position of a body is relative to that of other bodies. Everywhere there is incessant relative change in position throughout the universe, and the observer is always at the center of things." *De la Causa, principio et uno*. (The astronauts had no trouble figuring out they were on the Moon, yet the essence of the first point is correct. Bruno could not have imagined the power of relativity in the hands of Albert Einstein.)

• Bruno used the Earth as a model. There is intelligent life everywhere, both on the surfaces of planets and stars. (No one expects to find anything alive in the scorching heat of stars. There is no other intelligent life in our solar system. The key astrobiological question of how common life is elsewhere remains unanswered.)

• Geometry is largely a waste of time. Mathematics are not much help in understanding the universe. (Bruno knew enough geometry to recognize that

planets are not easily seen around distant stars. He sensed that the self-imposed limitations of medieval and Greek mathematics had put science in a straightjacket. He would be dumbfounded by modern mathematical physics.)

• The Earth is a living, animate object. (This seems like a metaphor to us, but Bruno meant it literally. The Gaia hypothesis of Lynn Margolis (b. 1938) and James Lovelock (b. 1919) has some aspects of the Earth as an animate object where global ecology is a consortium for the benefit of all.)

Bruno's philosophy. Bruno did a lot to anger the Church. His complex religious views are hard to pigeonhole. In modern terms, he was a Pantheist, someone who associates God with the impersonal forces of nature, and an Animist, one who places animate spirits in normally inanimate objects. He attracted no following on these issues. He had little interest in the issues dividing Protestants and Catholics, but was profoundly distressed by the carnage.

Why then was Bruno important enough to attract the wrath of the Cardinals of the Inquisition of Rome? As in Stalinist Russia, one had to be important to merit a show trial. Ignorant peasants and simple town folk could be slaughtered in great numbers, like the Huguenots on the St. Bartholomew's night in 1572. Nut cases could be locked up, held in reserve for show executions, or quietly terminated. Bruno, however, was well known. The Church sent a message to all of Europe.

The exact charges against Bruno are partly lost but they centered around his Pantheism, his rejection of Christian rites and his doubts about the Trinity. The manifest danger to the Church's worldview (included in the surviving charges) centered on his

many habitable worlds and the insignificance of mankind and its home the Earth. One need merely read Galileo and see that he dared not even discuss whether the Sun is a star. The Inquisitors could not linger on this point without promulgating it. Bruno's Cardinals failed to recognize the link between Copernicus, who believed in a limited Sun-centered cosmos, to the idea of a multitude of worlds around a multitude of stars. Copernicus (1473-1543) had only revived the thoughts of the Greek astronomer Aristarchus (310-230 BC). Also, Copernican theory had just proved quite useful in reforming the calendar; its methods of calculation were not to be jettisoned lightly.

Real politics came into play. Spain and the Church had a mortal enemy in Queen Elizabeth, to whom Bruno had dedicated several books. The Spanish Armada had just been destroyed by Elizabeth (and bad weather combined with poor planning), succeeding only in introducing a few half-drowned Spanish surnames into Ireland. Spain pushed for Bruno's execution.

(D1.9: photo Clay Hamilton) Update. Italian republicans erected a statue to Giordano Bruno in the Campo De' Fiori in Rome to mark the end of the Pope's secular power over much of Italy. The Catholic Church is alive and well, but its cozy

medieval cosmos is long gone. The Church now opposes all forms of capital punishment. Jesuits have distinguished themselves in science, including astronomy, geology, and seismology. The Vatican Observatory commands a distinguished reputation. Spain, once the center of the Inquisition, is a leading center of astrobiology.

Bruno is a patron martyr for free thought. Deists (who believe in an impersonal god, often only of the first cause), agnostics (who do not know whether god exists and typically believe it is impossible to find out), and atheists (who believe no god exists) all use the insignificance of the Earth as a prime argument. Thomas Paine (1737-1809), the Deist American revolutionary, took the existence of a vast number of inhabited planets as given. "The person who is irreverently called the Son of God, and sometimes God Himself, would have nothing else to do than to travel from world to world in an endless succession of death, with scarcely a momentary interval of life." *Age of Reason,* 1774.

There has been no shortage of religious wars and religious prosecution from the time of Bruno to the present. Heresy, apostasy, and blasphemy carry the death penalty for a significant fraction of the world's population. The treatment of peasants by Deists of the French Revolution in the Vendée and by the Atheists Stalin, Mao, and the Khymer Rouge would make proud any fanatic of the Wars of the Reformation. Agnostics have authored no major atrocities. It is hard to get militant about a philosophy that admits ignorance.

Bottom Line, Science: tell it like it is

To many, Bruno is an unattractive founder of modern science. Whether we like it or not, neither Galileo nor Newton came up with the concept that the Sun is a star. Neither

did Leonardo da Vinci, Archimedes, nor Aristotle. Bruno, a profoundly medieval man, triggered the development of science separate from philosophy. Science focused on issues resolvable by observations. Data not careful rereading of Aristotle or the Bible became the arbitrator of controversy. Bruno strongly advocated science as continual progress as more is learned, rather than one that resolved issues on the basis of ancient authority.

Bruno's teachings sliced into the heart of the medieval worldview of the fine tuned control of nature by a personal deity. An impersonal view of nature was certainly not new and had been evolving since the Bronze Age. But Bruno proposed that the astronomical heavens were basically like the Earth and governed by the same physical processes. The concept that the Sun is a star struck at the special Earth created for the benefit of mankind. Bruno ably articulated the philosophical implication that we live on an insignificant planet, whether we like it or not.

The religious and political climate was lethal for Bruno but good for the germination of science in general. The possibility of inhabited worlds, perhaps even on the Moon, the Sun, and the visible planets excited the populace of 1600s just as the possibility of ET, fossils from Mars, and earthlike planets around other stars excite today. The backlash of the traditionally religious fanned interest in the controversy. The division of Europe into numerous states and religious sects provided a shifting patchwork of safe havens. Technology played a major role. Printed copies of several of Bruno's works survive to the present day. Good communications carried his fate as intended by the Churchmen across Europe.

(D1.10) Science as we know it arose in the decades after Bruno's death. The learned shifted from trying to immediately amass a full worldview to making careful systematic observations and using logic and mathematics to generalize from them. This is still the case. However, science and technology have progressed to a point where they can address the key issues of extraterrestrial life and the origin of life on our own planet.

Well-functioning science is a big tent. At one end, the Reformation strengthened monotheism among both Catholics and Protestants and the worldview that one God following firm rules, not an anarchy of many feuding demons and spirits, controls nature. Our word "pandemonium" has lost this connotation.

Profoundly religious men welcome science as a search for order, that is, God's Plan. In the middle, the practical care only that science leads to improved technology and explains data. Others espouse the goal that religion and worldview should not influence science. My opinion is that everyone has a worldview. It is best to recognize your biases and then proceed into science. I also believe it is counterproductive in a free society for scientists to proselytize Atheism as a proven scientific result.

Bruno's thought processes and even those of his critics remain the foundation of science: using common sense and intuition to generalize from observations. Nothing is sacred in modern science, but science cannot function without some tentative trust of

accumulated information, like the actually microscope magnifies. In 1600, it was not unreasonable to trust our daily experience that the Earth is firmly fixed. It was not unreasonable to expect works surviving from antiquity, including those of Aristotle that had just been recovered with great effort and the Bible to be reliable.

Common sense and folk knowledge remain excellent guides but poor masters. They are bulwarks against pseudoscience and the starting point for scientific instruction. Generalizing from experience is not infallible. Superstition and failed scientific hypotheses differ mainly in sophistication. Both become dogma when held blindly in the face of observations and logic.

Finally, we see the sampling bias of propinquity where we attach extra importance to recent and nearby events. History remembers Giordano Bruno's fate today, simply because it was the last such atrocity against a scientist in Western Europe in the name of religion. The Catholic Church merely had the misfortune of being the perpetrator. Similarly, we remember the hanging (not burning) of witches at Salem, this time by Protestants in 1692, and the Hatfield versus McCoy feud in the United States that ended in 1891. It was the last such feud because these educated rural gentry did not like being portrayed as unlettered bumpkins in the popular press. The initial affront is clouded in time. My grandmother's (née Mary Agnes Hatfield) tradition was that one of their wagons crossing the Appalachians broke down in about 1800 and the entire family settled right there on what the McCoy family regarded as part of their land. It is grossly inappropriate to judge modern Catholics, Protestants, the Hatfield family, and the McCoy family by these events.

Notes

A good source for Bruno's life is the book *Giordano Bruno His life and Thought* by Dorothea Waley Singer (Greenwood Press, New York, 1968). It includes a translation of *On the Infinite Universe and Worlds*: http://www.positiveatheism.org/hist/bruno03.htm

For a contrary view of Bruno's importance to science see *The Folly of Bruno* by Richard W. Pogge: http://www.setileague.org/editor/brunoalt.htm

The Catholic Encyclopedia gives the Church's current view of Bruno: http://www.newadvent.org/cathen/03016a.htm.

Giordano Bruno by Ingrid D. Rowland gives an excellent account of Bruno's life, times, and associates. Nicolaus Cusanus (1401-1464) speculated on many habitable worlds. He advanced to the rank of Cardinal. Rowland had access to documents unavailable to Singer.

Shakespeare presented *Hamlet* shortly after Bruno's death. The play contains far more allusions to Copernican theory than can be explained by chance. Finding allusions in Shakespeare to Bruno is a cottage industry. You can get a myriad of hits on the web but none are certain. Shakespeare had an acute spectator interest in science. The book *Shakespeare and science; a study of Shakespeare's interest in, and literary and dramatic use of, natural phenomena; with an account of the astronomy, astrology, and alchemy of his day, and his attitude towards these sciences by* Cumberland Clark in 1929 has been reprinted and is available from web-based booksellers. The Irish author James Joyce (1882-1941), like Shakespeare, was an avid spectator of science. He featured Bruno, *Hamlet*, and astronomy in his novels. Physicists honored his interest with the name

"quark" for a class of subatomic particles. Astronomers honor Shakespeare by naming moons of Uranus after characters in his plays.

The Correspondence of Pope Gregory VII compiled and translated by Ephraim Emerton is a good starting place for those interested in the worldview of the late medieval Church. It is available from the web-based booksellers.

The initial intent (and to a large extent the practice) of the Inquisition was to bring the hunt for heretics under disciplined central control. Previously, anyone with sufficient force at his disposal could hunt heretics, take their lives, and keep their property. This naturally led to unfounded accusations. Ingrid Rowland (in *Giordano Bruno*) discusses the operation of the Inquisition of Venice at the time it held Bruno. It spared the unlettered and escapees from Muslim slavery. Inquisition throughout Italy required two witnesses. One anonymous witness sufficed in Spain.

Indulgences were not officially licenses to sin although their critics and many of their buyers interpreted them as such. Rather they offered to shorten one's stay or a dead relative's stay in Purgatory for sins already committed. Luther was certainly not the first person to object to the sale of indulgences. For example, Geoffrey Chaucer (d. 1500) mocked them in his *Canterbury Tales*.

See article "Armageddon's Earthquakes" by Amos Nur and Hagai Ron in *International Geology Review* (volume 20, pages 522-541, 1997) for a discussion of geological and archeological evidence for earthquakes. "*Apocalypse: Earthquakes, Archaeology, and the Wrath of God*" by Amos Nur and Dawn Burgess (2008, 324 pp., Princeton Univeristy Press) provides a more complete account.

The listing of banned books in an Index by the Catholic Church was complicated and

haphazard, as someone had to first object to their contents. For example, Bruno's works did not come to the censors' attention until just after his death. Before then, Galileo could and did openly read them. High churchmen could read the banned books; practically, someone had to read to censor and ban. The need for Church approval provided a crude form of copyright to Italian publishers. By the time of Bruno's capture, the approval process had become slow and cumbersome. The center of publication had already moved into Protestant northern Europe.

The Catholic Church mostly ceased updating the Index in 1948 and abolished it in 1966. It still holds "moral force" in the eyes of more conservative Churchmen. The Index has become increasing irrelevant given that countless books have been published since 1948 and that the concepts in banned Renaissance scientific works are available in more readable formats within modern science textbooks. The Index included works like those of Bruno that might rock one's faith as well as sexually explicit works.

The Index continued to hold local secular power somewhat after 1966. For example as late as the 1970s, the public libraries in the major city of Montréal Québec maintained separate shelving for books on the index along with other "objectionable" books that never formally made the Index, for example, those by Karl Marx. A college student had to ask specifically to access a book by Marx or Descartes to read it for her history class.