TOMORROW IS YESTERDAY: PROTOSCIENCE FROM THE MEDIEVAL MANUSCRIPT TO THE GOLDEN AGE OF SCIENCE-FICTION

by

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ABSTRACT

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Protosciences, or new sciences trying to establish their legitimacy, are ubiquitous in literature. In the old stories we hear of alchemists who can only dream of the discoveries that modern chemists take for granted, and in the new stories we hear of travelers moving faster than light as our greatest physicists attempt to make that fantasy a reality. Limiting our viewpoint to the modern scientific reductionist view of the universe not only makes little sense if we consider Michael Polanyi's theories of emergence and 'personal knowledge', but it robs medieval scholars for the conceptual credit they are due for theories they could not satisfactorily explain by the future's standards, and stifles the sorts of fantastic possibilities that are opened by the great science-fiction authors. Medieval authors' expositions of protoscientific thought laid the ground work for our own modern disciplines, and by reexamining how this happened we can develop a new appreciation for the power of the imagination.

DEDICATION

This manuscript is dedicated to my niece, Scarlet Rose Nicole Leivers-Palm. I wish I could come up with the words to express how brilliant tomorrow will be for you, Little Buddy, but instead I shall borrow some from Alfred Lord Tennyson's "Locksley Hall":

> For I dip't in to the future, far as human eye could see;
>
> Saw the vision of the world, and all the wonder that would be.

TOMORROW IS YESTERDAY: PROTOSCIENCE FROM THE MEDIEVAL MANUSCRIPT TO THE GOLDEN AGE OF SCIENCE-FICTION

I. INTRODUCTION

Protosciences, or new sciences trying to establish their legitimacy, are ubiquitous in literature. In the old stories we hear of alchemists who can only dream of the discoveries that our modern chemists take for granted, and in the new stories we hear of travelers moving faster than light as our greatest physicists attempt to make that fantasy a reality. In knowledge lies power, and to that end the most powerful figures in our tales, for better or worse, are educated in the knowledge of their times. The most important protoscience in medieval times was theology: the theory was that if one seeks to comprehend the underlying structure of reality, the way to do that was through study of the divine. In the Early Middle Ages, rulers such as Alfred the Great wrote of the great importance of education, the need to explore various kinds of research, and the exhortation to learn regardless of the ramifications of that learning. King Alfred’s reasoning was very succinct: ignorance promotes sin, and this is displeasing to God; the world is vast, and not exploring it undermines the religious duty we have as caretakers of our world; and since the Garden of Eden, we have already chosen the hard path of knowledge, so there is simply no turning back now. Many see the time between the collapse of Rome and the European Renaissance as a time of intellectual hiatus, but the extensive collection of protoscientific manuscripts—ironically preserved by those who would later have science turn against them—begs otherwise.

This marriage of belief and science continued through to the High Middle Ages, where the use of both imagination and logic allowed illuminating breakthroughs in scientific ideas, and authors like Dante provided powerful secular explanations for the world of the divine. By the Late Middle Ages, science and religion had entered into a competition, and writers like Chaucer show that in the popular culture of the time the secular had begun to attract some disdain, though science had proved with some of its early successes that it was a serious contender in the arena of knowledge. Yet it seems that the theological outlook was still the heavyweight in this arena. At this time an ultimatum seemed to be set: one can believe in Scripture, or one can believe in science. For the researcher-clerics of the day, it must have been very difficult to know that whatever truths they discovered would be concealed if it did not accord with theological thinking on the same subject.

We can see then that medieval times had come full circle, from Alfred's exhortation of learning to Chaucer's mocking yet begrudging respect of the power knowledge brings. Five centuries later, many of society's important critical thinkers—Lévi-Strauss, Marx, Engels, Russell, Wittgenstein; the list goes on at length— deemed that science had eclipsed religion in terms of which has more veridical and practical value, and came to promote the atheistic view of the universe that their conclusions suggested. But in the 20th century when these thinkers had thought of themselves as all but putting the nail in the coffin as far as the value of religious discourse on scientific subjects, the authors of the Golden Age of science-fiction showed us possible ways to bring secularism and religion back into a complementary balance, since a world without either once again seems inconceivable. These speculative writers saw the world as a unified whole, not a physical scientific world and a separate incorporeal spiritual world. The two aspects of the world were seen as contradictory in that they could not confirm each other by their methodologies, but the sci-fi writers still managed to present their contemporaries with the challenge of explaining that divergence in terms of the difference between what something is and what it seems to be.

To illustrate what I mean, consider the oscilloscope: it gives us a visual representation of a soundwave, which in some scientific endeavors is extremely important. But consider also the synesthesia we force upon ourselves by using our eyes to do the job of our ears: we can watch Beethoven's Fifth Symphony arc and jig across the screen, but is the oscilloscope reading in terms of pure sound pressure fluctuations still music? Does it make us feel? When the wave form reaches its crescendo do our hearts race? The answer is no, but this analogy serves to illustrate a valuable point: early thinkers and sci-fi writers are describing a symphony they hear, while "hard" scientists are staring at a little screen that seals off knowledge of the music into a single dimension, that of the frequency ranges of its component sounds. When faced with the choice of both looking at and listening to music, we can analyze both, but only fully experience the one. To explore a unified world of science and mind, as the writers of medieval times and of the Golden Age of sci-fi did, we require both the truth and regularity of factual science combined with the creative boundlessness of the flexible and imaginative mind. One philosopher in the last century who best embodies this drive to unify the secular and religious, and the man who provided the intellectual inspiration for this thesis, is Michael Polanyi.

Polanyi formulated the concept of “personal” knowledge, or knowledge without scientific rationalization, based on his belief that science was merely one of many possible practices of knowing, theology being another. The lower-level properties that science determines for us are descriptive, but contrary to reductionist beliefs these properties cannot account on their own for the emergent higher level realities and structures they create. By way of example consider a book. I am sure that throwing it into a mass spectrometer will give us many fascinating insights into the composition of the book, how much carbon it contains, its mass and density, and so forth. Nevertheless, reading the book is an example of a higher-level emergent structure: the letters and words have semantic content that can teach someone who reads it far more than they would learn by simply analyzing the book’s physical structure.

In looking at how science fails by narrowing its perspective, we might conclude that all sciences are protosciences, in that their legitimacy will never be proven because they cannot describe every thing in every way. Now that we have some theoretical background that suggests the compatibility rather than exclusivity of the scientific and religious methodologies, we can look back over the last 1400 years of literature and see Polanyi’s theory of tacit knowledge in action, sometimes moving science and religion closer together, and sometimes splitting them further apart, but always maintaining that they are two modes of understanding a single reality.

To illustrate this idea, one might consider Dante and Chaucer, in whose writing we see protoscientific ideas used to frame religious elements into realistic narratives, and the novels from the Golden Age of sci-fi, such as Walter M. Miller’s *A Canticle for Leibowitz* and A.E. van Vogt’s *The Voyage of the Space Beagle*, which ask us to take a leap of faith outside of the hard realistic facts that comprise their settings, adding a level beyond the possible in order to make their stories more meaningful. These sci-fi narratives make a strong argument for seeing the world as a single religious and scientific experience as the medieval writers did.

In order to combine these two vastly different views of the world, we must compare and find points of commonality between them. If there is a single ontological truth that both a cleric and a scientist can hold to, for example, it is the view of nomological determinism, that things' circumstantial limitations determine how they are and cannot be any other way. This idea has fundamentally shaped how mankind has examined the tendencies of nature, the structure of reality, and the mechanics of human thought since the beginning of religious and philosophic thought millennia ago. As the medieval protosciences started to make progress, the simple argument that "we understand the world because God made it so" lacked in profundity and empirical demonstration for those of a more advanced philosophic or scientific bent. Though the entire medieval canon is formed upon this backdrop of mandatory biblical exegesis, many clerics found themselves inspired rather than constrained by that ideological framework, and proceeded to expound on scientific ideas, in Polanyi's words "tacitly knowing" that the data they gathered, though in opposition to doctrine, was the truth.

Medieval literature is replete with narratives that explore this dynamic between what is real and what is merely in reality. Exposition of protoscience abounds throughout Dante's *Divine Comedy*, and in some of the religious and poetic musings the poet utters, his explanation of the world hits very close to the mark of what modern science would say is actually happening. The type of reasoning he uses to accurately describe physical phenomena is based on both intuition and deduction, interpreting the innate knowing gained from religious experience along with the protoscientific knowledge available to him. In *The Canterbury Tales*, Chaucer shows us the antagonism experienced by clerics and scholars, showing at times disdain for scholars as disreputable characters, such as in the *Canon's Yeoman's Tale*. This tale is of particular import, because it portrays the party of pilgrims—who are supposed to be a demographic snapshot of the Late Middle Ages—as deeply skeptical of scientific experimentation and alchemy and all who practice it, yet these same pilgrims are also fascinated by the allure and power that science promises. It is important to elaborate at this point about some of the protoscientific themes these authors explore before again returning to discuss their function of unifying those protoscientific ideals with the religious dicta of their day. If we consider what was discussed earlier, that the unity of the scientific and the spiritual waxes and wanes, we can see from these last two examples that the two frameworks were more tightly intertwined during Dante's time than during Chaucer's.

By the time of the later narratives I will be analyzing, this rationalization is inverted, yet similar: in the Golden Age of sci-fi, it is irrational and unscientific thinking that ultimately prevails in worlds that are much like the 20th century, where science is supreme and everything else is merely hokey-ness or illusory epiphenomena. Tales such as those of Miller and van Vogt show us that science itself is only a means to shape and explain the world, but it is not the world or an end to pursue in of itself.

Through specious reasoning, we can dismiss half of the reality available to us. In the following paragraphs, I want to demonstrate the value of Polanyi's ideas in reexamining what we consider fantastic or impossible in our tales when looking solely from a scientific or philosophical vantage point. Even the primitive protoscientific writing of scholars such as the Venerable Bede demonstrates the metaphysical ideal: using innate knowledge, it is possible to categorize and bring order to reality. Both clerics and scientists seek answers to the same questions, and whether it is to please a deity or better humanity through discovery, by working together they can explain far more than they can apart. Like Polanyi, the Golden Age of science fiction writers do not discount the operational and probative successes of science, yet they join him in being critical of the most troubling aspects of modern scientific reductionism.

At this point some background into Polanyi's views on reductionism is warranted before examining why reductionism is problematic, despite science's intent to discover underlying causes of truth. In "Life's Irreducible Structure", Polanyi illustrates reductionism's shortcomings with a simple example: a DNA molecule, like the metaphorical book I spoke of in an earlier example, contains information that cannot be explained simply by chemistry or physics. Because it exists, a molecule or book has physical and chemical properties, but these alone cannot account for what Polanyi terms higher-level ordering principles, like cognition or language. Consider the connections and relationships we can examine in reality that are not simply confined to the spatial and temporal attributes of a subject: Polanyi calls this enfolded or implicate order, like the information in DNA or books. The abstraction and recombination that arises from all possible implicate orders, including those examined by theologians, makes up our innate knowledge, mindedness, and cognition on an even higher level: Polanyi calls this explicate or unfolded order.

Polanyi's argument against reductionism is obvious, and helps support the ideas in subsequent chapters from the Middle Ages and the Golden Age of sci-fi which emphasize a whole-ist view of reality. Polanyi's main criticism of the reductionist or mechanistic worldview is presented in "Transcendence and Self-transcendence", where he states that the normative postulates and limitations assigned to implicate orders—like the sciences that would have us believe in a clockwork universe—hinder their integration into the overarching explicate order. By looking back at the medieval protoscientists' work, we can see that though their familiarity with the ordering principles of science as the modern world sees it was slight, their expertise in the theological ordering principles more than made up for it and managed to put them on track to understanding the highest, explicate order centuries ahead of those who went by science alone. The sci-fi authors that will be mentioned in the last chapter, using the wealth of knowledge in all fields available in the 20th century as their source material, demonstrate the imaginative power of using all available modes of thinking to push back the limits of what is considered impossible.

Before presenting counter-arguments and intellectual foils to the ideas of Polanyi's presented above, it would be helpful to give a brief overview of the protoscientific authors discussed in subsequent chapters of this thesis and how their conclusions—drawn mostly from classical logic, exegesis, and tacit-knowledge and only very slightly from hard science-hit awfully close to the mark. The first chapter of this thesis begins with The Venerable Bede (or Bede the Ecclesiast, but hereafter in the text, he will be referred to simply as Bede), who lived from 672 until 735. The discussion starts with an extract from his *Lesser Chronicle*, in which he uncannily predicted the end of time, though this went against the church teaching of eternity. What renders his conclusions even more interesting is that they prefigure the cold-death theory of the universe by thirteen centuries. The next text used to illustrate the importance of critical thinking to medieval audiences is Alcuin of York's (735-804) *Problems to Sharpen the Young*, which was a very popular school textbook that contained mathematical and logical problems. Unfortunately, though it contains the solutions to the problems presented, they are explained in a haphazard fashion that shows no working proofs, though they are correct in outcome. Alfred the Great's (849-899) *Preface to the Translation of St. Gregory's Pastoral Care* is one of the more important pieces from this era for reasons mentioned above, but also because Alfred is keenly aware of knowledge that has been lost from the classical era, and the importance of using one's mind to recover such knowledge and pass it on. Adelard of Bath (1080-1152) in the dialog *De Homo* agrees with this, and suggests that any question that can be thought up can be provided with an answer. He suggests further that knowledge is a continuum, and by understanding root causes of things in the past, we will be able to predict their final effects in the future.

The second chapter will include support from Robert Grosseteste (1175-1253), the founder of the Oxford Franciscan School, who in *De Luce* provides an epistemologically sound theory of cosmogeny that is not far removed from what most physicists believe today. John of Sacrobosco (1195-1256) is in accord with Grosseteste, and provides further insights into the size of the earth and its placement in the universe that are far closer to today's views than the Ptolemaic and geocentric models the medieval period is attributed with adhering to. Roger Bacon (1214-1294) provides some of the earliest criticism of science, suggesting in the *Opus Majus* that though alchemy has valuable practical applications for health and wealth, the greed of men keeps the best knowledge in the hands of a few. The final part of this chapter will discuss Dante's (1265-1321) *Divine Comedy,* which is an excellent example of almost all of the protoscientific knowledge gathered throughout the High Middle Ages woven into a narrative that blurs the line between the physic and metaphysic, the real and the fantastic.

The third chapter begins with a brief analysis of John Duns Scotus (1266-1308), who in *A Treatise on God as First Principle* considers St. Augustine's argument that "Knowledge is born of the knower and the known" and suggests that knowledge builds upon itself in a consistent manner. Next we will consider William of Ockham (1287-1347), the formulator of the concept of parsimony. Ockham has gained both wide appeal and drawn heavy criticism from logicians and scientists for its simplistic approach to an ontological problem. Thomas Bradwardine (1290-1349), of the Oxford Calculators, will also be examined for his novel resolution to Socrates' Liar Paradox, which has deep implications for what we consider certainty.

To put these scientific ideas from the late Middle Ages into their cultural setting, we will look to Chaucer's *Canterbury Tales* to provide a wealth of illustrative examples of both the role of science in medieval society, but also the start of the discord between the fields. *The Pardoner's Tale* is of notable interest, since he is using sound scientific principles that would be familiar to any psychology student from the modern day to explain behavior that had previously been attributed to some teleological origin. *The House of Fame* contains one of the first accurate descriptions of how sound actually works, and even though it is a fantastic dream, it gives remarkable insight at the conclusions that can be drawn from creative thinking. *A Treatise on the Astrolabe* is an instruction manual for his ten-year old son on the use of said instrument, which shows to us an audience interested in astrology in the 14th century, just as the audience of the 20th was interested in astronomy.

The final chapter of this thesis will examine in depth Miller's *A Canticle for Leibowitz*, examining a future in which the Catholic Church is preserving scientific knowledge without any ability to use it after a nuclear fallout, and van Vogt's *The Voyage of the Space Beagle*, in which the first human intergalactic voyage is attacked by god-like life-forms and is rescued by a member of the crew who studies "Nexialism", a meta-science comprised of all scientific disciplines. Criticism in this final chapter will cover knowledge and reality representation, the limitations of scientific representation, the inability to ignore science's roots in myth, the hazy frontier between applied and pure science, the abuse of knowledge, and possible worlds that allow for science and religion to be part of a single master disciplinary discourse called protoscience.

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II. THE EARLY MIDDLE AGES

In popular culture, the early Middle Ages conjure up an image of civilization in ruin after the collapse of Rome, a time when knowledge lay dormant until the Renaissance. Medievalists are more knowledgeable about and willing to defend the advancements of the early Middle Ages, but it is important to realize that this was the major turning point for scientific research and educational practices in the West. The history of monastic scholasticism is fascinating because the conclusions these clerics reach about reality by using only Biblical exegesis arguably accord with what many modern physicists believe. These men did not simply chant, pray, and labor in God's name, but made textbooks on logic and math for mass distribution. Translation of Scripture into the vernacular was encouraged, despite the widely held modern belief that the church deliberately tried to keep the masses unintelligent. Research was encouraged, as to understand God's creation was to become closer to Him. Greek and Arab texts were acquired and studied at length, and the clerics added to the conversation—ongoing to this day—about logical and causal paradoxes.

This chapter will briefly look at Bede's "On the Ages of the World", an early treatise on cosmology, then Alcuin's "Problems to Sharpen the Young," and an accompanying criticism by John Hadley and David Singmaster in which they are critical of the way that Alcuin withheld information that would have been helpful for students and would have been found in any modern textbook. King Alfred the Great's *Preface to the Translation of St. Gregory's Pastoral Care* shows us that the governments of the Dark Ages were at least as concerned with the intellectual welfare of their people as our society is, and we can clearly see that subsidized education, even if it has a religious basis, has always been the impetus behind scientific innovation. Alfred also stressed, as I am trying to do, that revisiting the knowledge of the past is immensely valuable. Translation for these passages was done by Elaine Treharne. The final primary source examined in this chapter, Adelard's "Of Man", attempts to explain that using science for predictive purposes is not against God's will, since science is a part of creation within our understanding. Accompanying criticism from Thomas Martin's *Poiesis and Possible Worlds* gives valuable insight to the problem of logical equivalence that Adelard describes.

One question for which there are only protoscientifically theoretical answers is 'what will happen at the end of time'? The Bible, from which most of the medieval scholars drew their ideological frameworks, describes the eschaton as the end of time. When the universe reaches maximum entropy, or thermodynamic equilibrium, there will be no stars, or gravity or therefore time, according to the theory of the Heat-Death of the Universe proposed by Kelvin. As in the Bible, at the end of time there will be nothing of what the monks and physicists consider reality: no sunshine, no matter, no people. But what both parties do agree on is that there will be something else when there is no more time. In chapter sixteen of the "Lesser Chronicle", entitled 'On the Ages of the World', Bede describes the first five ages according to classical and Biblical sources. He says that "The sixth [age], which runs now, is not certain of its generations or times but—like creaking age—must finish with the death of all time." Though he knows nothing of entropy or thermodynamics, Bede is able to see the world around him as simply as it is: plants grow strong then wither, great cliffs are eroded, yesterday's children are tomorrow's elders. Bede does not need billion-dollar telescopes or a grasp of the underlying theories behind proton decay. By simply applying the transitive property, he is making some really accurate inferences. There are ages of the universe, and the timescales that comprise them are often inversely correlated to their importance, just as in the biblical timeline that Bede provides based on that conjectured by St. Augustine of Hippo.

Before returning to our exposition of the protoscientific advances of the Early Middle Ages, it would be helpful to elaborate somewhat upon the idea presented by Bede about the timeline of man. As mentioned before, Saint Augustine was the first to adapt the classical idea of the stages of man for a Christian ideological framework in his work *De Catechizandis Rudibus*. The classical ages of man, as described by Hesiod in *Works and Days* and Ovid in *Metamorphoses*, show the same trend that Bede and Augustine also describe, that the universe and humanity are gradually getting worse and that time itself is a highly variable phenomenon. Augustine took his queue for this last idea from Scripture, where in the Second Epistle of Saint Peter it is written that "one day with the Lord is as a thousand years, and a thousand years as one day" (II Peter 3:8).

Each age gets longer, though men's lives get shorter, and each shows less and less involvement from the creator deity than the age before. In looking at a graphical timeline from the Big Bang to the Heat Death of the Universe, we see that there are also six stages before the end of time, and in each one less 'stuff' to do with the initial creation occurs at much slower rates over longer periods of time. To put all this into perspective let us take a look at the first biblical age, the creation. Most skeptics of religion scoff at the idea that the universe was created in a week, but cosmological physical evidence shows that every hydrogen atom in the universe—therefore all matter—was in fact brought into existence between one microsecond and one second after the Big Bang. The Biblical account of the ages suggests that living things lived longer earlier on in history, such as the famed old Methuselah. Biological accounts show that more modern species, such as hominids, do not last as long as those from earlier species such as dinosaurs. What is of critical importance here is that there are so many ideas that are dead accurate: time is relative, it will end, life and the universe are slowing down and growing weaker till the end of all things. It is easy to adjust the time scales Bede deals with to our own, but only from a 21st century standpoint with all the wealth of knowledge in cosmology and paleontology that our time provides.

Medieval protoscientists were not just interested in the theoretical aspects of science. Alcuin's *Propositiones ad Acuendos Juvenes* is both fun and practical, and is one of the earliest examples of what we might consider a math textbook. In their translation and commentary entitled "Problems to Sharpen the Young" Hadley and Singmaster say that Alcuin's "solutions are generally very sketchy, usually simply verifying that the answer works with no indication of its derivation" (104). Some solutions are actually very useful once translated into contemporary arithmetic, such as the barrel-sharing problem.

Alcuin's barrel-sharing problem—Problem #12 as it is known in the text—sets as its premise a father who has died leaving an inheritance to his three sons that consists of thirty glass flasks, of which ten are full of oil, ten are half-full, and ten are empty. Alcuin wants his students to explain how the oil can be divided so that each son gets an equal amount of both oil and flasks. By using Alcuin's formula—

$$\frac{x^3}{(1-x^2)(1-x^3)(1-x^4)} = x^3 + x^5 + x^6 + 2x^7 + x^8 + 3x^9 + \cdots .$$

—we can see that the terms of his sequence correspond to the number of solutions for each kind of flask. Though the formula above would not have been able to have been written by Alcuin in such a fashion without extensive knowledge of algebra, that does not detract from the fact that he still managed to both work out the problem and pass that knowledge to others.

Having demonstrated the power of algebra without algebraic form, it would be remiss not to point out some of the contradictions in Alcuin's method. Hadley and Singmaster are particular concerned with some of the problem-problems, such as #43. A man wants his three hundred pigs slaughtered over three days, with an uneven number killed each day. Alcuin provides no solution, and Hadley and Singmaster conjecture that this is an exercise to put 'smart' students in their place. My own theory is that Alcuin was still using the Roman concept of *nulla*, or N—which early European mathematicians did not know what to make of as a number but still used—rather than the digit 0, which did not arrive until the Moors brought the base-ten system through Iberia in the 11th century.

If we only have Alcuin's knowledge of zero, which is about as advanced as Xeno's, then we might consider that nothing is paradoxically not divisible by two, so would not be an even number. Therefore, the butcher could take a day off and the problem is solved, though this is not an answer in keeping with today's more complete set of mathematical rules.

This drive towards education and scientific exploration in the early Middle Ages was aided in no small part by King Alfred the Great. *Bright's Old English Grammar and Reader* contains a missive written in the king of Wessex's own words called "Preface to the Translation of St. Gregory's *Pastoral Care*." Alfred begins by deploring the lack of teachers in England, because people simply won't or can't study. He says:

> Ond for ðon ic ðe bebiode ðæt ðu do swæ ic geliefe ðæt ðu wille, ðæt ðu ðe ðissa woruldðinga to ðæm geæmetige swæ ðu oftost mæge, ðæt ðu ðone wisdom ðe ðe God sealde ðær ðær ðu hiene befæstan mæge, befæste. l.18
>
> And therefore I command thee to do as I believe thou art willing, to disengage thyself from worldly matters as often as thou canst, that thou mayest apply the wisdom which God has given thee wherever thou canst.
>
> (Treharne 15)

The rhetoric Alfred employs is powerful: he is a liege lord giving an order, but he makes the proposition seem appealing. He tells his people he believes they are capable of great learning, and gives no caveats or restrictive limitations on what to study. Alfred is keenly aware that much knowledge had been lost, not just from antiquity, but between recent generations. He chastises his readers, saying:

> Ure ieldran, ða ðe ðas stowa ær hioldon, hie lufodon wisdom & ðurh ðone hie begeaton welan & us læfdon. Her mon mæg giet gesion hiora swæð, ac we him ne cunnon æfterspyrigean, Ond forðæm we habbað nu ægðer forlæten ge ðone welan ge ðone wisdom, forðæmðe we noldon to ðæm spore mid ure mode onlutan.
>
> Our forefathers, who formerly held these places, loved wisdom, and through it they obtained wealth and bequeathed it to us. In this we can still see their tracks, but we cannot follow them, and therefore we have lost both the wealth and the wisdom, because we would not incline our hearts after their example.
>
> (Treharne 15)

Wisdom here is not simply a resource to be harnessed, though it is very important in that respect, but for Alfred it is also a way to honor one's ancestors and their cultural achievements in keeping with Christian ideals of piety. His directive to translate Scripture into the vernacular was a way to empower more people to learn, even church services, the backbone of any medieval community's education, were conducted in Latin. It is interesting to note that science today similarly has such specialized jargon that higher order ideas are often as inaccessible to the layperson as religious teaching would have been to a commoner of Alfred's time. The message of Alfred's letter should be reexamined today, when we have many subjects of inquiry that are taboo on religious grounds, even though it was evident to clerics more than a millennium ago that God would not put things in front of us to study if He did not want us so to do. As for the caution about waning between generations, consider that our father's fathers conquered the Moon, but our contribution to civilization is televisions that are bigger and flatter than our elders'. It is hard work to keep the conversation going, but as our final source will show in the chapter, the rewards for diligence in scientific inquiry are numerous.

In *Conversations with his Nephew*, Adelard writes a series of dialogues in the Platonic style in which he discusses the state of knowledge about natural phenomena in the 12th century. In the dialogue "On Man", his nephew at one point complains that Adelard's questions are too difficult in that their answers only generate more difficult questions. Demonstrating deep insight into the working of the human mind, Adelard replies to his nephew:

> You say that innumerable thorns in the mind arise from my questions, but they are neither too many to number, nor should they be called thorns. Understand it in this way, if you are intelligent enough. The supremely good Creator of things (*res*), drawing all things into his likeness (as far as their nature permits), has adorned the soul with mind, which the Greeks call '*noys*'. The soul uses this with clarity when she is in her pure state, lacking any disturbance from outside. She reaches not only things (*res*) themselves, but also their causes and the beginnings of their causes, and from present things understands those to come, a long time in advance. (17)

To make this clear for a modern audience, Adelard is saying that if the mind uses all of its abilities and avoid outside interruptions, there is no limit to the amount of knowledge that can be gained. Adelard's views are fairly unique among his contemporaries since he is emphatically stating that in matters natural and scientific, the human ability to reason will triumph over any authoritarian dogma, that logic in many cases was more useful than faith alone. The fact that Adelard was also willing to embrace Arabic teachings, despite the clear antagonism between Christianity and Islam, made him a champion for those that would put discovery ahead of politics, or who considered all men, even those whose souls were not pledged to Jesus, to have intellect and therefore value.

Faith in God and the ability to use reasoning to seek knowledge are not mutually exclusive, but if we consider the logical-equivalence problem, they will always be so. In *Poiesis and Possible Worlds*, Thomas Martin explains that:

> If two terms are logically equivalent, then any true statement made about one term will be equally true in the substitution of the other term in the statement [...] The problem arises when we try to carry this principle over into modal contexts, particularly those pertaining to knowledge and belief [...] Thus another way we could formulate the problem is to say this: a believes P is true, and at the same time a believes Q is false; but since P is logically equivalent to Q, we encounter problems because the person would therefore believe the proposition to be both true and false at the same time and in the same way. So what do we do with the problem of logical equivalence in modal contexts? (107)

I would argue that in many cases contexts are not considered modal, particularly the Scriptural and not the merely literary. To the audience of the early Middle Ages, Scripture was a fact, neither merely possible nor simply *divertissement*. To a modern audience, beliefs are irrelevant and only facts matter. Consider the creation of the cosmos. Origin P, the snap of a deity’s fingers, and origin Q, a quantum singularity, are logically equivalent. No matter which premise one believes, they both explain the same thing, but using vastly different kinds of evidence. I would not make the case that both are wrong because we have no final evidence either way, nor would I make the case that they are both right in an apologist's promotion of the intangibility of language. The only thing that is sure is that Adelard's idea that maybe P makes Q happen, or that Q is how P does it is lost on a modern audience. We might cynically say where else could anything be learned than at a church, one of the only sites of literacy in the medieval world? But to do this takes so much away from the Church's early promotion of scientific endeavor, and fails entirely to try to recapture the spirit of a single unified reality that these early protoscientists believed in, rather than a real world and a spiritual one that our modern society tries hard to keep apart.

III. DANTE

By the high Middle Ages, thanks in great part to the push towards education described in the last chapter, many of the practices and ideas that would eventually shift the protosciences into the mainstream were taking shape. Monastic orders of the 12th century began to develop what would be considered ‘real’ scientific methodology as we would see it today. The ideas at this time about cosmogony were almost analogous to our modern physicists, as were concepts of the shape of the universe and the earth’s place therein. The protoscience alchemy, which became chemistry in post-Enlightenment labeling, also took great strides at this time in theory if not in practice. But the most interesting thing to note is that during this period is when protoscience started entering into literature and narratives, which gives us valuable information about science’s role in popular culture in medieval times, and gives us opportunity for reflection about science’s role in our more modern narratives.

The chapter will begin with Robert Grosseteste’s *On the Metaphysics of Light*, which provides an early attempt to explain how energy becomes matter and spreads out across dimensions, using Clare Riedl’s insightful translation and interpretation. Thorndike of *The Sphere of Sacrobosco* follows, accompanied by another valuable translation from the Latin by Lynn. Though Sacrobosco’s reasoning about how the ‘firmament’ works is flawed, his interpretation of the work of Alfraganus about the sizes and distances of astral objects predates many ideas not put forward until Galileo, Halley and Hubble.

The final protoscientific source I will be examining in this chapter is an extract from Roger Bacon's *Opus Majus,* in which he describes some alchemical possibilities, and then subsequently warns that that particular science is dangerous knowledge in terms of is abuse potential. The modern English translation of Bacon's thoughts on alchemy provided by Robert Belle Burke is very succinct and clear to interpret with respect to the nuance of Latin vocabulary. To conclude the chapter, the grand ideas presented by these scientists will all be shown in a narrative context that illustrates the importance of the artist in presenting protoscientific ideas to the public. Dante's *Divine Comedy* is a snapshot of the High Middle Ages' ideological framework, and a thorough review of the scientific references throughout this religious poem shows a culture, like ours, that embraced both the hardness of their reality and the possibilities of the next world. The secondary sources used to complement the analysis of protoscience in Dante will include William Egginton's "On Dante, Hyperspheres and the Curvature of the Medieval Cosmos" to help us ascertain the difference between four-dimensional topologies for a medieval and modern audience and finally Mario Trovato's "Against Aristotle" which looks at cosmological representation in other Dante works such as the *Convivio* to show that Dante was willing to change and adapt his ideas as new information became available. The evidence selected should provide a strong case for reexamining the beliefs of the medieval audience, because though they were simplistic enough to believe in an earth below and a heaven above they were complex enough to think of the former as spherical long before Columbus and the latter as four-dimensional long before Schrödinger.

To Robert Grosseteste, the founder of the Oxford Franciscan School, experimental science was a way to explain the mechanics of the things discussed in theological and metaphysical debates. By close reading *On the Metaphysics of Light* we can see that Grosseteste is another example of a medieval scholar thinking far ahead of his time, considering light, or in modern parlance electromagnetic radiation, as the primary building block of existence from which all other matter is derived. The relationship between energy and matter, especially concerning light, continues to be debated in physics today.

Grosseteste begins the passage by explaining his belief that light was the first thing to have substance, or corporeity. He says this is because “light as its very nature diffuses itself in every direction in such a way that a point of light will produce instantaneously a sphere of light of any size whatsoever, unless some opaque object stands in the way” (10). Without really knowing anything about the speed c or wave-particle duality or surface radiation absorption and reflection, Grosseteste is still able to realize that these are things without the proper vocabulary to express it the way we do or the proper equipment to measure it as we do. He says that for something to have corporeity, or embodiment, the matter that composes it must extend out into the appropriate form in three dimensional reality, but that neither corporeity nor matter have dimensions and their spatial presence is an epiphenomenon. He goes on to say that:

> A form that is in itself simple and without dimension could not introduce dimension in every direction into matter, which is likewise simple and without dimension, except by multiplying itself and diffusing itself instantaneously in every direction and thus extending matter in its own diffusion. (10)

To interpret this bluntly, for a thing to have its shape requires it to have some force to push constantly outwards to occupy dimensions, and the only thing in nature that Grosseteste observes constantly expanding to its boundary all the time is light. Our own universe is quite similar: objects exist only by the grace of the gravitational forces without and the atomic forces within. That all matter—from diffuse nebular plasma to our heaviest synthetic elements—and that all energy—from the cosmic microwave background to the pull of the oceans by the Moon—came from a single undifferentiated meta-force.

I will pause here for a minute in my explanation of Grosseteste's description of matter to talk a little bit more about this primal energy that created it. In chapter two, we saw when comparing Bede's timeline of man according to the Bible and the timeline of the universe according to physics that in the beginning, there was nothing and then there was light. Theologians and particle physicists agree on this much at least.

To better understand how uncannily accurate Grosseteste's hypothesis on the primal meta-force was, it would be best to inquire with a modern source for confirmation. In *Quarks, Leptons and the Big Bang*, physicist Jonathan Allday explains that in the current cosmological developmental model, based on the assumption that there is still a Grand Unification theory as yet undiscovered, the first forty-three seconds after the Big

Bang were called the Planck epoch. The grand-unification energy is estimated at over a thousand Giga-electron-Volts and the temperature of the universe at this time is estimated at being over one thousand Kelvin. At this time, electromagnetism, strong nuclear interaction and weak nuclear interaction were all a single property called the electronuclear force, which at the end of the Plank era had already separated itself from the gravitational force. To cut a long story short, mass, charge and spin were nonexistent at this point since there were no distinguished forces yet to let either matter or the forces that control it to form.

The next thirty-six seconds after the Planck epoch—one minute and nineteen seconds after the Big Bang—were called the Grand Unification epoch. At this point the fundamental forces that constituted the electronuclear force split from each other, and the temperature of the universe cooled enough so that bosons—the glue that holds the universe together—could be created. Simultaneously, baryons were also formed at this time, that is to say the types of particles that constitute much of the matter in the universe. As these forces and particles formed, they triggered the Inflationary epoch, wherein the universe began its rapid expansion.

If we consider again Grosseteste's idea of light spreading out and recombining on into new forms over time, this is almost exactly what we just learned from Allday without the confusing scientific discourse, but instead delivered by Grosseteste in a somewhat poetic manner in keeping with Medieval writing conventions. The fact that he deduced all of this from merely considering the dispersal pattern of candlelight on the wall simply beggars the mind.

After presenting the uncannily accurate medieval view of how the universe was in its early stages, it stands to reason to next examine a source that describes the then current shape of the universe. John of Sacrobosco as a man of faith believed in a Ptolemaic cosmos, but believed that the earth's size was so insignificant that its centrality was of little import. In *The Sphere of Sacrobosco*, Lynn Thorndike translates to us that Sacrobosco believed that the Earth was:

> [...] a mere point in the universe [...] That same consideration is assigned that the earth is as a center and point with respect to the firmament, since, if the earth were of any size compared with the firmament, it would not be possible to see half the heavens. Also, suppose a plane passed through the center of the earth, dividing it and the firmament into equal halves. An eye at the earth's center would see half the sky, and one on the earth's surface would see the same half. From which it is inferred that the magnitude of the earth from surface to center is inappreciable and, consequently, that the magnitude of the entire earth is inappreciable compared to the firmament. Also Alfraganus says that the least of the fixed stars which we can see is larger than the whole earth. But that star, compared with the firmament, is a mere point. Much more so is the Earth, which is smaller than it. (122)

It is useful to pause a moment with Sacrobosco's argument and provide a little background on the primary source he presents.

Abu al-Abbas Ahmad ibn Muhammad ibn Kathir al-Farghani, better known to the medieval and modern westernized audience as Alfraganus, was one of the most influential Baghdad astronomers of the Islamic Golden Age of the ninth century. In addition to the research on the scaling of the universe that Sacrobosco alludes to in the preceding paragraph, he also calculated the diameter of the planet by measuring the length of the meridian arc, composed a treaty on the astrolabe that in no small part influenced the one written by Geoffrey Chaucer that we will examine in chapter four, and was charged with the construction of the Nilometer in Cairo. Alfraganus, by rediscovering and reinterpreting the work of Ptolemy as presented in the Almagest, was able to add to and then transmit that knowledge to his European counterparts. Apart from Sacrobosco and Chaucer, we will also see in chapter three that many of Dante's explications of the celestial motion are drawn from the work of Alfraganus.

Now that we have established the background for the universe's topography, we can return to Sacrobosco's scaling problem to see how protoscientists tackled problems our modern astronomers still grapple with. Astronomers have a problem in that as they look outwards in a telescope, they are also looking back in time. The edge is both physical and temporal and equidistant in every direction. It may simply be observer bias, but Sacrobosco has nailed the idea that as insignificant as our world is, for all intents and purposes, it is in the middle of everything. People on another world would also see the edge as far away as we do, and would also be in the center from their own point of view. Though there is a problem with his hypothetical plane exercise in that it does not account for the different set of visible stars in the southern hemisphere—medieval protoscientists were not widely travelled—his observation that the stars are in the same places and appear the same sizes at least half way around the earth is accurate, as is his conclusion that the earth must be infinitesimally small compared to the 'firmament' or cosmos as we would call it. Borrowing from Alfraganus, he also correctly infers that even the smallest star is more massive than the earth, but is of itself also inconsequential compared to the firmament as a whole. This might also suggest that the firmament is a giant sphere, wherein any point might be the center. Until the 20th century discoveries of astronomer Edwin Hubble, everyone simply assumed any remna of geocentric theories as wrong, since the earth was not even in the middle of its own galaxy, and a spherical universe might be a workaround that would be amenable to the pious mind. As seen in the previous example this, the protoscience of the Middle Ages does not need any experimentation, only observation and theory to explain the universe centuries ahead of those who receive credit for it.

Protoscience in the High Middle Ages was not just concerned with ephemeral subjects such as the nature of time and space, but also more practical matters with everyday applications. Alchemy served in that time as a precursor to a range of modern disciplines, including chemistry, metallurgy and pharmacology. Roger Bacon, an Oxford Franciscan and an apprentice of Grosseteste's, devoted almost all of his research towards practical ends, including helping to develop a more accurate calendar, providing the first western description of gunpowder and its creation, and attempting to explain the legitimate principles behind alchemical transmutation. In the third exemplum of part six of the second volume of his *Opus Majus*, Bacon tells us that:

> The dignity of [experimental] science can be exemplified in alchemy [...] for that whole art is scarcely so perfected that the greater metals may be produced from

> the lighter ones, as gold from lead, and silver from copper [...] but that art never suffices to show the natural and artificial grades of gold and the modes of its grades [...] since this art is not known to the majority of those who are eager for gold, many frauds consequently are perpetrated in this world [...] the art of alchemy not only omits these modes, but this gold of twenty-four degrees [carats] is very rarely found, and with the greatest difficulty. (626)

What Bacon is saying here is that though alchemy is legitimate, it is not being done in a methodical enough fashion to achieve its full potential. To elaborate consider the problem Bacon describes in being able to find pure twenty-four karat gold. An alloy of eighteen carat gold will have very different properties if the 25% impurity is lead or if it is silver, and its purity can either be measured by mass or by volume.

A useful side note here would be to provide an explanation for the different possible ways to calculate a gold alloy's karat value. The first way, that the medieval alchemists were entirely dependent on, relied on gauging the alloys mass and followed the following formula:

$$X = 24\,\frac{M_g}{M_m}$$

The mass of gold divided by the mass of impurities multiplied by twenty-four—the maximum karat value of a quantity of gold—yields the karat value of the alloy. In modern times, with the knowledge we have about atomic weight and matter density, we use instead a volumetric formula that goes:

$$V_{Au} = \frac{M_a \times \frac{kt}{24}}{19.32}$$

The total volume of gold is found by taking the mass of the alloy and multiplying it by the alleged karat value of the alloy divided by twenty-four, and then dividing this number by the density of gold, or 19.32 grams per centimeter cubed. Not knowing about volume and density, we are quite lucky that Bacon and alchemy enthusiasts like him were able to get close to the mark, and furthermore that their earlier formula eventually became one of the operant elements of the later one.

Bacon's observations also serve as a potent reminder of our own science-for-profit culture, as he chalks up both the uncertainties of the discipline and the lack of pure raw materials to men's greed. Considering this, it is no surprise that the most lucrative and useful protosciences are often the ones that take longest to either progress or be debunked. It would have been impossible obviously for Bacon to predict modern advancements in neutron-bombardment techniques that can literally transmute elements, but his faith in the order of the part of the system that he could observe allowed him to imagine possibilities that took centuries to come about.

The imagination of medieval protoscientists and the power of their ideas ensured a place would be carved for them in the public consciousness, and no one can give us a better impression of the importance of protoscience in the High Middle Ages than Dante Alighieri. In *La Commedia*, the poet is able to deduce or guess the nature of advanced concepts from the fields of astronomy, quantum mechanics, probability, atomic theory, geology and the equatorial bulge, holography, gravitation, faster-than-light travel, cosmology and space-travel. Many of Dante's comments are so subtle that at first glance they seem quite far off the mark from how modern scientists understand them. In *Par* 15.13-18, Dante accurately describes a meteorite, saying that:

> As now and then through calm and cloudless skies
> a sudden streak of fire cuts the dark,
> catching the eye that watches listlessly,
> as if a star were changing places there
> (except that from the place where it flared up
> no star is missing, and the blaze dies down).

A casual observer might say that this is not what is happening, as meteors are not stars, but lumps of rock. Any astronomer would point out that Dante is quite correct: all of the elements heavier than hydrogen and helium are ejected from the cores of burnt-out stars when they go supernova. These rocky compounds form the asteroids that burn up in our upper atmosphere or in Dante's terms the "sphere of fire" that encircles the planet. During Beatrice and Dante's intergalactic journey in the Paradise, they enter into a long discussion about the nature and composition of the moon and the spatial medium.

Before elaborating upon Dante's theory about the nature of space, it would be useful to examine some of the more modern scientific theories upon the same subject, again to support the assumption of this thesis that the medieval protoscientists and their audiences were advancing science by leaps and bounds, but because they are not using the scientific discourse we are habituated to, their efforts were for naught.

Physicist V. Trimble, in "Existence and Nature of Dark Matter in the Universe," confirms that outer space, the void between cosmological phenomena, is neither really space nor void. Space is a hard vacuum permeated by a diffuse field of hydrogen, helium and electromagnetic radiation. From the early formational epochs of the universe that we discussed earlier, the universe has now cooled to 2.7°K. In intergalactic space, the hydrogen plasma is far more diffuse but is much hotter, and this accounts for most of the matter that exists. But what is most interesting in Trimble's description of space is the fact that ninety percent of the matter that should exist according to mathematical models is in an undetectable form known as dark matter, which experiences gravitational effects, but not electromagnetic ones. Scientists, for all the faith they put in the observable and testable, are more than willing to jump aboard the dark matter train based upon nothing but the internal consistency of the concept's mathematics. It is up to us to decide whether this is ironic or hypocritical.

So having seen what modern science says space is actually like, let us compare that knowledge to a particular moment in the first canto of the *Paradise* when Dante correctly describes space as an omnipresent force that pervades everything to different degrees. In describing the moon in the next canto, we must examine the poet's words a little more carefully:

> True to the glad nature from which it flows,
> This blended virtue shines throughout that body,
> As happiness shines forth through living eyes,
> And from this virtue, not from dense and rare,
> Derive those differences in light we see:
> This is the formal principle that gives,

According to its virtue, dark and light.

Paradiso c. II

As I have said earlier, all matter energy and everything in our universe is some variation on a single set of physical principles as yet undiscovered. Considering this, one might say that compared to the void of space, the air that I breathe is as solid as the laptop in my hands. From the most basic scientific standpoint the universe quite simply is bits of light and dark, as seen earlier in this chapter. Dante not only explains the mechanics of the universe but also attempts to explain the motivation behind them. In *Paradise* canto XXI, Dante discusses the nature of causality with the monk Peter Damian. The poet implies that there is some sort of predestination, since God is omniscient. Peter Damian's reply is reminiscent of the Schrödinger's Cat thought experiment. Quantum superposition is the idea that all possibilities are valid until they are stripped down to a single event that is reality.

Peter Damian could have been equally served using baseball as an analogy to a modern reader: before a game begins you know there will be a winner, but in order for you to find out the game must be played. Even if the players were given the final box-score before the game, how could they possibly understand the minutiae of each player's choice over the entire nine innings to change the outcome significantly? The poet describes destiny as being made apparent in its playing-out far more eloquently:

Every substantial form, being distinct
From matter, yet somehow conjoined with it,
Contains within itself a certain power 51

Not visible except as it is made

Manifest through its workings and effects:

As life in plants is proved by their green leaves. 54

So, man cannot know where his cognizance

Of primal concepts comes from-or his bent

For those primary objects of desire; 57

Purgatorio c. XVIII

Earlier in *Purgatory,* in Canto VI, we are presented negatively with the image of rolling the dice. Dante is perhaps suggesting that since God must know the outcome of the roll, it is foolish to engage in games of chance as it is a futile and wasteful exercise in the tempting of fate.

The famed physicist Werner von Heisenberg explains this idea of Dante's with a modern concept called the Uncertainty Principle. In measuring physical particles the better one knows the position of the particle the less one knows the momentum. Likewise if we wish to carefully measure the momentum, we will not be able to know the particle's position. In terms of probability and free-will, one choice must be made and once made none other can be. This concept would help explain to a degree why the souls of the *Inferno* know precise details of the distant future (much like our modern physicists) but not every shift in momentum or mortal's choice on the road from here to there. It is a paradox, but if God did not understand what lies behind a paradox he wouldn't be omniscient. When Virgil asks Beatrice how she made a journey "all the way down to this point of spacelessness" (*Inf*. 2.83), he is literally saying "this point that always existed in the future, but was not manifest until we made it so.” The problem of predestination is thus concluded and Dante is supported in his view by what we know about quantum physics. The very building blocks of our universe our based on the whole idea that many things are possible, but only certain things will occur.

Dante did however take a religious stance rather than a ‘hard’ science stance on cosmology, even though he surely knew that:

> Aristotelian-Averroistic philosophers were presenting a vision of the universe in conflict with Genesis. At this time, philosophers and theologians were debating the existence of a tenth Empyrean heaven, a sphere of pure light and seat of the divine. Is the universe made of nine or ten heavens? If the Empyrean exists, does it exist in physical space? Does it contain within itself all other heavens, without being contained by space? Neither radical nor moderate Aristotelians accepted the existence of the Empyrean heaven. (Trovato 33)

What Trovato does not tell the reader in “Against Aristotle” is that Dante proves the Empyrean exists if one considers modern evidence on the Cosmic Microwave Background, the thermal radiation signature at the ‘edge’ of the universe, by which I mean the point from which we cannot see starlight. Before looking to the experts to elaborate further, let us first look at the way the poet describes the universe as light scattered across the universe rather uniformly:

> I saw how it contains within its depths
>
> All things bound in a single book by love
>
> Of which creation is the scattered leaves: 87

How substance, accident, and their relation
Were fused in such a way that what I now
Describe is but a glimmer of that Light.

Paradiso c. XXXIII

Dante believes God, or the Prime Mover, and the mystery of His creation lie at the edge of the stars, in a timeless beginning. It would seem that:

> As we train our vision on the distant reaches of space, we are also looking back in time, such that the light that has traveled the furthest is also the oldest; and the uniformity we see at the edges of the visible cosmos is the uniformity of the cosmos itself, a relatively short time after its birth. (Egginton 197)

We can infer from what John of Sacrobosco taught us earlier that if you had a very fast spaceship and took off in any direction, you would arrive in the same place as a friend who took off in the opposite direction, and that you would both be at the beginning of time, or as Dante puts it, in God's presence. The High Middle Ages were truly a Golden Age for a unified religion and physics based meta-science.

IV. CHAUCER

The Late Middle Ages marked a sharp turning point in the relationship between science and religion. The suspicions that arose between followers of the two different paths to knowledge in this last age of protoscientific development before the Enlightenment shaped many of the conceptions in the public consciousness still held today. I hope to show in this chapter that this competition in many ways spurred discoveries in science and new insights into religion, proving that when separated, the two still affect each other potently. The directive to study anything given by King Alfred had been rescinded by the Church, and the science presented in such stories as Dante's was subject to much censure by this time. Many of the protosciences examined in previous chapters at this time were legitimized, while others' reputations waned, and a few clerics made last-ditch efforts to explain reality using Biblical rhetoric.

The source material on protoscience for this chapter will include selections from John Duns Scotus' *Treatise on God as First Principle,* showing how effective and advanced epistemological theory was in the late Middle Ages; "The Myth of Occam's Razor", a critique by William Thorburn of William of Ockham's Summa *Totius Logicae* and *Quaestiones et Decisiones in Quattuor Libros Sententiarum* questioning the effectiveness of parsimony as a scientific methodology; and Stephen Read's "Plural Signification and the Liar Paradox," which shows the merits of Thomas Bradwardine's ideas that would eventually develop into pluralist logic. The final part of the chapter will examine the role of science in the popular culture of the time by examining descriptions of science and scholars in Chaucer, since his depictions echo the sentiment of the age that science was good for some things, and worse than terrible for others. Of the *Canterbury Tales, The Pardoner's Tale* gives us insight into late medieval psychology, and the *Canon's Yeoman's Tale* serves as a caution against as well as an admission of the power of alchemy. Other texts of Chaucer's expressing his scientific insights include *A Treatise on the Astrolabe*, which is an early technical manual for the eponymous instrument, and *The House of Fame*, which though a fantasy presents a theory of acoustics far ahead of Chaucer's time.

In order to attempt to close the ontological gap between religion and science, arguments must be presented in a way that they can apply to both, which means that they must be put on a level playing field using the same terms. One scholar to answer this tall order was John Duns Scotus, who eventually gained the epithet "the subtle doctor" for the measured and rational approach he took in his deliberations. His theory of univocity, that all terms must mean the same things in all contexts, is particularly helpful since it is a safeguard against undefined and undefinable terms and through this allows us to be closer in understanding God as He understands us. Since complex things are made of simple things, we should logically be able to keep building on knowledge indefinitely. In chapter four of *A Treatise on God as First Principle*, Duns Scotus tells us that:

> Complex cognition is the result of a joint knowledge of cause and effect. Now it is true that what results from the first cause and second together is more perfect than

> what results from the second alone. To the contrary: The first finite cause by itself can produce a more perfect effect than can the second alone. Now the second can produce a vision [or intuitive cognition] of itself, hence the first can also produce this alone. I reply: True, the first cause alone can produce something (for example, a vision of itself) which is a more perfect effect than the second can produce alone. But it is not able to cause more perfectly that precise effect which the second by nature was designed to produce either as a secondary cause or rather as a primary cause so far as all other finite causes are concerned. For in causing such cognition [e.g. an intuition of itself] the second cause seems to be only accidentally ordered to any prior finite cause, for such knowledge was not destined by nature to be produced by any finite cause above it. Hence, the vision would exist, even if the thing seen were uncaused by such a higher cause, or if it existed and the intellect existed without the coexistence of any prior finite cause. (53)

To clarify briefly, the primary cause to Scotus is God, and the secondary cause is any other expression of agency, such as the choices humans make. The deeper question that he raises is whether meta-cognition is real as a secondary cause, or whether it is merely an illusory epiphenomenon following the will of the primary cause. Regardless of which is true, John Duns Scotus advances the argument without offending either the scientific or religious parties, and leaves the solution open to both possibilities.

Often, when one is faced with two equally valid solutions to a problem, the simplest is usually true. This concept, called parsimony, does not help resolve the free-will issue, since neither quantum-indeterminism or a deity-assigned destiny are particularly succinct explanations, but it does provide a logical methodological approach to other equivalency problems. Formulated by William of Ockham, parsimony has two tenets: *frustra fit per plura, quod potest fieri per pauciora*, meaning that it is pointless to do with more what can be done with fewer, and *numquam ponenda est pluralitas sine necessitate,* meaning that plurality is never to be posited without necessity. In "The Myth of Occam's Razor", William Thorburn summarizes the principle of parsimony but then expresses a very persuasive reservation about how it might indeed lead to scientific reduction and how must keep the door open to complexity and holism: "It is folly, to complicate research by multiplying the objects of inquiry; but we know too little of the ultimate constitution of the Universe, to assume that it cannot be far more complex than it seems, or than we have any actual reason to suppose" (352).

As an example to support his counter-argument, Thorburn mentions the discovery of chemical isotopes as something that can be explained in simple terms, but the manifestation of which in reality is infinitely complex. Along with the lack of foreknowledge and assumptions that the use of Occam's razor requires Thorburn is critical that it was used at the time it to pass off dogmatic over-simplification of ontological ideas, though he does state that the logic behind Ockham's theory is sound. We are left to wonder whether having a more complete picture of the universe will give us so much predictive power that parsimony would make choices irrelevant. Paradoxes like these are what connect the minds of scholars today to the medieval logicians, and the knowledge they preserved, recovered and interpreted from the ancients. The pseudomenon – “this sentence is false” – dates back to archaic Greece, but Thomas Bradwardine of the Oxford Calculators is the first of the western thinkers to articulate it as both a binary logic problem, in which it is false, and a self-referential semantics problem, in which it is true. In “Plural Signification and the Liar Paradox”, Stephen Read suggests that:

> What Bradwardine does is to show that self-falsifying utterances like Socrates' signify other things as well. His theory of signification is pluralist: utterances signify many things [but] the inference concluding that an utterance is true is warranted only if everything it signifies obtains, and in such cases that is impossible.” (364)

The ‘profound doctor’, as Bradwardine was called, is telling us that though each answer can be true depending upon the criteria set, they cannot both be true at the same time following the same rules. Thought experiments like these can be encountered in practical physics situations every day. Consider the wave-particle duality of light: sometimes light acts like a particle, and sometimes it acts like a wave. What kind of test is being performed and what kind of equipment is being used and what is trying to be proved will all affect how we perceive the end result. Similarly, the Heisenberg uncertainty principle tells us that we can know the position of a particle, or its momentum, but not both. We have to shift our point of view so that even if seeing the ‘big’ picture is impossible, we might still have some idea of what it is from making a composite of as many of its facets as we can.

To get the clearest picture of how everyday late medieval characters would grapple with these advanced problems and how protoscience shaped their worldview to the extent that religion would allow, it is best to examine the works of Geoffrey Chaucer. *The Pardoner's Tale* is an excellent example of exploring paradox and irony through narrative, turning more logical scholarly discourses as those cited previously into ironic and paradoxical situations to make an audience think and feel and learn. *The Pardoner's Tale* asks the audience not to merely consider how a prophecy brings itself to pass, but also causes the audience to reflect upon how they themselves might act if faced with the double-edged sword that is prescience. The most modern view on the subject suggests that we try to make predictions happen: consider a teacher who tells one student just before a test "you will do poorly" and tells another "you shall do well"; modern psychologists and sociologists tell us that what the teacher said would happen is the likeliest outcome. In Chaucer's story the hooligans seek Death, and they find him; yet they wouldn't have had they not been told where to find him. What Chaucer and the ancients ascribe to the divinely ordained natural order, that those who sow evil reap it, can instead be succinctly explained as ordinary human behavior without teleological origin. Robert Merton, the psychologist who coined the term 'self-fulfilling prophecy', first presented it in a parable much like Frank Capra's *It's a Wonderful Life*: the customers of a bank hear the bank is insolvent, and so rush to retrieve their money, causing the insolvency that they fear. As Merton says, "the parable tells us that public definitions of a situation (prophecies or predictions) become an integral part of the situation and thus affect subsequent developments” (Merton 477), suggesting that the customers, had they heard no prophecy, would most likely have been fine.

The tale of the Pardoner can be clearly compared to this phenomenon. This phenomenon raises an interesting question about the power of the human mind over matter, but also its limitations: if the old man had predicted a full moon, he could not be affecting the Earth’s gravitational pull, and his ‘prophecy’ would be disingenuous, yet he does ensure that the thugs find Death. He does this by defining the parameters of the prophecy in deliberately ambivalent or obfuscating language, or in Merton’s words “the self-fulfilling prophecy is, in the beginning, a false definition of the situation evoking a new behavior which makes the original false conception come 'true'” (Merton 123). Unduly accepting the prophecy as ‘truth’ leads to behavioral changes that will bring the prediction about; this in turn will only later strengthen the prophet’s claim that his prediction was accurate from the beginning. Since Chaucer was well educated in the examples of philosophy mentioned in the previous chapter, he would well have been aware that his story presents a kind of double-entendre, in which people are both completely in control yet utterly powerless with regards to the future. Also worth considering is that Chaucer appears to be subtly criticizing the Pardoner, as he is misusing learning and knowledge, twisting up truths to meet his own ends.

The tale of Chaucer’s that is most critical of protoscience is the *Canon’s Yeoman’s Tale*, while in admitting that the discipline of alchemy is ‘real’, also states that there are too many charlatans for any of the subject’s greatest promises, such as the Philosopher’s Stone or the Elixir of Life, to ever be fulfilled. In “Perpetual Motion,” influential Chaucer scholar Lee Patterson demonstrates that the tale presents many ambiguous attitudes towards the subject, like the audience knows they are to be weary of science, but deep down they also know that it has potential not to be ignored. He presents textual evidence that shows that some of Chaucer's alchemical knowledge and use of specialized discourse is advanced, whilst some is amateurish. Chaucer showed great concern for how the economy might fail if the secret of alchemy was ever cracked, and worried more that it was economic concerns and guild-secrecy culture that made alchemists write their treatises in language that is far from straightforward, preempting somewhat our own age's encryption and data copy protection protocols.

Having heard what the Yeoman has to say about the lack of data-sharing in the alchemical field, at this time it might be helpful to explore this idea of collaborative knowledge in terms of Polanyi's theories. In *The Contempt of Freedom* and *The Logic of Liberty*, Polanyi uses the analogy of agent-self-coordination within free-markets as a way to describe the co-operation of scientists. Before we can explain how this works in order to follow Polanyi's argument, we must first acquaint ourselves with the concept of spontaneous order, which is defined as the emergence of order from apparent chaos.

In the free-market example that Polanyi describes, consumers—though only interested in themselves—unwittingly create a socially based order with like-minded individuals. Polanyi suggests that it is this individuality, not the collectivity it accidentally creates, that has the potential to let science flourish since all are free under these circumstances to pursue the study of whatever they want. Polanyi summarizes the point I am trying to convey here most eloquently:

> [Scientists], freely making their own choice of problems and pursuing them in the light of their own personal judgment, are in fact co-operating as members of a closely knit organization [...] Such self-co-ordination of independent initiatives leads to a joint result which is unpremeditated by any of those who bring it about [...] Any attempt to organize the group ... under a single authority would eliminate their independent initiatives, and thus reduce their joint effectiveness to that of the single person directing them from the center. It would, in effect, paralyze their co-operation. (Polanyi)

Polanyi developed the idea of spontaneous order based on the operational principles of Gestalt psychology. Gestalt psychology suggests that our brains have the tendency to organize themselves: when our eyes look at something, we notice the whole object before we ever consider its component parts, supporting the old cliché about the sum being greater, a piece of tacit-knowledge many subscribe to. Gestalt psychology is interested in how we develop a cohesive perceptive mind despite the continuous bombardment of all of our senses all of the time from external stimuli.

Polanyi takes this a step further by suggesting that there are both simple and complex levels of spontaneous order, lamenting that the practice of science is undermined by skepticism and utilitarianism. I will pause for just a moment to define these last two terms just to make sure the nuance of Polanyi's argument is being fully understood. Utilitarianism is a normative ethical theory that is perhaps familiar to the popular mind in Gene Roddenberry's creation of Vulcan philosophy in which "The needs of the many outweigh the needs of the few." If we make usefulness as the paramount virtue of scientific research, this might have a very limiting effect on science. Skepticism can be considered useful in terms of its inquisitiveness and caution, but can often be taken too far if used to question the basic assumptions that few doubt. Polanyi used the ideas presented here to support his ideas about the importance of a free-society, not because of any sense of entitlement over his own liberty, but believed that if everyone pursued whatever knowledge they wanted, both individuals and society as a whole could more easily achieve their objective goals. The idea that we serve society by serving ourselves is a little strange, but Polanyi would say that this is the very nature of spontaneous order in social systems. In his words:

> When order is achieved among human beings by allowing them to interact with each other on their own initiative—subject only to the laws which uniformly apply to all of them—we have a system of spontaneous order in society. (159)

If we think back a little ways to our Yeoman, we can see that alchemists in the Late Middle Ages were putting many of these ideas into practice: they all pursued their art according to their whim and knowledge was shared, despite often being shared in a coded or oblique manner.

Considering the ample evidence presented on alchemy's relative success in becoming an accepted discipline in its time, an interesting inquiry we can make is into the current state of affairs in the alchemical field. As mentioned briefly in the introduction, alchemy today pretty much works. Elemental synthesis is a process whereby an element can be transmuted into another using a technique called neutron-bombardment. To make gold with this method, one needs mercury—or quicksilver as our medieval audience would call it—and a radiation suit. We can see from this revealing and interesting fact that alchemy's "impossible" end goals are in instances realities in the modern world, which also has an ongoing conversation about the morality and legality of some forms of research, especially when the researchers give the impression of 'playing God.'

Despite the legal edict by Pope John XXII that outlawed alchemy in 1317, scholars continued their work. Chaucer's Yeoman is grieved by the apparent randomness of his art, but remains encouraged, saying:

> 678 Yet is it fals, but ay we han good hope
> 679 It for to doon, and after it we grope.
> 680 But that science is so fer us biforn,
> 681 We mowen nat, although we hadden it sworn,
> 682 It overtake, it slit awey so faste.
> 683 It wole us maken beggers atte laste."

The Yeoman is one of the best medieval examples of faith in science for its own sake: so much has been proven by alchemy and so much put into it that giving up now for the Yeoman, and I think he speaks for all researchers of his era, is unthinkable. The idea that we can flip a coin a trillion times without it landing on its edge does not make it an impossibility for knowledge-seekers of the Yeoman's ilk. On failure he says:

> 944 And though this thyng myshapped have as now,
> 945 Another tyme it may be well ynow.

The Yeoman’s faith in science is backed and justified by his faith in God, echoing the argument put forward by Alfred five centuries before. His eloquent reasoning for God’s approval of the alchemical pursuits is as follows:

> 1467 For unto Crist it is so lief and deere
> 1468 That he wol nat that it discovered bee,
> 1469 But where it liketh to his deitee
> 1470 Men for t'enspire, and eek for to deffende
> 1471 Whom that hym liketh; lo, this is the ende.

One might easily try to turn the Yeoman’s logic against him, saying that it is precisely because of God’s will that alchemy’s truth remains locked away. In Patterson’s words “This divine willfulness, an arbitrariness that refuses to be constrained by human desires or deserts, thus forecloses alchemical effort without denying the possibility of alchemical success” and furthermore that “By insisting that the process is foreclosed by an arbitrary act of divine will, the Yeoman shows that what is in doubt is not the existence of the alchemical truth, but the efficacy of explanation” (35). The explanation itself is an equivalency problem, because as Patterson says “Alchemy is both simpleminded and heavy with consequence, both a shabby fraud and the ultimate portent” (38). There are still many protoscientific subjects that some people believe fraudulent, and some people believe legitimate. Take chiropractic therapy, or acupuncture, or any other alternate medical practice: like alchemy, some swear by their powers while others believe them to simply be scams, but this does not diminish the fact that they are bringing about effective therapeutic results for their patients. Also, when we consider that the Yeoman and

Patterson say that the art is arbitrary, the importance shifts not from what is being done, but whether the practitioner is the proper person to do it, whether they have the instinct for the knowledge they seek, In Patterson's words:

> Alchemical understanding requires a pre-understanding that obviates the need for learning [...] like the biblical exegete, but lacking his institutional support, the alchemist is placed in the uncomfortable position of having to know everything before he can know anything, to possess the truth before he can learn what it is [...] individual items of information are useless apart from a totalized knowledge that cannot be attained gradually but only possessed all at once. (45-6)

In this light, we get the impression that rather than being a skill that can be developed, cognition is a talent, and that total understanding is not for everyone.

Chaucer thinks that partial understanding, however, was within everyone's reach according to their measure, and for this reason it was possible for the Canon and his Yeoman to make some progress, to eke out some meager living though they had an incomplete picture of all of the knowledge in their field. But they knew that the knowledge that they did have, however slight, was still powerful as an idea even if it was impractical. Patterson tells us that:

> Alchemy's challenge to medieval culture can be found most profoundly in its commitment to an applied science – a technology – capable of transforming the material conditions of human life [...] As we have seen, alchemical theory argued that all metals aspire to the condition of gold, and would in time attain to it; but

> alchemy could speed up the process, could bring about in a moment what nature needed eons to achieve. (50-1)

We can see here in Chaucer a direct link to our own modern concerns about science and the ethical considerations of it, that we must be mindful that our reach not exceed our grasp. As the sources earlier in the chapter show, the late medieval concern with a pluralist view that did not bring the condemnation of the Church is in evidence, but Chaucer shows that the conflict between the two ontological theories of science and religion had already begun in the hearts and minds of ordinary people. Again, Patterson finds the *mot-juste* to describe the situation when he writes that "Despite the major advances in technological practice that were made throughout the period, technology as an ideology was always regarded with suspicion if not outright hostility" (51-2). The fact of the matter is that it is very difficult, even in our modern world, to not see reality as binaries. It would also be remiss to not point out that alchemy was like any of the more complex modern sciences in that it was a marginal subject that most people did not have any participation in. Simpler subjects, with more practical, realizable goals that were not controversial were well known, however, and had almost a hobby-like status in medieval culture.

In *Treatise on the Astrolabe*, Chaucer explains the workings of the tool so that a child can go use it, just as today we have all manner of back-yard astronomers. Nobody minds the presence of amateurs if what they are doing has no real ramification. To contrast the medieval and modern viewpoints, one might say that using an astrolabe to watch the stars then is analogous to using a telescope today. But a discipline such as alchemy, with the possibility of conferring eternal life or wealth, would be analogous today to having one’s own gene laboratory or counterfeiting operation, which would clearly be unacceptable. Instead, when experimental or practical science would present problems for the practitioner, medieval authors would simply conjecture and try to present their theory in as beautiful words as possible, making the most out of ideas that would only ever be ideas, and therefore mostly harmless.

For example Chaucer, in *The House of Fame*, describes a dream vision about a glass temple where the famous dwell. Despite the obvious impossibility of such, in the midst of this fantastic adventure, the complexity of Chaucer’s thought is revealed, as when he tries to explain how the denizens of the eponymous house hear everything that takes place below, he in fact describes how sound works two centuries before Galileo’s vibration theory:

'Soun is noght but air y-broken,
And every speche that is spoken,
Loud or privee, foul or fair,
In his substaunce is but air;
For as flaumbe is but lighted smoke,
Right so soun is air y-broke.
But this may be in many wyse,
Of which I wil thee two devise,
As soun that comth of pype or harpe.
For whan a pype is blowen sharpe,

The air is twist with violence,
And rent; lo, this is my sentence;
Eke, whan men harpe-stringes smyte,
Whether hit be moche or lyte,
Lo, with the strook the air to-breketh;
Right so hit breketh whan men speketh.
Thus wost thou wel what thing is speche.

When we hear Chaucer describe sound as broken air that breaks depending on the type of sound that interacts with it, we picture experiments with an oscilloscope in high school that show us in a technical manner what the poet says in an artistic manner. In the Renaissance and Enlightenment that were to follow Chaucer’s time with their institution of the scientific method, combined narratives and theoretical explanations, except in terms of biblical exegesis, became rarer and rarer until the 20th century’s golden-age of science fiction, where narratives again would try to present a unified vision of the universe and portray all knowledge as protoscience, as insignificant compared to the possibilities of a vast universe.

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V. THE GOLDEN AGE OF SCIENCE-FICTION

In this final chapter I would like to show how all of the protoscientific ideas explored by medieval clerics were revisited in the Golden Age of science-fiction. The reason for this is that in times of great scientific breakthrough, authors' and artists' imaginations usually take off proportionally. The century after Chaucer saw technological advances such as firearms, trans-oceanic ships, and the printing press, just as the decades after the Golden Age of sci-fi brought the world ballistic missiles, space travel and the computer.

Literature, in medieval and modern times alike, is a way to explore a field of knowledge before it exists, to conjecture about what we will do with knowledge once we already have it. We might say that all science-fiction is a sort of protoscience, since it treats the hypothetical as a given, making up for a shortfall in the testability of its ideas with the imaginativeness of them. It is important to note that this is a cyclic relationship: real scientists create an idea, an artist takes it to the next step, and then a younger scholar is inspired by the narrative to turn fantasy into reality. But what is even more interesting to observe is the function of religion in the modern sci-fi genre: it is not simply 'what there was before knowledge', but it is revisited and in many ways almost reconciled with the science it had so long been pitted against. In the 20th century, when most of what had beforehand been considered impossible became merely improbable, the writers of the science-fiction genre faced an almost opposite dilemma to the clerics of centuries before. In an age where science had proven itself supreme, there was still a nagging suspicion that simple beliefs, that old mythologies and primitive ideas, still had some intrinsic exploratory and explanatory value in their own right.

To explore this overlap of reality and the imagination, or the Middle-Ages-like unity of cognitive and physical truth in narratives of the future, this chapter will examine Walter M. Miller's *A Canticle for Leibowitz*, the story of earth experiencing a second manuscript-age after a nuclear apocalypse, and A.E van Vogt's *The Voyage of the Space Beagle*, which tells the story of mankind's first intergalactic journey and the attempts of a scientist in a new and controversial field to save his crew mates from aggressive entities with God-like powers. Modern criticism on the limitations of science alone to accompany these examples Bonnie Nardi on the breaking down of the barriers between pure and applied sciences, and J.R.R. Tolkien and Thomas Martin on the problem of human conceptual limitations and truth. These critical analyses serve to demonstrate the prescient quality that emerges from narratives that try to combine logic and imagination to their very limits, reflecting the attitudes of the manuscript era discussed in previous chapters.

One of the more popular ideas from the Golden-Age of science-fiction is that history is cyclic. Examples of narratives that depict a return to feudalism after a planetary catastrophe are numerous, but one of the best examples of the genre is Walter Miller's *A Canticle for Leibowitz*. The story is presented in three parts: the first is about a monk called Brother Francis and his life's work in preserving and illuminating a circuit diagram from before the semi-mythical ‘Flame Deluge’ or nuclear war that destroyed civilization centuries before. The second part, set centuries after the first, deals with the conflict between the Catholic Church and a monk named Brother Kornhoer over his successful recreation of an electric arc-lamp. The final part of the story shows a future more advanced than our own current civilization and the earth on the brink of nuclear war again. This iteration of the cycle of history has made it a little further scientifically than the one before, so the Church charges itself with loading the earth’s knowledge onto an interplanetary ship in order to avoid the thousand years of repeating the dark ages and reconstructing what is about to be lost all over again, as depicted in the first two parts of the novel.

Miller is a master of describing modern things such as fallout-shelters, light-bulbs, and concrete roads as a person from the middle ages would, as strange mysteries that have a function and method of crafting only to be guessed at. On top of this, were any of those guesses even accurate there would be no way to verify it. In part one, entitled “Fiat Homo”, Miller portrays how the monks of the Leibowitz Abbey are completely and single-mindedly devoted to preserve the remains of the past, and we see a weird reflection of our own Middle Ages in this future “Middle Ages”, where instead of having conjectural protoscience that remained to be proven legitimate, the monks in the novel have real, verified, accurate knowledge that they have no way to understand or apply. In chapter six, Miller succinctly describes the monks’ diligence:

> The monks waited. It mattered not at all to them that the knowledge they saved was useless, that much of it was not really knowledge now, was as inscrutable to

> the monks in some instances as it would be to an illiterate wild-boy from the hills; this knowledge was empty of content, its subject matter long since gone. Still, such knowledge had a symbolic structure that was peculiar to itself, and at least the symbol-interplay could be observed. To observe the way a knowledge-system is knit together is to learn at least a minimum knowledge-of-knowledge, until someday—someday, or some century—an Integrator would come, and things would be fitted together again. So time mattered not at all. The Memorabilia was there, and it was given to them by duty to preserve, and preserve it they would if the darkness in the world lasted ten more centuries, or even ten thousand years (62)

What the monks do not realize is that they are the Integrators. In the novel we are told that the survivors of the nuclear war turned against learning of all kinds, but spared religious teaching. When faced with the choice in following a simple, religious, safe ideology, or a scientific ideology that is complex, doesn't work, and would bring about a death sentence, the monks of Leibowitz choose both, much like their medieval examples in earlier chapters. They use logic to deduce that even nothing is something, such as Bother Francis' electrical diagram, which to him must look as the Voynich Manuscript looks to us.

I want like to digress slightly before discussing the second part of *A Canticle for Leibowitz* to provide some background information to the reference that I just made. The Voynich Manuscript, dated to the early 15th century, is a medieval handbook on astronomy, cosmology, biology, pharmacology, herbalism and cuisine, or so we infer from its pages and pages of detailed illustrations. But the manuscript itself is written in an unknown script in an unknown language. The eldritch quality of the manuscript ends not there: many of the plants, animals and stellar phenomena depicted have been recorded nowhere else but the Voynich. Like Brother Francis with his diagram, we don't know what we're looking at, yet we know, likely from Polanyi's tacit knowledge, that it must mean something to someone somewhere, because such a conclusion simply "feels" right.

In the second part of the novel, entitled "Fiat Lux", the monks of the Abbey of Leibowitz grapple the same questions faced by Alfred, Dante and Chaucer: is it right to study anything? Is science a valid way to explain the divine? Should usefulness dictate the acceptability of scientific pursuit? In an allusion to this part of the novel's chapter title, 'Let there be light', the Abbot of St. Leibowitz's is horrified when he witnesses Brother Kornhoer's demonstration of an arc lamp for the first time, and immediately prohibits its usage. Later on in the story, an official observer from the Holy See named Thon Taddeo arrives at the Abbey with a particular interest in collecting and copying all of the monks' data on electronics, and insists against the abbot's wishes in seeing a demonstration of the arc-lamp for himself. When leaving the abbey in chapter twenty, Taddeo gives an impassioned speech to the assembled brothers, exhorting them to be neither timid nor tepid in their protoscientific endeavors. In a sobering reality check to the clerics, he says that:

> Reasoning which touches experimental reality nowhere is the business of angelologists and theologians, not of physical scientists. And yet such papers as these describe systems which touch our experience nowhere. Were they within the

> experimental reach of the ancients? Certain references tend to indicate it. One paper refers to elemental transmutation—which we just recently established as theoretically impossible—and then it says—'experiment proves.' But how? (193-4)

It is interesting to note that Taddeo’s wish to separate ‘experimental reality’ and ‘the business of angelologists and theologians’ requires the brothers to have faith in the words of the ancients, no matter how little semantic value is expressed therein.

Imagine for a moment the world that Miller is writing in, a world that has gone from the Wright brothers to Sputnik in five decades, and consider what a medieval audience might have believed about even the possibility of flight, though they had the example of Daedalus from their own ancients to inspire them. We could say that the limits of our imagination grow with each impossible scenario modern science turns into a reality, and we can track in the stories of the future ideas from the distant past, and though they are delivered in an almost purely scientific rhetoric, still leave room for and even encourage the use of the subjective human imagination as a powerful tool of exploration and abstraction.

The second text I have chosen from the Golden-Age of science-fiction that best explores ideas about both the importance of the past and the desirability of a unified scientific discipline is A.E. van Vogt’s *The Voyage of the Space Beagle*. Credited with being the inspiration for the show *Star Trek* and the film *Alien*, the book presents to its audience all manner of impressive alien life-forms that, for lack of scientific discourse, would have simply been called demons in the medieval era.

The first of the monstrous creations of van Vogt's that the crew of the *Beagle* encounter the felinoid Coeurl, a genetic construct and biological weapon from a devastated civilization that can control the electromagnetic spectrum and feeds brutally on the ionized potassium in living being's nerves. As an intelligent creature that has gone feral through isolation Coeurl still has remnants of knowledge that allow him to infer that the humans who have arrived are scientists, which emboldens him since "Scientists would investigate, and not destroy [...] scientists would refrain from killing him if he did not attack [...] scientists in their way were fools" (2). This space-monster has tapped into one of the greatest vulnerabilities of science: without data, scientists are unable or unwilling to fear the worst until experience tells them otherwise. A few of the crew-members do give in to their baser instinctual fear of the unknown and religious cultural heritage, and take to calling the creature a 'devil'. The main character of the novel, Elliot Grosvenor, is the only scientist to ascertain—for reasons other than primal terror—the creature's danger before it becomes manifest.

Grosvenor is a 'Nexialist', which might best be explained using the semi-analogous terms polymath or renaissance-man, but really reflects the Greek idea of 'paideia', or complete fulfillment of human potential. Like the characters of Sherlock Holmes or Lieutenant Commander Spock, Grosvenor uses a wealth of knowledge in all fields to quickly and efficiently size up a situation and make predictions for its future, though his conclusions often confuse his peers and they resist believing him until he is either proven right or provides context and rationalization for his deductions. The problem is that his fellow crew-mates each only see the universe through their own specialty, whether it be math, chemistry, archaeology, or what-have-you, while Grosvenor's approach is described as "applied whole-ism" (18). He tells his crewmates that "at the Nexial Foundation we teach that behind all the grosser aspects of any science there is an intricate tie-up with other sciences [...] that is an old notion, of course, but there is a difference between giving lip service to an idea and applying it in practice" (22). Grosvenor's arch-rival in the novel is the duplicitous head of the chemistry department named Gregory Kent. As he wheedles and wrangles his way throughout the ranks trying to get himself elected as mission director, he rarely contains his disdain for Grosvenor's methodology, and when he finally receives the command he schemed for, he makes Grosvenor's life as difficult as possible.

Kent's biggest problem is that the scope of Nexialism is too vast, that it claims too much authority and ability. Upon Grosvenor's presentation of his solution to the Coeurl problem, Kent exclaims ""I never heard such a story in my life. Possibilities. Probabilities. Fantasies. If this is Nexialism, it will have to be presented much better than that before I'll be interested" (23). But the problem with Kent's close-mindedness is that he fails to consider his own personal bias and ego with concerns to his knowledge: if he had to explain a complex chemistry problem to someone, they would require at least some background knowledge in the subject or his explanation would take forever, starting at atomic structure and slowly building up to the point he is trying to make. In *The Voyage of the Space Beagle*, we see many instances of scientists desperately struggling to make their knowledge relevant to the partialism of the narrow specialists of the crew, though each of their disciplines are only small pieces of a larger whole, and in spite of the reputation for rationality and shrewdness that is automatically attributed to all scientists. While trying to oust mission director Morton, for example, Kent's cronies say that the man is not a real scientist because he is a mathematician. A bemused Grosvenor says that he was under the impression that math was a science, but another crewmate counters that:

> Because of the superficial resemblance, it is a delusion [...] scientists have to stick together. Just imagine, here's an entire shipload of us, and what do they put over us?—a man who deals in abstractions [...] that's no training for handling practical problems. (28)

Grosvenor tries to point out that virtually all of the other scientific disciplines represented on the ship require both mathematics and abstraction, but is ignored. Korita, the head of the history department on board the Beagle, tries to explain to Grosvenor that the skepticism in the crew is not a fault of their own making, but a condition of the society they live in. Korita explains the rise and fall of worlds as analogous to the seasons of the year: the spring is the dawn of civilization, the summer the feudal period, the autumn is the industrial period, and finally the science and technology minded modern society is the winter period. Korita explains that:

> The outstanding common denominator of the 'winter' periods of civilization is the comprehension on the part of millions of individuals of how things work. People become impatient with superstitious or supernatural explanations of what goes on in their minds and bodies, and in the world around them. With the gradual accumulation of knowledge, even the simplest minds for the first time 'see

> through' and consciously reject the claims of a minority to hereditary superiority [...] it is this widespread struggle for personal aggrandizement that constitutes the most significant parallel between all the 'winter' periods in the civilizations of recorded history [...] the late-comer to the field, not understanding his motivations, plunges blindly into the battle for power. The result is a veritable mêlée of undisciplined intelligence. (35-6)

I think what Korita suggests is that once ideas become all-or-nothing propositions, scientists become very close-minded.

This fallibility is illustrated by van Vogt when the crew has their second alien encounter with a psychic avian race called the Riim. Each crew member hallucinates differently in the psychic field projected from the Riim homeworld, and so faced with a thousand different frames of reference for reality communication between the crew members become impossible, until Grosvenor, with his view of the ‘big picture’, manages to communicate to the aliens to cease their communication attempt. The crew’s dedication to their own disciplines above others here is taken to the highest possible level, with absolute isolated subjectivity forced upon each. We can see that exclusion of one truth over another is goes against the very foundation of scientific thought, or as mission director Morton says in the novel “As scientists, all is grist for our mill [...] Everything must be investigated” (55). The lack of finality in scientific disciplines, or rather the lack of ability to integrate them with each other, ensures that each in their own way will remain a protoscience, waiting for a more comprehensive theory to bring it closer to completion. We see in van Vogt's novel that Nexialism is a highly fanaticized solution to this problem, that:

> The problems which Nexialism confronts are whole problems [...] Man has divided life and matter into separate compartments of knowledge and being [...] and, even though he sometimes uses words which indicate his awareness of the wholeness of nature, he continues to behave as if the one, changing universe had many separately functioning parts. (239)

By the end of the novel the crew comes to trust in the Nexial methodology after it helps them to survive encounters with Ixtl, a xenomorph-like entity that can control atomic structures and lay its hatchlings into living human hosts, and Anabis, a nebulous and God-like consciousness that decimates entire galaxies.

In our real world, without the benefits of Nexialism, we are faced with the same problem as our medieval forbearers in that our experiences are often at odds with our explanations, and even when they are not, the problem of assuming we know almost everything because we know a lot of things is problematic. Was it possible for Bede, or would it be possible for Grosvenor, to ever successfully conclude that the knowledge they have is true knowledge, and not just another infinitesimal step up the protoscientific ladder?

The reason the Ptolemaic system was so popular for centuries was that it seemed legitimate despite the lack of absolute certainty: indeed, this last was dependent upon developing appropriate verification technology that paradoxically had no need to be built since the system was already accepted as fact. Ethnographer Bonnie Nardi, in her article

“Activity Theory and Human-Computer Interaction”, proposes that one possible solution to the limitations of ready-made science is to employ activity theory, “which focuses on practice, which obviates the need to distinguish 'applied' from 'pure' science—understanding everyday practice in the real world is the very objective of scientific practice [...] the object of activity theory is to understand the unity of consciousness and activity" (7). Nardi is suggesting that it is more important to know how to work a computer than how a computer works.

We might say that literature, especially that of medieval times and the Golden Age of science-fiction, is one of the few spaces where the unity of the reality in our minds and that without can be explored in ways that our protoscientific methods strive for, but cannot achieve. The problem lies with the limitations of human conceptions: the demons in Dante have nothing on those of van Vogt, because the limitations of their audience’s minds are very different, and are based on what their knowledge about the universe is. In “On Færie-Stories,” J. R. R. Tolkien decries the disconnection between the spiritual and the factual, saying that he:

> ...was keenly alive to the beauty of “Real things,” but it seemed to me quibbling to confuse this with the wonder of “Other things.” I was eager to study Nature, actually more eager than I was to read most fairy-stories; but I did not want to be quibbled into Science and cheated out of Faerie by people who seemed to assume that by some kind of original sin I should prefer fairy-tales, but according to some kind of new religion I ought to be induced to like science. Nature is no doubt a life-study, or a study for eternity (for those so gifted); but there is a part of man

> which is not "Nature," and which therefore is not obliged to study it, and is, in fact, wholly unsatisfied by it. (31)

Consider the physicist who first will discover the grand unified theorem, consider the neuroscientist that in the future will break down the minutiae of the nervous mechanics of how the physicist came to his conclusion, and then consider the writer who will help them develop the terminology they will require to do all of this and explain it satisfactorily to those not in the know so that due credit is received. Of the three disciplines, which is the most critical in reconciling what is real and what is merely a cognitive epiphenomenon, and is there any hope at reconciling them outside of made-up literary contexts? In *Poiesis and Possible Worlds*, Thomas Martin tells us that:

> Apart from the *roman-à-clef*, the fictional takes the logical form of the conditional; we understand it as if it were true [...] A problem arises when we banish or otherwise reduce the modal distinction, assimilating the real to the fictional or the fictional to the real. (84)

There is a difference between falseness and fiction, just as there is a difference between the true and the real. Consider the imaginary number in mathematics: it is nothing tangible, but absolutely essential in terms of real applications.

In chapter seventeen of *A Demon-Haunted World* entitled "The Marriage of Skepticism and Wonder," Carl Sagan asks to consider that:

> At the heart of science is an essential balance between two seemingly contradictory attitudes—an openness to new ideas, no matter how bizarre or counterintuitive, and the most ruthlessly skeptical scrutiny of all ideas, old and

> new. This is how deep truths are winnowed from deep nonsense. The collective enterprise of creative thinking and skeptical thinking, working together, keeps the field on track. Those two seemingly contradictory attitudes are, though, in some tension. (304)

The value of examining the old way of doing things should be obvious at this point, but I will give a couple of examples to illustrate a pair of ways in which we cannot match the technical achievements of our forbearers, a limitation shared by even the most imaginative of our modern sci-fi writers and scientists. The two pieces of technology I am referring to are Damascus steel and Stradivarius violins. When Damascus steel is observed under a microscope, it reveals a pattern of carbon nanotubules woven throughout the Indian Wootz steel that it is smithed from. Our finest materiel nano-engineers are not even close to developing such a structure, let alone putting it to practical use. Stradivarius violins, handcrafted in the 17th and 18th century, are likewise un-replicable. Scans of the wood density might enable us to crank one out on a three-dimensional printer, but it will never sound right until Stradivarius' techniques can be replicated precisely using egg white and borax and trees that likely now no longer exist in the same form as they did in Stradivarius' day. With all that we have, and all that we know, the thought that we are missing out on the sharpest blades and the most dulcet-toned fiddles should make us yearn for a new era of rediscovery of our scientific heritage. We might say that knowledge of acoustics and metallurgy was secondary to the innate or "tacit" knowledge these ancient artificers used to create their masterpieces.

This last example brings us right round again to our old friend Michael Polanski, who can shed light one final time about the importance of individual commitment and unconventional thinking as it relates to the master craftworks examined in the previous paragraph. In “Transcendence and Self-Transcendence”, Polanyi gives an important piece of advice derived from the ideas within the research presented here. He tells his readers that:

> Our view of life must account for how we know life; biological theories must allow for their own discovery and employment. Theories of evolution must provide for the creative acts which brought such theories into existence. Beginning with our own embodiment our theory of knowledge must endorse the ways we manifestly transcend our embodiment by acts of indwelling and extension into more subtle and intangible realms of being, where we meet our ultimate ends. (Polanyi)

This is the best point that could be made about the thesis you have just read. It is our duty, as scholars, educators, and decent Terrans to transcend the threshold that keep great ideas from complementing each other to their fullest potential.

Mindedness is the capacity for higher level expression and discrimination in cognitive beings. Polanyi says that to enrich our awareness of the world, we must set ideals for ourselves to pursue such as honor and honesty. Polanyi complains that reductionism is a kind of moral inversion where higher-level realities are discarded in deference to lower-level realities. The reductionists are as fanatical about their viewpoint as the most rabid of Bible-bashers, but Polanyi believes this to be a symptom of our times rather than a problem with individuals. The false conception of scientific knowledge that has been explained over the last five chapters, while helpful with regards to the relevant disciplines, causes problems in the non-sciences. Polanyi believes that when reductionist values are applied to the humanities, they negate many of the aspects of living that are most putatively significant, leading ultimately to nihilism. I think the idea I have presented in this thesis about the power of both primitive and conjectural protoscience will only show more validity as long as philosophers of science keep everyone aware of the fact that everything we will ever do or think has a basis in reality, which means that religion and science are simply two different ways to examine a single problem.

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