Chapter 1 HISTORICAL OVERVIEW

From Aristotle to the 18th Century

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CONTENTS – CHAPTER 1

1.1 INTRODUCTION

These notes will give a brief overview of the development of science from the classical period to the present day, and emphasise some of the salient issues that have emerged. Two main periods will be discussed.

1.1.1 From Aristotle to the 18th Century

This period saw the development of classical science, the rise of Christianity, and the integration of many aspects of the classical worldview and world picture into Christian thought. No sooner had this been achieved however, than classical science was challenged by the development of modern science.

1.1.2 19th Century and beyond

Much of the change from the classical to the modern scientific world pictures has been a change from a static to a dynamic understanding of the world. From being to becoming, as is sometimes said. Part of this change was also the recognition of the material insignificance of the earth and humanity in space and time. The challenges of these discoveries for Christian thought, largely framed in classical terms, were immense.

1.1.3 Importance of History

Why do we bother to study history? There are several reasons. By discovering how we got here we can better understand where we are. In the process we can rediscover lost perspectives and avoid pitfalls. In the context of studying the relationship between science and faith, studying the history of that interaction allows us to see what issues were important in the past, discover the roots of current debates, and from these forge better intellectual tools for understanding and use.

1.1.4 Major Events

This chapter sets out to answer three questions: The first is to identify the major events in the history of the science-faith interaction from about 200 BC to the middle ages. The second is to identify the themes that have characterised this interaction. The third is to underline the lessons that these hold for the present and future?

1.1.5 Themes

Several themes come through any historical overview. These include the facts that Christians have always integrated their theology with the contemporary understanding of the world. This is fraught with danger as the contemporary understanding is always in flux. There have been times when Christians have defended as "the" Christian position an obsolete scientific world picture.

1.1.6 Lessons

The lessons that emerge for Christians from this history are many. However several predominate. The first is not to attempt to develop a scientific model on the basis of the Biblical worldview – all attempts will fail. A second is to hold loosely to any attempt to relate or integrate Christian theology with contemporary science – the science will inevitably change. A third, and probably most important, is to exercise humility and charity with those with whom we differ.

1.2 FROM ARISTOTLE TO THE 18TH CENTURY

1.2.1 Rapid development

In contrast to classical science, modern science (that which developed subsequent to about 1600) has developed very rapidly. In 400 years our understanding of the natural world has changed more than in the 4,000 years previously. Equally impressive has been the application of that knowledge to technology. What is behind this explosive development?

1.2.2 Origins

Greek Science (6th-2nd Centuries BC)

The importance of classical thought to science is often overstated, as we will see. However, it cannot be denied that rediscovery of the science of the classical world, of which the Greeks were the epitome, was an important factor leading to modern science.

Judeo - Christian Theology

Less well known to the popular mind, but of at least equal and probably greater importance was the Judeo-Christian worldview. In particular the doctrine of creation allowed an attitude to the world that permitted modern science to develop and flourish.

1.3 GREEK SCIENCE

1.3.1 Positive Features

Nature was ordered, not capricious, therefore capable of rational explanation

The Greeks believed the world was *Kosmos*, not *Kaos.* It was ordered, orderly, and therefore could be understood by the rational mind. The great contribution of Greek thought to modern science was the importance of logic and mathematics.

Knowledge about nature was important

The Greeks were curious about the world. Explaining why the world was the way it is was important to them. Combined with their emphasis on reason, this allowed speculation about the world to be a legitimate activity.

Could be derived by deductive reason

Deductive reasoning about the nature of the world was an important part of Greek science. Through deduction, the Greeks arrived at conclusions about the shape and size of the earth, and speculated about the existence of atoms, the possibility of life beyond the earth, organic evolution and whether or not the earth was the centre of the universe.

1.3.2 Negative Features

Nature was non-created, eternal and therefore divine

This created a problem for the acceptance of Greek science in Christendom. There were temporary bans placed on Aristotle's natural philosophy in the University of Paris in 1210 and 1215, and an attempt to expurgate them in 1231. Regarding nature as divine also resulted in a worship of nature and an attitude of worship towards the world. Inquiring into its workings could be seen as risking blasphemy.

Nature was governed by an inner force

Naturalism, pantheism, and vitalism are the common consequences of viewing the world as divine. Together with excessive rationalism, a contempt for hands-on

experience, the rise of mysticism in the classical world led to the near extinction of Greek science by about 200 BC.

Man's reason was paramount and linked to nature.

With mankind as the measure of all things, it was considered possible to comprehend the universe through reason alone. This suited the cultural prejudices of the Greek world. Manual work was associated with slaves and artisans and therefore menial, compared with the lofty thoughts of the elevated classes. Experiments or observations required doing the sort of tasks associated with slaves and artisans, not philosophers.

Thus experimental science was suppressed

Reason and rationalism was superior to empirical knowledge and experimental science. Reason declared that the heavens were perfect and unchanging. Therefore comets and meteorites were declared atmospheric phenomena, and supernovae ignored.

1.4 MEDIEVAL SCIENCE

1.4.1 Arab Science

The Arabs made many contributions to medieval science. First of these was the preservation of many Greek and Roman writings on scientific and mathematical matters. Secondly, the Arabs adopted many scientific ideas from the Indian subcontinent and China. Most important of these were "Arabic" numbers and zero, both Indian inventions. Thirdly, the Arabs themselves contributed much to mathematics, architecture, navigation, medicine, metallurgy, and astronomy. The arrival of this knowledge in Europe led to the full flowering of the medieval worldview and laid the foundations for the Renaissance.

For a more recent perspective, consult Peters *et al.* (2002).

1.4.2 Aristotelian Christian Synthesis – Thomism

Properties of God derived by reason.

1.4.3 Problems – Nature of God and Creation

The philosophy of Aristotle stood in sharp contrast to clear Biblical teaching.

Aristotle taught that the world was eternal, that God was an impersonal first principle, and that celestial matter was different to terrestrial matter, sharing some divine attributes. He also held that the soul (or souls) died with the body. Aristotle thus represented a great problem to Christian scholars of the 10th–14th centuries. He was clearly the greatest philosophical authority and this knowledge invaluable. Furthermore, Aristotelian metaphysics and logic were among the most developed in the ancient world and set the standard. On the other hand, Aristotle clearly held many things contrary to Christian doctrine. The options for Christian scholars were to reject Aristotle, and all the learning that went with it, to use him selectively, or to Christianise Aristotelian philosophy.

1.4.4 Role of Natural Theology and Revealed theology

Natural theology is the study of what can be deduced about God from the natural world. Revealed theology is the study of what the Bible says about God. Overall, natural theology can be seen as revealing God's impersonal attributes, while revealed theology is about His personal attributes. The relationship between the two is often strained. Natural theology, of itself, has tendencies to pantheism and deism. Revealed theologians have often ignored what is known about the world from science, especially when writing in the areas of creation, providence, and

eschatology. Both natural and revealed theology were part of the Thomistic synthesis, with natural theology closely identified with Aristotelian science.

1.5 SCIENTIFIC REVOLUTION – 16TH & 17TH Centuries

1.5.1 Renaissance

The Renaissance is the subject of much mythology. The myth suggests that it occurred when Europe rediscovered the purity of Greek rationalism and cast off the chains of ecclesiastical thought. In reality the rediscovery of the ancients and of Arab science occurred during the 12th and 13th Centuries. The scientific revolution of the 16th and 17th centuries was the sifting and rejection of much of classical science, not its rediscovery. The breaking of ecclesiastical chains was the Reformation, not the scientific revolution. Nevertheless, the reformation played a key role in preparing the intellectual ground for the scientific revolution.

1.5.2 Reformation – New Understanding of Scripture

The reformers critically re-evaluated earlier theology against the standard of Scripture. They also recognised that spiritual truth in the Scriptures was accessible to all those who sought it humbly before God. The reformers recognised the dignity of manual work as an act of worship (the so-called Protestant work ethic). Finally, there was a recognition that theology had to be useful, in encouraging ordinary people towards godliness.

1.5.3 Judeo-Christian Input

God as creator

Creation exists by His will, thus purpose is not intrinsic but resides in God. God is faithful in creation; therefore what we learn from it is trustworthy, because the creator is trustworthy.

Cosmos as creation

As creation, the cosmos is neither eternal nor divine. Therefore it should not be worshipped; rather it shares humanity's createdness. Since the cosmos is contingent on God, its properties can only be discovered by investigation and experiment, not by pure reason. Because creation is not divine such investigation is permissible.

Man is God's regent – steward

God has placed humanity in a position of responsibility in creation. These responsibilities include subduing and caring for creation, to fill it, to name the animals and till the earth.

Sanctity of work

Contrary to the ancient Greeks, work in the Bible is a gift from God; it is something humanity is commanded to do. Furthermore, work is sanctified by the Biblical revelation of God's activity as a worker, such as a farmer, shepherd, potter, and metal smith.

Rational Empiricism, Induction

The scientific revolution of the 16th and 17th Centuries followed on from the Reformation with many similarities in basic methodology. It was characterised by the linking of two approaches hitherto largely separate. These were rational empiricism common to the practical artisans of the medieval period with the induction of classical and scholastic thought, combined with an imperative to see what the evidence actually pointed to, rather than relying on authority. This approach closely resembled that of the reformers for theology and Scripture. With respect to the relationship between science and the Bible, Bacon, among others,

argued for a "two books" approach. These were the book of nature and the book of Scripture.

1.5.4 Bacon's Two Books

Book of Nature

Also known as the book of God's works, the natural world could be investigated by science to discover God's ways in it.

Book of Scripture

Also known as the book of God's words, Scripture could be investigated to discover God's will and purpose for His people.

1.6 COPERNICAN REVOLUTION

1.6.1 Copernican Astronomy - Prelude to Galileo

Aristotelian /Ptolemaic Astronomy

Built on the astronomy of the classical Greco-Roman period which, in its turn, is based on Babylonian and Egyptian astronomy. Key aspects of Aristotelian/Ptolemaic astronomy, as it was interpreted in the late Medieval period consisted of the following:

Authority, Tradition and Reason

Aristotle and Ptolemy were the authoritative texts. Although both these ancient scientists had made observations, in the late medieval period the rationalistic tradition was so strong that contrary observations were ignored.

An Eternal Cosmos

Aristotle believed that the heavens beyond the moon were eternal, unchanging, and composed of distinctly different material to the changing earth. The eternal nature of the heavens was not transferred across into the Medieval Christian understanding, but the unchanging character of the heavens was.

A Central Earth

The earth was central, not only to classical astronomy, but also classical physics.

Circular motions

The circle was the perfect shape in classical thought. It was obvious therefore that heavenly bodies would be both circular (or spherical) and move in circles.

See Fig 6.1 from Poole, M, *Belief and Values in Science Education.*

Alternative Systems

See Fig 6.6 from Poole (1995).

Copernicus - (1473-1542)

Copernicus suggested a central sun, but on purely rationalistic grounds; there was no empirical evidence to support it. It had little going for it except apparent simplicity.

Tycho Brahe – (1546-1601)

Tycho accepted the telescopic evidence that Mercury and Venus orbited the sun, but believed that the sun still orbited the earth, as did the other planets.

Kepler

Kepler postulated elliptical orbits, in one of the most significant breaks with classical astronomy after the abandoning of the geocentric universe.

1.7 THE GALILEO CONTROVERSY

1.7.1 Introduction

Nineteenth century writers on science and Christianity such as Draper and White used the Galileo debate as an example of their conflict model *par excellence.* The reality is both more complex and more interesting. Arthur Koestler in his Galileo biography *Sleepwalkers* observes,

> *The fame of this outstanding genius rests on discoveries he never made and on feats he never performed. Contrary to statements in even recent outlines of science, Galileo did not invent the telescope, nor the microscope: nor the thermometer, nor the pendulum clock. He did not discover the law of inertia, nor the parallelogram of forces or motions nor the sunspots. He made no contribution to theoretical astronomy, he did not throw weights down from the leaning tower of Pisa, and did not prove the truth of the Copernican system. He was not tortured by the Inquisition, did not languish in its dungeons and he was not a martyr of science.*

The Galileo debate was initially a scientific debate with Aristotelian scientists. The theological problem came later and was largely precipitated by Galileo's cavalier treatment of Pope Urban VIII. Koestler observes,

> *[Urban VIII] was the first Pope to allow a monument to be erected to him in his lifetime. His vanity was indeed monumental and conspicuous even in an age which had little use for the virtue of humility. His famous statement that he "knew better than all the cardinals put together" was only equalled by Galileo's that he alone had discovered everything new in the sky. They both considered themselves supermen and started on a basis of mutual adulation type of relationship which as a rule comes to a bitter end.*

The Galileo controversy can be divided into three phases.

1589 – 1610 - Scientific Controversy

Although known chiefly as an astronomer, Galileo (1564-1642) was notable also as a physicist (see below). Galileo studied medicine at Pisa, but did not complete his degree. He returned home and studied physics under a private tutor.

Galileo's professional life included appointments at the universities of Padua and Pisa, and as Philosopher to the Grand Duke of Florence. During his career from 1589–1633 Galileo was involved in 6 major controversies with colleagues. Most of these involved his refutations of Aristotle, which aroused the antagonism of most of his contemporaries. These controversies demonstrated Galileo's abilities at both debate and at antagonising his opponents in public controversy.

1611 – 1633 - Theological Controversy

Galileo's 5th controversy in 1614 was over Copernican astronomy. The debate had taken a theological twist owing to the introduction of Biblical arguments in defence of geocentricity by Galileo's opponents and Galileo's use of hermeneutics to defend himself. It led to him being given written orders that it could be neither defended nor held. He avoided Copernicanism for the next 8 years, but in 1630 discussed Copernicanism, as he thought, hypothetically, in his book *Dialogue concerning the two world systems*. This book led to further accusations of Copernicanism and of ridiculing pope Urban VIII, which led directly to his trial and conviction in 1633.

1633-1642 – Final Years

Galileo was placed under house arrest following his trial. This meant being released into the custody of a friend and living in his house. Many of the restrictions of his sentence were ignored or soon lifted. Later that year he moved to his own home near Florence and continued to work on physics. Despite suffering increasing blindness from 1637 Galileo continued his researches and died in 1642.

1.7.2 1589-1610 — Scientific Controversy

University Background

Pisa 1589-1592

During this period Galileo began to study physics. He began the first of his disagreements with his Aristotelian contemporaries, most especially in the field of mechanics.

Padua 1592-1610

Galileo's appointment to the University of Padua over the head of an Aristotelian rival was also a cause for controversy. This did not endear him to his opponents. During this period Galileo began to investigate optics, leading to more controversy. More important it led to experiments in lenses for telescope making, and the first telescopic astronomical observations.

Florence - 1610

Appointed to a prestigious post as a "philosopher" (scientific adviser in modern parlance) to the Duke of Florence, Galileo continued his astronomical research. He also began publishing his results, which led to the final controversy.

Contemporary Scientific Developments/Controversy

Supernova discovered

In 1572 and 1604 Tycho observed supernovae, new stars. The Chinese had known these for millennia, but they had been ignored in the western world. Kepler's observations placed them among the fixed stars, challenging the assumption about the unchanging heavens.

1609 Telescope and its discoveries

In rapid succession Galileo discovered with his telescope the moons of Jupiter— proving that the earth was not always the centre of the universe, sun spots— showing that the sun was not unblemished and changeless, and the phases of Venus— strong evidence for a heliocentric astronomy. Galileo also showed that Saturn had strange protuberances, indicating that things in the heaven were not perfect circles or disks.

Comets

Tycho had also showed that comets were more distant that the moon. They moved in strange and then unpredictable ways, further undermining confidence in the eternal perfection of the heavens.

Character of Galileo

Aggressive, Antagonised opponents, "The Wrangler"

Galileo was a ruthless and aggressive debater. He not only offended his enemies, but alienated those who might have been sympathetic. He also was unprepared to admit mistakes, even when they were shown to him.

Populariser – Books in Italian widely read both for content and style

Galileo was a great populariser. He wrote in Italian for the ordinary person, rather than the more learned Latin. This upset many contemporary academics, just as modern popularisers such as Carl Sagan and Steven Gould upset theirs.

1.7.3 1611-1633 — Theological Controversy

Acceptance and opposition

1611 Visit to Rome

Despite being controversial and his own worst enemy Galileo was well accepted in his 1611 visit to the Jesuit College. This college was teaching the Copernican system. He was also well received by Pope Paul V and impressed Cardinal Berberini, who became Pope Urban VIII in 1623.

1611-1613 — Organised Resistance "Liga" - Colombe

Galileo had so antagonised his academic colleagues that several joined together to form a conspiracy to discredit him. To do so they raised the issue that his astronomical views were contrary to Scripture, in particular that his view of the centrality of Earth undermined the authority of Scripture. Galileo defended himself through judicious Biblical interpretation. These were delicate times for such a practice.

Sensitivity of the times (Reformation and the Counter reformation and Council of Trent 1545-1563)

Protestant threat

To the Catholic authorities the Protestant threat lay in the lay interpretation of Scripture. If everyone interpreted the Bible as they wished, then there might be no limit to the heresies that might be promulgated. Subsequent events have shown this fear to be not entirely without substance. Any lay interpretation was seen as an attack on the Church. Galileo offered a theological defence of his position on three occasions.

Theological Debate

1613 - Liga

The first was in a letter to Castelli, a student of his, defending himself against the verbal attacks on him.

1614 - Caccini Sermon

The second was in response to a sermon by Caccini attacking his astronomy and claiming that the Bible clearly indicated that the earth was fixed. In this Galileo argued theologically about the nature of Biblical revelation.

1615 - Letter to Empress Christina

The most important of Galileo's theological defences was his letter to the Grand Duchess Christina. This is a key document in the relationship between Christianity and Science. It had the following main points:
*The issue had been brought to the Roman court for the wrong reasons.
*Astronomical theories could not be matters of faith.
*The new cosmology was in harmony with biblical teaching if the Bible were interpreted correctly by established principles (but not by Trent)

Some extracts from the Letter to the Grand Duchess Christina

These indicate Galileo's approach to science and scripture.

Regarding Scripture

The Holy Bible can never speak untruth, whenever its true meaning is understood. But the meaning is not always obvious from the literal sense as anyone can see in the Bible's use of anthropomorphic terms for God's hands and feet and eyes. Such terms are inspired by the Holy Spirit in order to accommodate them to the capacities of the common people, rude and unlearned as they are.

Galileo and the Book of Nature

The Holy Bible and the Phenomena of Nature proceed alike from the Divine Word … God can be known by Nature in His works - and by doctrine in His

revealed word. The Bible is written for the primary purpose of the salvation of souls and the service of God.

Quoting From Cardinal Baronius

The Bible tells us how to go to heaven not how the heavens go.

Quoting From Augustine

Usually, even a non-Christian knows something about the earth, the heavens, and other elements of this world, about the motion and orbit of the stars and even their size ..., and this knowledge he holds to as being certain from reason and experience. Now, it is a disgraceful and dangerous thing for an infidel to hear a Christian, presumably giving the meaning of Holy Scripture, talking nonsense on these topics; and we should take all means to prevent such an embarrassing situation, in which people show up vast ignorance in a Christian and laugh it to scorn ... If they find a Christian mistaken in a field which they themselves know well and hear him maintaining his foolish opinions about our books, how are they going to believe those books in matters concerning the resurrection of the dead, the hope of eternal life, and the kingdom of heaven?

1616 - Admonition by the Vatican

Cardinal Bellermine

The doctrine attributed to Copernicus that the earth moves around the sun is contrary to Holy Scripture and therefore cannot be defended or held.

Galileo was formally admonished in the letter from Cardinal Bellarmine. In it he was told that he was neither to hold nor defend the Copernican system. Galileo followed this instruction for 8 years but in 1630 published his book *Dialogue concerning two world systems* in which he presented cogent arguments for the Copernican system. The book was published in Italian for maximum circulation.

1623 Berberini becomes Pope Urban VIII

1630 Dialogue Published

In a style common to the time, the *Dialogue* consisted of a literary conversation between two protagonists seeking to sway a third party. One person represented the Copernican position, arguing with Galileo's style and arguments, the other presented the official papal position as that of the ordinary, or common sense view. In a classical Latin dialogue this person was known as Simplicus, meaning straight forward. In Italian this became Simplicito with the implication of feeblemindedness. The Pope was furious, even though Simplicito carried the day.

1.7.4 1633- 1642 Final Years — Trial and Condemnation

Ecclesiastical concern over the *Dialogue* led to sales being halted and Galileo summoned to appear before the Inquisition in 1633. He was accused of holding, defending, and teaching Copernicanism in defiance of the church. Despite conflicting evidence whether or not Galileo had been told not to teach Copernicanism, the court considered that the *Dialogue* clearly defended it, something that had been expressly forbidden. Galileo was told to acknowledge this or face the consequences, most likely imprisonment. He acquiesced and signed a confession, essentially an out-of-court settlement. The *Dialogue* was placed on the index of prohibited books and Galileo placed under house arrest and excommunicated. His excommunication was only lifted by the Vatican in 1992.

1.8 17TH CENTURY SCIENCE – NEWTON AND THE MECHANISTIC UNIVERSE

The Newtonian revolution delineates a major watershed in the history of science. It marks the end of classical physical science that had dominated thought in physics and astronomy for almost two millennia. Copernicus, Kepler, and Galileo started the process in astronomy. Galileo and Kepler also began developing mathematical physics and were important predecessors of Newton. Kepler, Galileo and Newton showed the power of mathematics in describing the behaviour of the physical world.

The rise of rationalistic, mechanistic philosophy in the tradition of Descartes paralleled the development of the new physics. Indeed, the success of the new physics appeared to lend empirical support to this philosophy. The mechanistic world picture thus played a role in the rise of agnosticism, atheism, and deism.

A revolution of similar magnitude was the discovery of earth history. John Green wrote in *The Death of Adam* (1961) that the change from a static and cyclic to a dynamic and evolving world view was the most marked characteristic of the transition from medieval to modern science. Accompanying this was recognition that the same laws operated in the universe as on earth. This transition marked the eclipse of Aristotle in physics, Ptolemy in astronomy, and Genesis in geology. All this occurred in the 17th and 18th centuries. The 19th century saw the same process in biology and palaeontology, where the Aristotelian view on the fixity of species was overthrown by an evolutionary perspective. This is the subject of a later chapter. The rise of the nebula hypothesis in the 19th and early 20th century provides a further example.

Christian responses to these different developments were many. Initially some attempted to develop a Biblical alternative, known as Hutchinsonianism, to mechanistic physics. Natural theology rose later, and attempted to use the rationalistic philosophy of Descartes and the new scientific discoveries to provide, not only a rational basis for theology but outright proofs for the existence of God. In the case of geology, the main issue was how to reconcile discoveries of an ever increasing geological past with the text of Genesis. Christians proposed various exegetical and hermeneutic schemes to resolve the problem.

The Clockwork Universe

Rise of Newtonian physics

Aristotelean & neo-platonic physics

Classical physics as understood in the middle ages was dominated by the thought of Aristotle. It was rationalistic-speculative, there was little empirical observation, and experiment was ignored. Key aspects included the following. Terrestrial matter was made up of four elements (earth, air, fire, and water). Celestial matter was made of a fifth element, the *aether*. All things were arranged in a hierarchy in a concentric cosmos. Formless matter was at the centre and matterless form on the outside. All things could be classified into a small group of universal properties. Ironically, Aristotle himself recognised the importance of observation, while many of his followers did not. Aristotle made many important biological observations in addition to his physical speculations. He can be called the greatest biologist until Linnaeus in the 18th century.

Collapse of classical Greek physics

The rationalistic physics of Aristotle was consistently refuted by Galileo, whose fiercest disputes were with the Aristotelian professors. Galileo worked particularly in problems of mechanics, buoyancy, and optics. Like Archimedes he was particular interested in the practical application of his knowledge. The visible success of inventions and innovations such as the

pendulum clock, surveying instruments, and telescopes did much to cement the superiority of the new physics over the old. Kepler also played an important role, he disproved classical idealism, which saw the circle as superior to the ellipse and thereby the natural motion of the heavens. His studies of planetary motion showed that the planets moved in ellipses, not circles. They disproved classical idealism, which saw the circle as superior to the ellipse and thereby the natural motion of the heavens. His three laws of planetary motion anticipated Newton.

Newton developed new mathematical tools (calculus) to describe physical phenomena. He refined mechanics and optics to new precision. Newton also invented telescopes and through application of gravitational theory established the universal applicability of terrestrial physics. Newton thus completed the process begun by Galileo and Kepler in demonstrating the power of mathematics in describing the behaviour of the physical world.

1.8.2 Impact of Newtonian physics

Scientific

Newtonian physics transformed science and became the epitome of the scientific enterprise. The success of Newtonian physics in predicting the existence of Uranus and Neptune from the irregularities in the motions of other planets was perhaps its greatest triumph.

Newtonian physics was superseded in the 20th by quantum theory and relativity, but still provides a highly accurate way to describe and predict the behaviour of physical objects. Refinements and elaborations of Newton's physics continue to provide the basis for modern mechanical, structural, and civil engineering. The Newtonian vision also provided a great incentive to physical scientists studying chemistry and electricity.

Metaphysical

Newton's superb mathematical exposition of the behaviour of the physical world is often linked to the rise of naturalism. Mathematics explained the world so well, so the naturalists argued, that there was no need to invoke, or seek for, powers or forces beyond the material.

It is certainly true that metaphysical naturalism, both agnostic and atheistic, became more prevalent in the latter part of the 17th century. It is also true that many Christians were concerned by the materialistic implications of Newtonian philosophy. This partly gave rise to Hutchinsonianism (see below). Neither of these metaphysical consequences were direct consequences of Newton's own theology. The success of mechanistic explanations in physics was perceived as powerful confirmation of materialistic explanations of the world, laying the groundwork for the metaphysical scepticism of the Enlightenment.

1.8.3 Christian responses

The faith of the founding physicists

Galileo's faith has been discussed previously. Kepler was also strongly Christian (Lutheran) in outlook, although modern believers would be surprised in his practice of astrology and his leanings towards Pythagorean mysticism. Fascinated by harmony, Kepler saw the relationships of the natural world as evidence of God's handiwork. Despite being embroiled in religious controversy — he disagreed with both Catholics and Lutherans over the nature of the Communion—he appears to have remained remarkably free of religious animosity. Newton was a devout, if heterodox Protestant. His understanding of the relationship between God and His world was theistic. Personal research led Newton to adopt Arianism, a fact he kept hidden. His extensive Biblical research is far more voluminous than his science but was little known until this century. Newton also followed the "two books" approach, but he considered discussion of science and faith unprofitable. When

president of the Royal Society he banned any discussion of religious topics in the Society.

Mosaic science

Not all Christians were comfortable with the mathematical science of Newton and his contemporaries. Almost unknown today, the followers of John Hutchinson (1674–1737) attempted to create a Bible-based alternative to Newtonian physics. Hutchinsonianism gained a following amongst many educated people of the time, including several Bishops, Peers of the Realm, and Samuel Johnson, but had died out by the end of the 18th century.

Hutchinsonians objected to Newton on several grounds. These included the "unscientific" concepts such as action at a distance (gravity), its supposed association with Latitudinarianism and deism, and the superiority of a science built on Scripture. The fundamental assumption of the latter was the belief that the Hebrew text was philosophically true in every detail and that the language itself contained the key to all knowledge. Their writings attempted to form a biblically based science, that would help defend orthodox Christianity.

The Hutchinsonians failed for a combination of reasons including the inability of the Bible to sustain a scientific superstructure and the success of Newtonian physics. Ironically for defenders of orthodoxy, Hutchinsonians defended a self sufficient rather than contingent universe and emphasised God's transcendence as against His immanence. This was very similar to the deism that they opposed. In their attitude to science and their use of Scripture they resemble, in many ways, the modern Creation Science movement.

Deism and theism

The rise of deism may reflect the strongly deterministic nature of Newtonian science and the exclusion of the "God of the Gaps". Much of the theology of the enemies of Newtonianism was also conducive to deism, especially in the separation of God from the world and the emphasis of the world as a self contained machine.

Despite the popularity of deism, many Christians and scientists remained theistic in their outlook. Indeed, the Newtonian revolution heightened the need to see God as immanent as well as transcendent, and as the One who worked by natural law, as well as by miracle.

1.8.4 17th Century British Scientists

These saw themselves as observing the ways of God in Nature (studying the book of God's works). They did not see themselves in opposition to faith. The Royal Society was founded by such scientists. Unlike catholic Europe, Britain had a positive Science/Faith climate. With time however, some came to see that knowledge of God derived from the natural world was more reliable than revelation. Some have been referred to already.

Francis Bacon— Two Books

Book of Nature and Book of Scripture. Finding out about the ways of God.

Church Sympathetic to Copernican Science

Wilkins Master of Trinity 1659 and Bishop of Chester 1668 was the foremost Copernican proponent in Britain.

Royal Society — Sprat history 1667

Was founded by mainly Puritan Christians who saw themselves as exploring the ways of God in Nature and directing their study to the glory of God and the benefit of the human race.

Isaac Newton 1642-

His religious faith and theological writings have already been referred to. His *Principia* was published in 1679 and marked both the end of Aristotolian physics and the generation of the "mechanistic universe". Its concepts generated two directions in the Science/Religion debate: that of a universe with no need of God, atheism, and that of a universe displaying the works of God, theism. Newton remained in the latter group. In his regard for matters theological Newton can be regarded as typical of his time and place. Indeed, Newton wrote more words on theology than on science. However, much of his theology was not quite orthodox, he was both Arian and Unitarian in his thinking.

John Ray 1691

The father of Botany, whose book *Wisdom of God Manifested in the Work of Creation* was widely circulated and read.

Robert Boyle

As a further example of the close relationship between science and theology in the minds of 17th century English scientists we have Robert Boyle. He established the Boyle Lectures to consider the ways of God in Nature.

W Paley - Natural Theology

Paley's *Natural Theology — Evidences for the Existence of the Deity Collected from the Appearances of Nature* published in 1802 was to dominate the science scene in Britain until well into the 19th Century.

1.9 NATURAL THEOLOGY

1.9.1 Development

Theology used for its utility value — to establish the need for God. To prove a benevolent God. This was the purpose of the Boyle lectures. The first given by Richard Bentley in 1691 was entitled "A refutation of atheism from the origin and frame of the world". This role is illustrated by a quote from Linnaeus in 1754

If the maker had furnished this globe, like a museum, with the most admirable proofs of his wisdom and power; if this splendid theatre would be adorned in vain without a spectator; and if Man the most perfect of all his works is alone capable of considering the wonderful economy of the whole; it follows that man is made for the purpose of studying the Creator's works, that he may observe in them the evident marks of divine wisdom.

Natural theology became the dominant spirituality of the deists. Rejecting Biblical revelation, they attempted to base their faith on evidence for God in the natural world. Because it was rational and scientific, it was considered that natural theology was a truer road to knowledge of God than "corrupted" human texts. Deists believed that God had created in the beginning, but did not intervene in the world. Natural theology was also attractive to theists and semi deists, who saw in it a powerful apologetic tool.

1.9.2 William Paley

Natural Theology dominated (particularly in Britain) the relationship between science and theology during the 17th and 18th Centuries. It was successfully promoted by William Paley. His *Evidences for the Existence of the Deity* published in 1802 had enormous influence. It dominated Anglican Theology in late 18th and early 19th Centuries.

Paley portrayed nature as a watch and God as a watchmaker. Each aspect of nature was considered as a demonstration of the Deity — a proof of God as the master watchmaker (designer), e.g. eye , bird's wing etc. It also portrayed a static creation, each creature being individually brought into being by a special act of God.

Many scientists were of course clergy, and science was stimulated enormously by the search for ever more evidences of God's design in Nature. Natural theology declined as the deism to which it appealed declined towards the middle of the 19th century. Classic natural theology, in the style of Paley also went into eclipse when naturalistic accounts for the appearance of specific adapted organs such as the eye appeared to be provided by natural selection. More recently modified versions of natural theology have appeared in extrapolations from the apparent fine-tuning of the universe. It has also reappeared in the "Intelligent design" movement, which denies organic evolution and reinstates Paley.

1.10 THE ENLIGHTENMENT, DEISM AND ATHEISM

1.10.1 Weakness of Natural Theology

Contained the seeds of its own destruction — exploited by Hume 1779 in his *Dialogues Concerning Natural Religion*. Along with the purposefulness of nature had to be added its apparent purposelessness on occasions. The problem of natural evil made evident by the enormous death toll of the Lisbon earthquake was particularly salutary.

Cannot prove God, must always assume God's existence

By relying only on induction from scientific knowledge, natural theology could only offer God as a hypothesis. The likelihood of that hypothesis would wax and wane according to the evidence.

Removes a personal God

The deists denied revelation. By eliminating the God of the Bible who reveals Himself to his people and saves them, they were left with an emasculated religion of little personal substance beyond a vague mysticism. The deist's God was distant, impersonal, and powerless to act in the real world.

1.10.2 Deism, Atheism

Deism the outcome of a mechanistic philosophy has two outcomes. as Pier Maupertuis (*Essai de Cosmologie* 1756) observed

All the philosophers of our time belong to two sects. One group wishes to subjugate nature to a purely material order and to exclude all intelligent principles from it….. The others on the contrary, make constant use of final causes to discover the views of the Creator, penetrating his intent in the smallest of phenomena. According to the first group the universe could do without God. According to the latter, the tiniest parts of the universe constitute repeated demonstrations (of his being). His Power, Wisdom, and Goodness are painted on the wings of butterflies and in every spider's web.

Thus deism may, and in fact did, lead historically to both Atheism and Theism. To European Rationalism and the Enlightenment, to English Natural Theology and Paley's *Evidences*. Deism and its mechanistic philosophy may therefore:

Go on and exclude God — It may then lead to Atheism.

If they were not able to prove the Deist's God, they would be likely to lapse into atheism. This is what happened in most cases. Atheism was more attractive intellectually than the weak and distant God of the deists.

Go on and prove God — it may then lead to Theism.

If they were able to convince themselves of the existence of God there was always the likelihood they would come to realise that God was active in their lives. In this case they would become theists, especially Christian theists if they came to believe the God of the Bible manifest in Jesus. In

fact both intellectual destinations are flawed, or at least the track to them is flawed.

A mechanistic universe neither proves God nor removes the need for God. Paley's evidences affirm a God he believed in, and Laplace's "no need of that (God) hypothesis" simply disposes of a "God of the Gaps".

1.11 THE AGE AND HISTORY OF THE EARTH

1.11.1 History of Geology

Principles of Stratigraphy

Lithostratigraphy

Serious study of geology began with Nicholas Steno (1638-86), the first to elucidate the basic principles of stratigraphy. He also demonstrated beyond reasonable doubt that fossils were of organic origin. Steno's principles allowed the lithostratigraphic correlation of rocks over large areas.

Biostratigraphy — fossil sequences

By the end of the 19th century natural philosophers had begun to recognise that fossils always occurred in a particular sequence. This fossil or biostratigraphic succession made possible the correlation of rocks over long distances, even when rocks cropped out discontinuously or when lithological changes had occurred.

Biostratigraphy provided the basis for the geological time scale. It also showed that species were not eternal but appeared and became extinct through geological time.

Processes Involved

Diluvialism

A diverse group of people through the 17th and 18th century interpreted the earth in terms of Noah's flood. These were the diluvialists, most of whom were English Protestants. Diluvialists argued that the present configuration of the earth was not its original one. Oceans, valleys, and mountains were seen as imperfections absent on a world created perfect. The original earth was a perfect sphere, imperfections were the results of Noah's flood. Fossils in rocks were the flood's victims. Diluvialism fell out of favour for two reasons. Firstly, nobody was able to construct a consistent model for the rise and fall of the flood from Biblical data. Secondly, the diluvialists themselves discovered an increasing body of evidence that proved that the geological record was not the result of a single, world-wide flood. Instead it was clearly the result of a wide range of processes operating over a large, though indeterminate, period of time. By the early 19th century few diluvialists remained. Those that did were increasingly isolated from the mainstream of geological research.

Neptunism and Plutonism/Vulcanism

Neptunism and plutonism were two rival theories that, in the late 18th century, replaced diluvialism. Neptunists argued that the geological succession was the result of precipitation out of a primordial ocean, even for crystalline rocks such as granite. Plutonists did not deny the sedimentary origin of many rocks, but argued that granitic and other coarse crystalline rocks were the result of the crystallisation of melts deep underground. The plutonists are commonly held to have "won" the debate, but the neptunists also made many important contributions to geology and mineralogy. The data they collected together reinforced the conclusions of the diluvialists, that the geological record could not be adequately explained by a single global event. Experiments by Buffon (1707-88) on

rates of cooling suggested that the earth had taken 74,832 years to cool from an incandescent state to its present temperature.

Catastrophism

Detailed mapping in the British Isles and continental Europe showed a consistent geological succession. Each consisted of several systems of rocks defined by their characteristic fossils. Each system appeared separated by an unconformity, signifying a major deformation and erosional event. The systems came to be interpreted as representing separate creations, each lasting epochs, and terminated by a global catastrophe. The deluge was seen as the most recent of these. This interpretation of earth history was thus known as catastrophism.

Catastrophism dominated geological thought, particularly in Britain. It provided a fruitful and successful framework for the understanding and researching of earth history for the first 30 years of the 19th century. Within its framework, geologists such as Sedgewick, Murchison, Cuiver, and Buckland, established the detailed geological succession over much of Europe. Catastrophism collapsed for several reasons. One of these was that the unconformities were not world wide in extent, but restricted to particular areas.

Elsewhere, the transition between eras and epochs was gradational, or marked by only one fossil assemblage replacing another. Another reason was that geologists became better acquainted with sedimentary processes. Deposits formerly attributed to catastrophies were recognised to be the result of normal processes similar to those observable in many parts of the world. An example of this was the widespread layer of boulders and gravel found over much of northern Europe and North America. Catastrophists initially attributed this stratum to the deluge. Subsequent work showed that these deposits were due to glaciation.

Uniformitarianism

The concept of uniformitarianism is commonly associated with Lyell (1797–1875). Other geologists, including Fleming, Scrope, and Lomonosov, were also important in its inception. It replaced catastrophism as the dominant interpretative framework for geology. Uniformitarianism assumed that the geological record is the result of processes now operating. It arose because of extensive study of modern processes of volcanism, deformation, and sedimentation. These showed that contemporary processes were capable of producing most of the observed features of the geological record, given sufficient time. Uniformitarianism became a dogma, despite abundant evidence for past processes different from any now operating, and for past processes operating at different intensities and rates to the present. Such dogmatic adherence to uniformitarianism proved an obstacle to the acceptance of several new insights in geology. This has included the role played by asteroid impacts and catastrophic flooding related to natural dam bursts because they appeared to violate uniformitarianism. Some uniformitarians, such as Lyell, were originally hostile to organic evolution for the same reason.

Actualism

Modern geology appears to have outgrown specific interpretative frameworks such as uniformitarianism. Instead, geologists seek to determine, from the evidence of the rocks, the actual processes that have formed them. All rocks are the result of the interaction of physical, chemical, and, in some cases, biological processes. Different processes result in different end products. This approach has been termed actualism. This method is particularly important, as geology becomes increasingly the

study, not just of the earth, but of all solid bodies in the solar system and beyond.

1.12 CHRISTIAN RESPONSES TO GEOLOGY

1.12.1 Christian Geologists

The proportion of active lay Christians and clergy who played a key role in the development of geological science is remarkably high, even in an age where most claimed nominal adherence to Christianity. Geological research really began with the establishment of its basic principles by Steno. Clerics included Steno in Norway and Italy, Burnet, Chambers, Buckland, Sedgwick, and Fleming in Britain. Active lay Christians included Miller in Britain, and Gray, Dana, and Dawson in the United States. All these attempted to relate their geological researches to their interpretation of Genesis. Such interpretations have gone through three phases as geological knowledge progressed.

Literalism — Biblicist input influencing science

Literalism assumes that the Bible contains technical data pertinent to earth history. The Bible and geology are in accord and the geological evidence interpreted appropriately. Diluvialism was constructed within a literalistic framework. Some diluvialists (Whiston, Halley, Woodward, Catcott) were theologically orthodox. Others (Descartes, Newton, Burnet) were not.

Literalism decreased in popularity as diluvialism was increasingly falsified. Literalists were also unable to construct an internally consistent literal reading of Genesis. By the second half of the 19th century it was held only by Christians on the theological fringe, such as the Seventh Day Adventists. Modern proponents are numbered among the various forms of "creation science".

Concordism

Concordism is the reverse of literalism: Genesis is interpreted in the light of geology. Three main variants have been proposed, the restitution theory, day/age theory, and days of revelation theory. Concordism replaced literalism in the early 19th century and, in its various forms, was enthusiastically championed by Sedgewick, Buckland, Miller, Chambers, Gray, and Dawson. Almost all were conservative and evangelical theologians. Between about 1810 and 1960 many held to concordism. There are still many adherents.

Three factors served to reduce its popularity. The first was the resurgent of literalism in the guise of creation science among fundamentalist Christians. The second was the failure of concordism to develop a consistent correspondence between Genesis and geology. The third was the fear among fundamentalists that theologians had compromised too much in allowing science to determine the exegesis of Genesis.

Literary approach

The problems of concordism resulted in new approaches to the interpretation of Genesis. These were concerned primarily with discovering the theological teaching of Genesis within its cultural milieu. They did not attempt to use Genesis to constrain science, or to try and find correspondence between Genesis and geological history. These literary interpretations of Genesis focused on the theological content of Genesis, rather than the scientific, because 300 years of science had persuaded them that scientific readings of Genesis were not possible. This new approach appears to be a fruitful one, and draws on a hermeneutic tradition that extends as far back as Augustine.

1.12.2 Resurgence of Flood Geology

One of the most remarkable aspects of the relationship between Christianity and science in the last 40 years has been the reappearance of Young Earth Creationism (YEC) and flood geology in mainline denominations. Previously found mainly in fringe groups such as the Seventh Day Adventists, flood geology was reintroduced to other Christian groups in 1961 with the publication of *The Genesis Flood* by Whitcomb and Morris. Since then YEC has become the default position on science, faith, and the interpretation of genesis in many evangelical and fundamentalist denominations. Indeed, for many it has become the hallmark of orthodoxy. This is ironic because in their approach to Scripture and to science YEC is typically unorthodox. Nor has it successfully answered the problems that led to YEC and flood geology being abandoned in the 18th century.

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