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GOD AND THE BOOK OF NATURE

For the whole sensible world is like a kind of book written by the finger of God.

Hugh of St. Victor

WHY STUDY SCIENCE? One can answer this question from different angles. One can ask why you as an individual should study science. Doubtless, as a reader of this chapter you have answered that question for yourself. Perhaps the natural world has always fascinated you; maybe an influential parent or teacher inspired you; maybe you are just good at science and so you pursue it as a career to challenge yourself or support your family.

One can ask why we as a society should study science. The most obvious answer is that science has improved our lives. We live longer, healthier, more productive lives because of the technology that comes from scientific discovery. There are valid worries about science's power to destroy human life or whether it can satisfy the human desire for happiness. But most people take an optimistic view that science has been a significantly positive development in human history.

Is it possible, however, to give Christian reasons for studying science? Are there particular reasons why Christians might be motivated to enter a scientific career? Spend time in Christian communities and you may hear worries about a scientific education. Perhaps a focus on scientific knowledge will distract you from spiritual matters, or scientific knowledge will puff up your pride, making it impossible to obtain wisdom. Or, more fundamentally, science will teach you beliefs that contradict what God teaches in Scripture. We address these worries in other places in this book, but this chapter focuses on the question, Are there positive Christian reasons for studying science?

We argue yes, and will explain why using the most common metaphor for thinking about theology and science in the history of Christianity: God has spoken in the books of nature and Scripture. For over 1500 years, Christians have used the metaphor of God's two books to suggest the complementarity of natural and supernatural knowledge.[1] The rest of this chapter will outline some theological lessons implicit in the metaphor.

GOD'S TWO BOOKS

The first implication of the two books metaphor is that some knowledge of God can be gleaned from nature. We might look at the night sky and be overwhelmed by the power and wisdom of God. We can grasp the intricacies of the cell and feel awed by the complexity of the biological machinery that sustains life. Or we might recognize the amount of time used to form creation and marvel at the patience and infinitude of God. Countless other examples could be given, ranging from intricacies of subatomic matter to the vastness of the universe. Christians affirm that the natural world is governed by the wisdom of God, and so science allows us to glimpse God's wisdom more fully.

> It is the divine page that you must listen to; it is the book of the universe that you must observe. The pages of Scripture can only be read by those who know how to read and write, while everyone, even the illiterate, can read the book of the universe.
>
> Augustine, *Exposition of Psalm 45*

Spiritual knowledge that comes from reflecting on God's creation led some early luminaries of the Scientific Revolution to argue that science is a spiritual activity. Robert Boyle, a leading figure of the Scientific Revolution and discoverer of Boyle's law in chemistry, described scientists (who were then called natural philosophers) as "priests of nature" because they were uncovering God's fingerprints in creation.[2] He even argued that science should be seen as a form of worship, and thus an activity suitable for Sundays. Even if today we do not want to go as far as Boyle, we can acknowledge the special thrill for Christians in being able to unpack the structure of the natural world. Theological beliefs we bring to science help us to understand the significance of what is being discovered.

> We were made in the image of the Creator; we have the mind and reason to perfect our nature, and through them we have knowledge of God. And perceiving the beauties of nature carefully, we thereby recognize, as if through letters, God's great providence and wisdom concerning all things.
>
> St. Basil of Caesarea, *Homily on Thanksgiving*

Another implication is that since God is the author of both books, we as readers should not expect to find discrepancies between them. If we find places where nature and Scripture disagree, then it is a mistake of the readers—we simply have not read one or both of the texts correctly. The great early-church theologian Augustine said that whenever we have a sure result of science that conflicts with the Bible, the interpreter must bring the two back into alignment.[3] Thus learning about the natural world can help us interpret the Bible better. For example, until the invention of telescopes many Christians interpreted certain verses in Scripture to mean the earth was stationary. Psalm 96:10 states, "Say among the nations, 'The LORD reigns.' The world is firmly established, it cannot be moved; he will judge the peoples with equity." With the benefit of hindsight and scientific knowledge, Christians have no problem affirming that Christian Scripture does not teach the earth is stationary, though it may have been assumed by biblical writers. Science helped us to avoid an error in biblical interpretation.

If Christians do not recognize the value of science for interpreting the Bible, they might damage the credibility of Christianity by insisting that outdated science must be true in order to save traditional interpretations. Augustine also identified this error, writing:

> Often a non-Christian knows something about the earth, the heavens, and the other parts of the world, about the motions and orbits of the stars and even their sizes and distances . . . and this knowledge he holds with certainty from reason and experience. It is thus offensive and disgraceful for an unbeliever to hear a Christian talk nonsense about such things, claiming that what he is saying is based in Scripture.[4]

Non-Christians have the God-given gifts of reason and experience, which can be used to understand the natural world. All truth is God's truth, and so Christians should not fear what science discovers about creation.

Sometimes one hears the claim that true science should begin with Christian assumptions, thus creating a "Christian science" that differs from its secular counterpart. But Augustine argues that this strong skepticism of scientific inquiry could injure the faith: if Christians cannot be trusted on what can be empirically verified, then how can they be trusted on spiritual matters? Augustine himself left a rival religion for Christianity after he found its leader proffering bad science, saying, "It was providential that this man talked so much about scientific subjects, and got it wrong."[5] A better position is to affirm that secular scientists may not be wrong when they make empirical claims (i.e., inference drawn from reason and experience); they just fail to see the true spiritual significance of what they study. In other words, they do not comprehend the spiritual realities to which the physical realm bears witness, with the result that secular scientists are often wrong when they try to construct a worldview based on science.

> The church is called in every age afresh to give a coherent account of its faith, to testify to that living truth with which it has been trusted, the gospel of Christ.
>
> Trevor A. Hart, *Faith Thinking*

Though Scripture contains everything necessary for salvation, it is not an encyclopedia of all possible knowledge. Christians sometimes speak of Scripture as if it contained

modern scientific theories or hidden knowledge of nature if interpreted correctly. Of course, it was possible for God, as Creator of the universe, to give us a Bible like this. But Christian theologians since almost the start of church history have recognized that God's revelation has been accommodated to the understanding of the cultures in which it was written, which includes beliefs about the natural world. We will talk more about this principle in our chapter on biblical interpretation.

The difficulty, of course, is determining what theories in science have been empirically verified so that we may resist those who would use the authority of science to support anti-Christian conclusions. In such cases, Christians should not surrender basic beliefs in the name of "science." Yet these worries should not undermine the basic principle: where science shows us an empirical fact that conflicts with a traditional interpretation of a biblical passage, we need to reexamine our interpretations.

LIMITS OF THE TWO BOOKS METAPHOR

Having stressed the value of the two books metaphor, we do not want to push it too far. To head off misunderstandings, we will discuss some conclusions that the metaphor cannot support.

First, some have concluded that the basic message of the two books is essentially the same, thus making one redundant. If this were the case, one could build a theology from nature alone, without need of biblical revelation. The problem with this view is that the natural world leaves out crucial theological details. There seems little way to deduce the main tenets of Christian theology—especially about God as revealed in Jesus Christ—from the study of natural objects. As Francis Bacon, the famous philosopher of the Scientific Revolution, put it almost five hundred years ago, the works of God "show the omnipotency and wisdom of the maker, but not his image."[6] Christianity is a historical faith, meaning its content depends crucially on events that happened in human history, particularly in the life of Jesus and his immediate followers. There are thus fundamental limits on what one can learn about God from the natural world. One cannot construct a theology based on nature alone; but for Christians, it is appropriate and beneficial to read both texts in coordination with each other. Followers of Christ in every age have constructed "theologies of nature," which are attempts to articulate what we discover in the natural world in light of Christian belief.

quently have made their body of knowledge less stable over time. These discoveries may spur new theological reflections and developments, but the core of the Christian message will persist.

In conclusion, there has been a strong emphasis in Christian history on the value of studying nature. If done with the appropriate caution, which mainly avoids trying to prove too much, then it can be edifying to the faith. This is true on a personal level, where awe at the complexity of nature can lead to worship of the Creator. This is also true for the church on the whole, where a better understanding of nature can help with our interpretation of Scripture. Of course, not all see this basic compatibility of science and Christian theology. In the next chapter we will begin to explore why this is, using the history of science.

A second caution: both books need to be interpreted in a manner appropriate to their content. One way to stress the differences between interpreting the natural world and interpreting Scripture is to say they were composed in different languages. As Galileo famously said, the universe "cannot be understood unless one first learns to understand the language and knows the characters in which it is written. It is written in mathematical language, and its characters are triangles, circles, and other geometrical figures; without these it is humanly impossible to understand a word of it, and one wanders around pointlessly in a dark labyrinth."[7] Mathematizing nature is an important characteristic of the scientific process, which allows scientists with different religious or philosophical beliefs to draw conclusions from the data. In contrast, as we will discuss in chapter seven, the biblical interpreter does not use mathematical or experimental techniques to reveal hidden meanings, but first contextualizes the passage in its original cultural context.

> Let no man think or maintain that a man can search too far or be too well studied in the book of God's Word or in the book of God's Works, divinity or philosophy, but rather let men endeavor an endless progression of proficience in both; only let men beware that they apply both to charity and not to swelling; to use, and not to ostentation.
>
> Francis Bacon, *Advancement of Learning*

Finally, the metaphor of God's two books does not mean they should be given equal weight in terms of importance. Christianity deals with matters of eternal importance, and one can be a faithful Christian without holding any modern scientific beliefs. Indeed, the central message of Christianity has remained the same despite dramatic changes in Western philosophies of nature—whether Platonic, Aristotelian, Newtonian or modern ones centered on quantum mechanics, string theory and so on. This is not to deny development in theological doctrine over church history, but to recognize that Christians today can affirm "Jesus is Lord" just as their predecessors have done for almost two millennia. Scientists, by contrast, have discovered new things about the world that conse-

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CHRISTIANITY AND THE HISTORY OF SCIENCE

For many of the natural philosophers of the seventeenth century, science and religion—or, better, natural philosophy and theology—were inseparable, part and parcel of the endeavor to understand our world.

Margaret J. Osler, "Myth 10: That the Scientific Revolution Liberated Science from Religion" in *Galileo Goes to Jail*

HISTORY IS NOT ESSENTIAL for doing science, which explains why the history of one's discipline is only briefly discussed in most scientific textbooks. This is true even for theories still used in modern science. What matters most about Maxwell's equations, for example, is not how or why they were discovered, but whether you can use them to solve problems in physics.[1] However, history is essential for Christians who want an answer to the question, Why should Christians study science? As we will also see, one answer is that you are merely following in a long line of Christians who have studied science. Pick any science from any time period and it is almost certain that you will find Christians engaged in research on the topic.

Moreover, knowing the history of science will help inoculate you against common misunderstandings about the origins and nature of science. As we will explain in this chapter, there is a prominent story in our culture about the long history of conflict between science and Christianity, which you are likely to encounter often in your scientific career. It therefore is important to have a basic grasp of the history of science; otherwise you may be liable to accept parts of this story and thus assumptions about science that do not stand up to critical scrutiny. Just as the book of Genesis sets the basic framework for the rest of the biblical narrative, this scientific "origins" story helps frame one's understanding of theology and science.

Unwilling to be persuaded by the evidence of Galileo's telescopes, the Catholic Church forced him to recant under threat of torture and then sentenced him to house arrest. Newton too became a figure in this drama, with many classic histories of science portraying him as a "foe of irrationality" and superstition who believed that God was more Clockmaker than providential overseer.[2] Those who acknowledge Newton's extensive theological and alchemical pursuits do not see them as having a significant impact on his physics, which is why many libraries ignored his theological writings when they came on the market in the middle of the twentieth century.[3]

Fortunately for those who are both Christians and scientists, this conflict story is almost completely wrong. A large body of scholarship in the history of science over the last three decades has revealed the supportive role that Christianity played in the emergence of science. We give here some of the reasons why the conflict story is false and encourage you to supplement our brief account with books listed in the "For Further Reading" section at the end of the book.

PROBLEMS WITH THE TRIUMPHALIST STORY

One problem with the triumphalist story is its simplistic recounting of the history of science. It concentrates on the great heroes, such as Copernicus, Kepler, Galileo and Newton, because it assumes physics is the most fundamental science. But there are other valid ways to understand the changes of this period—particularly the experimental techniques that emerged out of the magical tradition—that do not support the same science-versus-Christianity storyline. The complexity of the developments of this period should make one suspicious of any simple stories about the emergence of science and its relationship to Christianity. A key lesson of recent history of science is that these stories reflect more the assumptions of those who tell them than the historical record.[4]

Another problem with triumphalism is the number of Christians who played a key role in the beginnings of science. As the historian John Henry remarks, "Whatever the tensions between religious institutions and science, it is a matter of historical fact that many, if not all, of the leading natural philosophers of the Scientific Revolution were devout believers."[5] Nicolaus Copernicus, Johannes Kepler, Galileo Galilei, Robert Boyle, Antony van Leeuwenhoek, William Harvey, Pierre Gassendi, Andreas Vesalius and even Isaac Newton (though he didn't believe in the doctrine of the Trinity) were devout Christians.

TRIUMPHALIST SCIENCE

In the minds of many scientists and non-scientists, Christianity and science have obviously struggled with each other since the start of the Scientific Revolution, traditionally dated to the publication of Copernicus's heliocentric model in the sixteenth century. This conflict story depends on what we might call the *triumphalist* image of science. On this account, science is the triumph of human rationality over other types of knowledge. This approach typically stresses the role of the scientific method as a remedy for human ignorance, holding that we should put little confidence in beliefs that cannot be verified using this method. While science may not yet know everything, science is said to be a straightforwardly objective body of knowledge.

Also central to this story is the idea that the Scientific Revolution represents a decisive break from the superstitious beliefs of the Middle Ages, the time when theologians ruled. The key emphasis of the traditional story is the rise of a new view of physics that replaced Aristotelian cosmology with a mechanical view of nature, which reached its completion in the work of Isaac Newton. Newton's theory, it is said, pictured nature as a machine, meaning matter blindly follows the laws of cause and effect.

> For all the sterling work produced by a generation of historians dismantling with forensic precision the presumptive conflict between science and religion . . . their work has made scarcely a dent on leading scientific spokesmen, never mind popular consciousness.
>
> David Livingstone, *Science and Religion*

Continuing the traditional story, the displacement of Christianity by science is directly tied to the mechanistic image of nature. The mechanistic worldview supposedly gave nature a new authority to resolve disputes, thus freeing humanity from the dogmatic and oppressive rule of the clergy. Rather than looking to religious opinion, people could now let nature arbitrate between facts and opinion. The church, threatened by the growing power of science, reacted with a vengeance, seen most clearly in the trial of Galileo.

> The close relationship between natural philosophy and theology is evident in almost every area of inquiry about the natural world during the Scientific Revolution.
>
> Margaret Osler, "Myth 10"

More crucial for science, however, was the way scientists' Christian identity shaped their engagement with the natural world. Here are a few examples of the way theological assumptions influenced the development of science. Francis Bacon provided an important theological rationale for the study of nature by arguing that it would lead to an increased appreciation of God's power and glory. Science should be judged by the "good fruits" it produced, as Scripture commanded of the believer.[6] Christian presuppositions can also be detected in the advocacy of experimental approaches to natural knowledge, where persons such as Bacon and Boyle argued that the effects of original sin required a cautious, experimental approach. Instead of speculating about general principles of nature, as philosophers tended to do, it would be far more helpful to focus on what happened during particular experiments.[7] Finally, the Protestant Reformation ushered in a central emphasis on the "literal" meaning of the biblical text, which was carried over to the reading of God's other book: nature.[8] The Protestant way of reading the Bible encouraged a break with premodern natural philosophy by encouraging nonsymbolic interpretations of objects in nature. Christian assumptions about God and nature helped lay the foundations for the emergence of science, which, at least for some historians, explains why modern science began in European culture.

Christian assumptions about nature explain why the new mechanistic philosophy of nature was not widely seen as anti-Christian. In the upheaval of post-Reformation Europe, theologians became increasingly worried about the danger of skepticism or, even worse, atheism. For thinkers such as Gassendi and Boyle, the mechanical philosophy provided a

satisfactory defense for God's existence. While this is surprising—because modern expectations closely associate reductionism and atheism—"the paradox is that among those seventeenth-century scholars who did most to usher in the mechanical metaphors were those who felt that, in so doing, they were enriching rather than emasculating conceptions of divine activity."[9] According to Gassendi, the proof of God's existence is an empirical inference from the nature of matter. Because matter is inert, it does not have the ability for self-motion, much less to organize in the complex ways displayed in the natural world. Thus Christians helped to introduce and encourage a mechanistic approach to nature, a philosophy of nature that was only seen as problematic for Christianity centuries later.

From a historian's perspective, the Galileo affair turns out not to be the clear-cut Christianity-versus-science story that is often depicted. For one reason, the trial of Galileo had more to do with his ability to alienate and embarrass supporters: the pope had encouraged Galileo's publication of *Dialogue Concerning the Two Chief World Systems*, but Galileo chose to put the pope's position in the mouth of Simplicio (i.e., Simpleton), the foolish defender of geocentric cosmology. Moreover, the Church was defending the scientific consensus of the day against Galileo—some of whose own arguments for a heliocentric universe, such as the claim that tides were caused by the earth's movement, were not correct. This is not to absolve the Church authorities of mistakes—especially judged from modern standards—but it is to say that added context changes our interpretation of the event.

> The Roman Catholic Church gave more financial and social support to the study of astronomy for over six centuries, from the recovery of ancient learning during the late Middle Ages into the Enlightenment, than any other, and, probably, all other institutions.
>
> Neil Heilbron. *The Sun in the Church*

Recent historians have also shown why Newton cannot fit in the conflict narrative. By no longer focusing exclusively on his natural philosophy and mathematics, a new generation of Newton scholars have explored the "other Newton," the person who wrote more than four million words on theology and one million on alchemy. By only focusing on his scientific works, we get a limited picture of his thinking. To make this point Richard Popkin has argued, partly tongue in cheek, that the question is not "why one of the world's greatest scientists should have spent so much time thinking and writing about religious matters," but "why did one of the greatest anti-Trinitarian theologians of the seventeenth century take time off to write works on natural science, like the *Principia Mathematica*?"[10] Some of Newton's theology was unorthodox, to be sure, but he was no Enlightenment rationalist. From Newton's intense interest in biblical prophecy to his studies of alchemy and celestial mechanics, it was his interest in how God acts in the world that gave Newton's activities a coherence that interpreters often overlook when focusing on his scientific work to the exclusion of everything else.

To conclude this subsection, Christianity and science have had a long and fruitful history, which is what you might expect given the prevalence of the "God's two books" metaphor in Christian theology. As the historian Peter Harrison argues, the "study of the historical relations between science and religion does not reveal any simple pattern at all. In so far as there is any general trend, it is that for much of the time religion has facilitated scientific endeavour and has done so in various ways."[11]

TWO VISIONS OF SCIENCE

If science and Christianity have historically had a close relationship, how did we get to our contemporary situation, where science is seen as a secular enterprise? Two related changes occurred at the end of the nineteenth century that would have important ramifications for the relationship of science and Christianity. The first is that science became professionalized, meaning standards were implemented that could distinguish scientists from amateurs.[12] Up until this period, science was often undertaken by "gentlemen" or clergy—in other words, those with sufficient leisure time and resources to pursue their investigations—because scientific research was not a part of the educational mission of colleges. The second change was the establishment of methodological naturalism as the standard for scientific debates, meaning scientists increasingly avoided invoking the supernatural as an explanation for phenomena within the natural world.[13]

> It is not the greatest of modern scientists who feel most sure that the object, stripped of its qualitative properties and reduced to mere quantity, is wholly real. Little scientists, and little unscientific followers of science, may think so. The great minds know very well that the object, so treated, is an artificial abstraction, that something of its reality has been lost.
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> C. S. Lewis, *Abolition of Man*

Methodological naturalism is controversial among Christians, but it need not threaten Christian belief, as illustrated by the countless number of scientists who have practiced their faith over the past 150 years. While methodological naturalism does limit the scope of scientific explanations, it also means that there are many aspects of our world that lie beyond the reach of science. As an analogy, we might say that scientists are naturalists in the same way that car mechanics are. No one finds it philosophically troubling when your mechanic searches for a naturalistic explanation for the odd noise coming from the engine. In the same way, we look to scientists for answers about how natural systems normally operate.

Nevertheless, for advocates of the triumphalist account of science recounted above, methodological naturalism does not go far enough. For them, the essence of science is a commitment to a fully naturalistic account of the world, a position often called *scientific naturalism* or *scientism*. Scientific naturalism leads many scientists to postulate naturalistic accounts of subjects where we still do not have a good scientific model of what is happening. For example, they might argue that those things humans find most significant in the world—such as the love of our parents or children—are nothing but blind chemical reactions in the brain. On this view, the essence of science is a commitment to a naturalistic story coupled with the ambition to offer a micromechanical explanation for everything.

The problem with scientific naturalism, however, is that it loses its accountability to experimental data, which is the essential element of scientific inquiry. Scientific naturalism is self-defeating because it explains away the conscious awareness, reasoning and values that motivate scientific inquiry in the first place. As physicist and priest John Polkinghorne argues, the fundamental lesson of science is that reality is abundantly more surprising than we are able to imagine, and so we should recognize the inherent limits on our ability to rationally deduce the way things must be.[14] We should thus not put too much stock in the meta-theories that scientific naturalists tell us about the world and ourselves. For Christians, science can help inform one's worldview, but it should not become an all-encompassing worldview because it offers only one window into a complex reality.[15] Christians should see the eternal picture to which science lacks access. We will say more about this in upcoming chapters.

3

SCIENCE AND ETHICS

I think you are right in speaking of the moral foundations of science; but you cannot turn it around and speak of the scientific foundations of morality.

Albert Einstein

THE FIRST AND SECOND CHAPTERS offered theological and historical defenses of why Christians should study science. This chapter argues that Christians need to be involved in science for ethical reasons. Modern science is too big and powerful—both in terms of the resources it requires and the outputs it produces—for Christians to leave scientific research to others. Examples of ethical dilemmas raised by science are everywhere—from weaponry to genetic alteration to the attempt to create artificial life forms. But the ethical questions are not reserved for a special few research topics: we argue here that science itself should be seen as an ethical activity. Understanding the ethical nature of scientific inquiry is an important step in seeing how one's Christian faith and one's scientific career relate to each other.

Before arguing for the ethical nature of science, we will first argue for the "moral ordinariness" of scientists themselves. In other words, scientists as a group are not superior to their fellow citizens. Strange as it may sound to some, this has actually been a topic of debate in the history of science.

THE VIRTUOUS SCIENTIST?

There is a long history of people claiming that scientists are ethically superior to their fellow citizens. During the Scientific Revolution this was often attributed to the theological nature of science, based on the belief that nature was a book written by God. In 1775, the English chemist Joseph Priestley wrote of the scientist: "Contemplation of the works of God should give sublimity to his virtue, should expand his benevolence, extinguish every thing mean, base, and selfish in [his] nature."[1] Just as studying Scripture should improve the moral outlook of its interpreters, so the same principle holds with the study of nature.

Over time a secular reason for scientific virtue became more common: scientists were virtuous because of their possession of the scientific method. On this view, the scientific method was unique in its ability to instill intellectual honesty. It is the scientist who truly understands the limits of human reason—by combating his or her own inclination to impose false interpretations onto nature—and thus can stand against useless speculation and superstition. For instance, French physiologist Claude Bernard argued, "The experimenter's mind differs from the metaphysician's or the scholastic's in its modesty because experiment makes him, moment by moment, conscious of both his relative and absolute ignorance. In teaching man, experimental science results in lessening his pride more and more."[2] This theme of scientific modesty is evident in the work of a popular philosopher of science in the twentieth century, Karl Popper. For Popper, a natural scientist can never profess with certainty the truth of a theory because no amount of positive evidence can prove it. What separates science from other disciplines is its complete and utter commitment to rooting out error. As one recent historian describes Popper's position, "The scientist becomes the only truly intellectually honest person, for only the scientist is so concerned for truth that he works on the assumption that his own theories are false."[3] The scientific method, it would seem, produces knowledge and ignorance at the same time.

As we discuss in chapter five, we think Popper's account of science only partially matches how scientific communities work. But in any case, there are good reasons to be skeptical of the idea that scientists are more immune to human frailties than the rest of society. As the famous sociologist Robert Merton argued in 1942, there is "no satisfactory evidence" that scientists are "recruited from the ranks of those who exhibit an unusual degree of moral integrity."[4] From a Christian perspective, the study of nature can be edifying for Christians, but there is little reason to think it, on its own, can instill the fruits of the Holy Spirit. The true significance of nature will not be obvious to those who lack the "eyes to see," thus blocking any moral benefit.

> By the end of the eighteenth century a new possibility for the character of the man of science had begun to open up, although the full development of that character was not to occur for many years. The man of science might be conceived of as someone who was neither particularly godly, nor particularly virtuous, nor particularly polite. It could be considered that there was nothing very special about the sorts of people drawn to the study of the natural world, nor anything very special about the effects on character wrought by the study of the natural world.
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> Steven Shapin, *The Image of the Man of Science*

In retrospect, the persistence of claims made for scientific virtue was tied to building the reputation of science.[5] While the image of the virtuous scientists began because of the Christian context in which science started, it persisted because it helped create trust in scientists. The public is often not able to verify the results or potential of scientific research, so they must determine whether scientists are trustworthy and worthy of investment. Stories about the scientific method help give the public a sense of confidence in scientific research.

The moral ordinariness of scientists does not mean that they are to be especially distrusted when compared to other groups. Our society tends to see scientists in either/or terms. Either they are especially trustworthy, playing the role of priests who can produce sacred truths for a secular society, or they are a corrupt institution because they are beholden to political pressures.[6] A better view, as the sociologist Harry Collins has explained, is to see scientists in a middle-ground category; scientists are merely experts, and as such "should be accorded all the attention and respect we give other experts in our society like potters, carpenters, real estate agents, and plumbers."[7] The main reason we trust experts is that they participate in communities that evaluate their actions. Just as an electrician must put in many hours of training and study to gain a license to work, we trust scientists because they have undergone years of training and have been judged by their peers to be qualified. More importantly, if they violate the norms that govern scientific activity—for example, by publishing incorrect data—then they can be expelled from the community. We trust individual scientists because they are part of an institution that requires members to justify their assertions to each other using rationality and standards of evidence.

FACTS AND VALUES

We now return to the topic raised at the beginning of the chapter: the ethical nature of science. At some point, practicing scientists will likely encounter what is called the fact/value distinction.[8] The fact/value distinction holds that values—what one judges as being worthy of being promoted or advanced—are human projections imposed on nature, not inherent within nature itself. Consequently, the scientist can only tell you what the world is like, not, from a scientific perspective, what the world should be like. From this perspective, one should distinguish between descriptive statements that reflect the world and normative statements that reflect human desires. If our descriptions of nature include no moral premises, then we can draw no moral conclusions.

> Of all signs there is none more certain or more noble than that taken from fruits. . . . Wherefore, as in religion we are warned to show our faith by works, so in [natural] philosophy by the same rule the system should be judged of by its fruits, and pronounced frivolous if it be barren.
>
> Francis Bacon, *The New Organon*

At first glance, this distinction seems pretty reasonable. Not only does it reflect a popular view of the natural world as indifferent to human desires, but it also sets up a

division of labor. Scientists provide the facts and society decides what should be done as a consequence. Nevertheless, the fact/value distinction is not a helpful way of understanding how a scientist does science. While in theory there may be good reasons to defend the fact/value distinction as a way to promote truth, in practice it is not an accurate way to describe scientific inquiry. It problematically suggests that scientists on a day-to-day basis offer a straightforward, perspective-free account of reality. As long as scientists are doing normal research, questions of ethics or politics do not pertain to their work. But even if it is possible in principle to have a value-free description of an objective reality, scientific theories cannot be value free because of the way humans reason about the world.

For one reason, scientific theories are always simplifications of reality, otherwise they would get too unwieldy to be useful. Thus what scientists seek about the world is not just truth—there are too many truths in the world to catalog them all—but significant truths, truths important from a human perspective.[9] The simplification is easily seen when scientists draw broader conclusions about the state of their field and "science" overall, for they must choose which subset of evidence to represent. When scientists tell these larger narratives, even when accurately presenting the scientific facts, one can always question whether their values have unduly influenced their presentation. Given the vast amount of scientific research, why include these facts and why leave others out? Many of the debates of the last century in science—the role played by our genes, the directedness of evolution, whether nature is deterministic—are helpfully analyzed against the large cultural values presumed by the particular scientist.

This is not to say that science is merely a projection of our values—empirical science can indeed make progress in dismissing hypotheses because they are unsupported. It is to say, however, that multiple ways of reading the significance of the empirical data are always possible, and values cannot be eliminated from those interpretations. Our values function as auxiliary hypotheses, indirectly influencing the beliefs formed about our direct experience. With no way to talk about the world without at the same time theorizing it from a particular viewpoint, we cannot neatly separate facts and values in our minds. Scientists should not be seen as computers following the algorithm of the scientific method, but as detectives who attempt to make good decisions about which leads are most promising. Decisions about which theories are best supported depend on expert judgment, which cannot be walled off in one's mind from ethical, metaphysical and cultural assumptions.

the tremendous power and moral responsibility of those who fund science, the fact/value distinction can be dangerous because it allows the choices of big companies and politicians to remain hidden behind a cloak of neutrality.[11]

The era of big science has consequences for Christians who wish to conduct themselves with integrity in their scientific profession. The very existence of some laboratories makes evident the often complex entanglement of facts and values in the day-to-day world of science. Many types of scientific research are too expensive to carry out alone, requiring one to enlist the support of an institution, whether a government, university or private company. Such funding sources can be a wonderful opportunity to expand one's own research program, but they also can make researchers feel pressure—explicitly or implicitly—to slant one's focus or the interpretation of results in ways that are favorable to the sponsoring institutions. Or at the very least, it can make researchers feel powerless to protest unjust or unethical decisions for fear of losing funding. In science as in other professions, there will be opportunities for courageous moral decisions that demonstrate one's commitment to Christ and his kingdom.

CONCLUSION

We conclude by drawing our discussions of scientific virtue and the fact/value distinction together. On the one hand, scientists should be recognized as experts because their technical expertise is needed in order to accurately size up some of the problems facing modern societies. It is hard to know what to do about climate change, for example, without understanding the accuracy and reliability of different types of evidence for it. And yet scientists are morally ordinary persons, meaning that once they have offered their technical opinions, they have no special ethical or political expertise about how best to solve the problems they identify. As the physicist Ralph Lapp argued in the 1960s: "Scientists as a group probably have no better sense of human values than any other group. To say that science seeks the truth does not endow scientists as a group with special wisdom of what is good for society."[12] This is not to say that scientists cannot offer good solutions to certain problems, only that they should not have a monopoly on policy decisions.

> Knowledge is not one-dimensional. It is not arrived at by one strategy or method. The methods of natural science, while uniquely powerful in their chosen domain, are not applicable to much of the knowledge we know.
>
> Ian Hutchinson, *Monopolizing Knowledge*

Moreover, scientists cannot escape the consequences of their research by appealing to a value-free ideal of science because each step along the path of scientific inquiry involves actions that can be ethically evaluated. Whether for applications that are seen as morally suspect (e.g., weapons research), as praiseworthy (e.g., many types of medical research) or, more likely, as neither (e.g., research into the chemical composition of stars), the acquiring of new knowledge requires the researchers to shape and be shaped by the world around them. Even when a research topic has no obvious ethical implications, scientific inquiry can be evaluated based on the research paths not taken. Since the search space that the sciences attempt to map is so vast, what questions will we attempt to answer using our finite resources? The paths scientists choose to explore and what money agencies choose to invest are expressions of what they value. Scientific activity should always be accountable to the public, not only for the consequences of the research, but also for the research problems being investigated.

The importance of values in scientific inquiry is heightened when we recognize that the structure of scientific inquiry has changed over the past century. We now live in the era of "big science." The majority of science since World War II has been funded by large companies or national governments, a shift encouraged by the Cold War. President Dwight Eisenhower noted this in his farewell address to the nation: "Today, the solitary inventor, tinkering in his shop, has been overshadowed by task forces of scientists in laboratories and testing fields. . . . The prospect of domination of the nation's scholars by Federal employment, project allocations, and the power of money is ever present—and is gravely to be regarded."[10] Eisenhower was wary of the transformation of science because governments and corporations are often interested in projects that maximize profits or destruction, shaping scientific development in ways that do not always benefit society. In light of

> The natural understanding of the value-laden character of our world is that there is a supreme Source of Value whose nature is reflected in all that is held in being. Otherwise the pervasive presence of value is hard to understand.
>
> John Polkinghorne, *Belief in God in an Age of Science*

An advocate of the fact/value distinction would at this point recommend that the scientist stick only to the facts and leave everything else to society. The problem with this position, as described above, is the fact/value distinction offers a misleading picture of scientific judgment, which allows values to sneak in without our being aware of them. It is far better to recognize our values than to pretend they do not exist.

Rather than denying the role of values in science, we should ask instead whether any particular scientific analysis has been abnormally skewed by someone's values. The way to determine bias is by having one's scientific work evaluated by other scientists to see what theories generate consensus. Scientific consensus is not infallible; we can think of many stories of famous scientists who disagreed with their peers and were ultimately proven correct. But even in these cases, the scientists are remembered because the scientific community eventually came around to see the merit of their theories.

If scientific consensus is going to be relied on as an indicator of scientific truth, then the scientific community needs to be a broad and diverse community, instead of consisting of one particular culture or perspective. Just as we are more likely to trust a government policy decision crafted by representatives of different constituencies, so too we are more likely to trust a scientific conclusion if it is backed by scientists from various backgrounds. As we will discuss more in later chapters, if Christians abandon science for fear of anti-Christian bias in scientific research, it only ensures that no Christians will be left to evaluate claims made in the name of science.

Once the role of values is recognized in science, it becomes easier to see how one's faith can impact one's scientific career. Christians are free to pursue outcomes that align with their convictions: alleviation of suffering, cherishing of life and stewardship of the earth, for example. And Christians can object to scientific research that runs counter to

these goals. In other words, one's scientific career can be motivated by the same Christian beliefs that guided our predecessors in the Scientific Revolution.