

The Mutuality of Theology and Science: An Example from Time and Thermodynamics

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A major intellectual issue facing Christians in the university is the relationship between Christian faith and our academic commitments. The natural and social sciences, in particular, can be places where our theological commitments seem out of place. Can a Christian be a good sociologist or biologist without splitting her mind into two boxes? While we often hear of the integration of faith and learning, there is plenty of room for further careful discussion of the proper relationship between faith and rational knowledge. In this paper I will discuss the relationship between theology and the sciences. I hope to persuade you that it is possible to integrate both in a broad Christian worldview, and will explore the example of thermodynamics and the Christian view of time (or history) as one illustration of the dialogue between theology and science. In particular, I will argue that a two-way dialogue can and should take place between theology and the sciences in the process of developing a Christian worldview. In pursuing this conclusion we will canvass the nature of explanation, and levels of explanation in theology and the sciences. I shall conclude that large-scale explanations of reality are the place where theology and the sciences can best be integrated.

On what basis can theology claim to have anything in common with the sciences? To start with, theology is a kind of “science,” a *scientia* whose goal is true wisdom about God and humanity. Yet while theology is a rigorous and scholarly activity yielding knowledge, it is not a purely academic exercise. Theology arises out of religious faith, and seeks to meet the needs of the human heart. Theology seeks wisdom about how we can live happily and well in the world, but such wisdom is also grounded in the truth about ultimate concerns. As physicist, priest, and theologian John Polkinghorne argues in many books, there is only one world.^[1] Both the theologian and the scientist are concerned about the truth concerning that one world. What is real? What is true? How do things work? How can we understand ourselves and the world? These are the kind of larger questions about reality around which theology and the sciences can build a dialogue.

Do Theology and Science Conflict?

For too long in the modern period, theology and the special sciences (that is, the natural and social sciences) were seen to be at war with one another. This perspective, called the “conflict model” by Ian Barbour,^[2] dominated the thinking of Enlightenment rationalists. These over-confident believers in the triumph of science accepted the general “cult of progress” found in Western culture from the early modern period until the World Wars. A good example of one such true believer in scientific “progress” was Andrew D. White (1832-1918), the first president of Cornell University. Cornell was the first private university founded in this country on purely secular principles, the implicit judgment being that religious

^[1]1 *One World* (London: SPCK, 1986), *Science and Creation* (London: SPCK, 1988), *Science and Providence* (London: SPCK, 1989), *Reason and Religion* (London: SPCK, 1991).

^[2]2 Ian Barbour, *Religion in an Age of Science* (San Francisco: Harper, 1990), 4.

bias warps the quest for scientific truth. Andrew White helped make the conflict model popular in his work, A History of the Warfare of Science with Theology (1896). In the minds of “enlightened” and truly “scientific” thinkers (as they thought of themselves) religion too often resulted in an unnecessary bias that presented a definite obstacle to scientific progress.

Alas, this warfare model (with science the ultimate victor) is not a relic of the past. Numerous contemporary publications still advocate such a position, working from either a secular humanist or a scientific materialist perspective. A striking example is the recent article by Norman and Lucia Hall, "Is the War between Science and Religion Over?" which appeared in The Humanist. The Halls insist that.^{3[3]}

While it may appear open-minded, modest, and comforting to many, this conciliatory view [that seeks harmony between religion and science] is nonsense. Science and religion are diametrically opposed at their deepest philosophical levels. And, because the two worldviews make claims to the same intellectual territory -- that of the origin of the universe and humankind's relationship to it -- conflict is inevitable.

I shall argue that this perspective is completely mistaken. Science and religion are not diametrically opposed, as the Halls state. The article by the Halls unfortunately perpetuates the usual errors made in popular works by scientific materialists. In particular, they continue to confuse “Science” (capital S!) with their own philosophy or worldview. They need to reflect on the fact that science is not a worldview. Natural science yields facts and theories about creation: but facts and theories alone do not constitute a worldview. The worldview of the Halls is scientific materialism or naturalism. It is this materialistic worldview -- not the teachings of science, but a secular philosophy -- that is deeply in conflict with religion. The ideals and teachings of modern science are in fact compatible with many worldviews, including Christianity, as I shall argue.

The warfare model misunderstands the character of both theology and science. Science simply cannot answer the questions that are addressed in religion, nor can religion hope to answer merely scientific questions from its basis of faith. Religion answers questions about ultimate concerns and spiritual or moral conundrums. The special sciences are concerned with factual issues concerning the natural and human world. There is some overlap, of course, but there should be no ultimate conflict.

While it is certainly true that prejudice, in the guise of religious faith, has opposed scientific advance, the warfare model overlooks the important contributions that theology has made to science, especially at the level of presuppositions and worldview. The warfare model ignores the historical fact that there would not be any such thing as modern Western science if it were not for the intellectual influence of the Christian faith. In his Lowell Lectures, Alfred North Whitehead notes the contributions of theology to the development of science in our cultural history.^{4[4]} Christian theology has provided the intellectual environment out of which natural science was able to develop. By founding a worldview in which reason and order were understood to be built into the world by a rational God, theology created the intellectual nursery in which early modern science was born and raised. The history of science contains many examples which support this conclusion. Just in physics alone, Copernicus, Kepler, Newton, and James Clerk Maxwell were all influenced in their understanding of the rationality of Creation by the Christian worldview. Of course, to suggest that Christianity alone is responsible for the rise of early modern science, or that science could not have arisen without Christian faith, is too simplistic an hypothesis. Many factors were involved, but belief in a rational and mathematical Creator was certainly central. To explore the soundness of this historical conclusion concerning the helpfulness of theology to science, let us consider more fully the example of Galileo, the man adherents of the warfare model quite often refer to.

Galileo Galilei (1564-1642) was a brilliant scientist whose work has influenced human culture and fundamentally shaped our understanding of the world. He made significant advances in many areas of natural science, and is justly famous for his work in physics and astronomy. His major methodological

3[3] Norman F. and Lucia Hall, "Is the War between Science and Religion Over?", The Humanist 46/3 (May-June, 1986), 26.

^{4[4]} Whitehead, Science and the Modern World (New York; Macmillan, 1925), chapt. 1. Many other scholars have argued this same point, although some are marred by apologetic certainty that science could only have arisen in a theistic environment (e.g., S. Jaki, The Road of Science and the Ways to God [Chicago: University of Chicago Press, 1978]).

contributions to the founding of modern science were his careful experimental method, and his insistence on the mathematical form of natural philosophy. While others engaged in mathematical work and in various kinds of experimentation, "before Galileo, the systematic appeal to experience in support of mathematical laws seems to have been lacking."^{5[5]} It is to Galileo, then, that we trace the scientific method of mathematical models supported and tested by experimental data.

It is certainly true that Galileo's work was opposed by Christian thinkers in his own day, and especially by conservative factions in the Roman Catholic Church. However, often overlooked is the fact that Galileo, like Kepler and Newton, was a Christian thinker who understood himself to be a "Catholic astronomer."^{6[6]} As physicist and theologian Stanley Jaki notes: "Little if any effort is made, for instance, to recall the role played in Galileo's scientific methodology by his repeated endorsements of the naturalness of perceiving the existence of God from the study of the book of nature."^{7[7]}

The influence of the Christian worldview on Galileo is clear from his most influential work, Dialogue Concerning the Two Chief World Systems (1632). Also significant are his several remarks on the relationship between theology and science, most importantly his Letter to the Grand Duchess Christina (1615).

For Galileo, both the great "book" of Nature and the book of Scripture equally reveal the greatness of God. Mathematical models and laws govern the physical universe because it is created by God. In turn, we can discover these laws through empirical research:

I think that in the discussion of physical problems we ought to begin not from the authority of scriptural passages, but from sense-experience and necessary [i.e., mathematical] demonstrations; for the Holy Bible and the phenomena of nature proceed alike from the divine Word, the former as the dictate of the Holy Ghost and the latter as the observational executrix of God's commands.^{8[8]}

In our Western history, many factors worked together to aid in the development of natural science and technology. The Christian faith was one of these factors. From [\[AP1\]](#) Galileo we learn that theology and science are not enemies, but different ways to the truth of God.

Comment [AP1]:

What, then, do we understand the proper model of the relationship between theology and science to be? Our brief glance at Galileo would lead us in the direction of an open dialogue between theology and the sciences, in which Christian scholars seek to build a worldview which is consistent with both. Theology must take its factual and empirical basis from the best of contemporary science, but may offer a basis for correcting interpretations of science, or preferring one view over another within a scientific discipline. In a similar manner, science can be guided or brought into question by theological conclusions. Our quest thus becomes the search for the truth in both disciplines, in order to develop a coherent worldview that meets our religious needs and satisfies our scientific thirst for knowledge.

The Nature of Explanation

In order to develop this "mutuality model" of the relationship between science and theology, we must look more closely at the nature of explanation. Explanation is an important, even central, idea in the quest for knowledge and understanding. This in turn raises the question of the nature of explanation in science and theology. Such an approach to the theology-science dialogue will afford us the opportunity to explore theological explanation in contrast to other kinds. In this way we can develop a model of mutual learning and edification between theology and science, in the development of a coherent worldview. The process of this intellectual exploration will lead us to three conclusions: (1) theological explanation is similar to explanation in the natural and social sciences, in that it develops models for a causal explanation, positing certain entities, with certain natures, powers, and relationships. (2) Theology assumes the findings of other disciplines in its explanatory scheme, and as such the natural and social sciences influence theology. In the same way the findings of theology may send us back to the other disciplines to rethink the

5[5] S. Drake, Galileo Studies (Ann Arbor: University of Michigan Press, 1970), 44.

6[6] Galileo Galilei, Discoveries and Opinions of Galileo, tr. and ed. S. Drake (Garden City: Anchor Books, 1957), 168.

7[7] Jaki, 47.

8[8] Galileo, Discoveries, 182 (from the "Letter to the Grand Duchess Christina").

basis of our scientific conclusions, and change our mind. (3) A consideration of the nature of levels of explanations, or explanatory schemes (also called "paradigms"), leaves an open place for a two-way dialogue that can and should take place between theology and the other disciplines of the university.

First we need to reflect on just what an "explanation" is. Broadly conceived, an explanation is some answer to a "why?" question.^{9[9]} But more narrowly understood, explanations tell us why the world is the way it is: why rivers run down hill, why clocks run slower in the presence of greater gravity, why the tides rise and fall, why all the members of the orchestra arrived at roughly the same time and place for the performance, and so forth. It is this sort of "explanation" of why things are the way they are, and why things happen as they do, that we are now interested in.

These short remarks lead us to another question: what counts as knowledge or scientia in the sense of scientific explanation? In the tradition of Aristotle,^{10[10]} perhaps it is best to see a "cause" as some reason for being, and thus an explanation will be any answer to a question about why a thing is, or how it got to be that way, or why things happen as they do. Scientific explanations, then, are (in part) causal accounts answering our "why" questions. Yet not all scientific explanation is causal. Neither Newton's nor Einstein's laws for gravitation are causal, for example, because they stipulate the mathematical laws that govern gravitational interaction but do not tell us what causes gravitational attraction. Instead, various theories of quantum gravity are now being tested, and if confirmed they will tell us the causes. What the example of gravity indicates is this: explanation without a causal account is incomplete. Scientists will continue to seek a full scientific explanation, which will include a causal element in the explanatory theory. Not all scientific explanation is causal, but causation is an integral element in explanation in the sciences. This is, of course, not the only way to understand scientific explanation, but it is the most promising view, as well as the one in accord with common sense.^{11[11]}

Levels of Explanation in Science

In my view, dialogue between theology and the special sciences is best understood as taking place between different levels of explanation. But before we can even begin to discuss levels of explanation in the sciences, we must consider the case of reductionism, or "nothing-buttery" as the late Donald MacKay was fond of calling it.^{12[12]} The general position we come from is post-Enlightenment, or "postmodern," taking a holistic approach to our understanding of reality. Logical positivists and other modernists often held that things must be dissected, and reduced to their most simple parts, in order to be understood. A postenlightenment philosophy will insist that the whole is more than the sum of the parts.

Let us take a concrete example of this kind of reductionism in explanation. F. H. Allport, in his book Social Psychology, in discussing the group psychology of crowds, wrote that:

given the situation of the crowd -- that is, of a number of persons within stimulating distance of one another -- we shall find that the actions of all are nothing more than the sum of the actions of each taken separately.^{13[13]}

9[9] This is the view of Sylvian Bromberger, "Why Questions," in Mind and Cosmos, ed. R. G. Colodny (Pittsburgh: University of Pittsburgh).

^{10[10]} Metaphysics, book A.

^{11[11]} Those who reject the idea that causation is an integral aspect of scientific explanation do so, for the most part, because of the many philosophical problems with this concept. Some of the finest minds in Western philosophy have struggled with this difficult philosophical problem, and the related problem of induction. I believe that this problem has a solution, and I am working on a paper entitled, "The Myth of the Problem of Induction." In the meantime, readers may wish to consult R. G. Swinburne, ed., The Justification of Induction (New York: Oxford University Press, 1974) and esp. two fine books by D. C. Stove, Probability and Hume's Inductive Scepticism (Oxford: Clarendon Press), and The Rationality of Induction (Oxford: Clarendon Press, 1986).

^{12[12]} See Donald M. MacKay, The Clockwork Image (Downers Grove: InterVarsity Press, 1974), 30-38.

13[13] New York: Houghton Mifflin, 5, his italics.

Now clearly there is something correct here. The action of a crowd is, ontologically, the sum of the actions of each member. But reductionism of this sort ignores an important explanatory (that is, an epistemological) dimension: even if we can explain each person's act individually, what then escapes explanation is the larger question of why these individuals all act in a like manner, together, as a unit. What need an explanation, then, are the similarities of group action, and of group thinking. Such things cannot be explained by atomistic methods.

The history of physics has shows a great tendency toward reductionism and atomism in explanations. Yet even physics has been pushed into a more holistic frame of explanation in recent times. One example of this would be the physics of dynamical systems, or chaos theory -- another would be thermodynamics. Perhaps the best known example is Quantum Mechanics (QM). Even though Einstein contributed to the early development of this area of physics, he did not agree with the anti-deterministic interpretation it was being given. He developed a famous thought-experiment, known as the Einstein-Podolsky-Rosen paradox (EPR), to show the counter-intuitive nature of QM. Recently, the EPR result has been given experimental verification, and the thought experiment has actually been performed in a lab. The entire discussion is rather complex, but it seems that sub-atomic particles can communicate with each other as a holistic system, even when such signals are forbidden by the Special Theory of Relativity when we consider each particle independently. The EPR result has caused us to give up "Einstein locality" for sub-atomic systems, and to treat them in a holistic way.

Biology and psychology, as well, are disciplines which raise the issue of levels of explanatory schemes most clearly.^{14[14]} The activities of living organisms can be "explained" from a variety of different perspectives. Why animals eat, for example, could be approached from a physical, chemical/thermodynamic, biological, or psychological scheme. It is not clear that any one of these points of view would necessarily be the correct one. They are all equally valid in terms of their own discipline. A physical scientist might focus on the chemical, especially the molecular, need for energy. This in turn could lead to an explanation of the living organism in terms of a thermodynamic system. A biologist might focus her explanation on the biological organism as a whole, and its relations to other living things in the ecosystem. Yet again, an animal psychologist would assume the truth of these other explanations, using them as assumptions to discuss the complex interactions between the individual, the group, other competitive species, and the natural environment in the description of eating habits of a particular species (say, spider monkeys), in particular environments (say, a given forest).

Once we grant that there are different sorts of schemes for explaining the same thing, and they do not reduce to each other, this raises the question of their inter-relationship. Since the sort of explanation we have in mind is causal, these schemes postulate certain causal relationships that hold between things. They develop models for the nature and powers of the things involved, their regular causal relations, laws describing the regularities in these relations, and general theories. What happens, it seems, is that some levels are more fundamental than others in the following sense: the accepted results of the scheme at the more fundamental level is used, and assumed, in the next level up. So particle physics is assumed in thermodynamics, and psychology and sociology are assumed in history.

It is also possible, although not as common as one might like, for there to be a two-way dialogue between levels of explanatory schemes. A good example of this is the case of gravity: the occurrence of gravitational force at one level has lead physicist to look for gravity waves, or gravitons, at a lower level. Particle physics has also learned a great deal from solid-state physics (especially the phenomenon of superconductivity) even though particle physicists in the past have been known to disdain their "squalid-state" siblings. Another interesting example is "chaos" or dynamical systems theory: a view which developed in meteorology (a higher-level physical science) but has great implications for other levels of physical, as well as biological, science.

Dialogue between levels is based not only on the fact that the more fundamental level is assumed in the higher, but also on the fact that findings in the higher levels can cause us to turn back to the more fundamental levels to re-think our results and assumptions. Chaos theory is an excellent example of this

^{14[14]} See also Arthur Peacocke, Creation and the World of Science (Oxford: Clarendon Press, 1979), but his understanding of these levels sometime conflates levels of being (scientific ontology) with levels of explanation (epistemology).

from recent science. The gravamen of this essay is, the same sort of thing is possible in the theology-science dialogue.

The social sciences use causal explanations, but of course they also use other types of understanding. The general confusion as to the nature of understanding in the social sciences is in part the result of there being three types of understanding at work in the social sciences: (1) ordinary causal explanations based on natural sciences; (2) socio-psychological causal explanations, based on social and psychological forces, conventions, and complex background influences (this area deals with a quite different kind of causal "power" from the first) and (3) a hermeneutical concern for interpretation or understanding, for example, in sociology or history.^{15[15]} It is quite important for the kinds of understanding found in (2) and (3) that we deal with human beliefs, intentions, desires, drives, and the like (both for individuals and for collectives) and not merely with physical causal structures. We cannot possibly consider all the issues here, even briefly. The main point is that, while the social sciences involve more than simply causal explanation, causal explanation is an important element of social science which cannot be reduced to nor subsumed under "understanding" (#3 above).

The social sciences likewise illustrate the fact that whether one explanatory scheme is more fundamental than another is not always clear. The inter-relationship may be more complex than our simple "levels" model. In psychology and sociology, for example, neither one seems obviously "higher" than the other. Both disciplines use explanatory schemes which assume the results of the other. There can be a mutuality of interaction, then, one scheme acting as fundamental to the other scheme and/or discipline in some respects, but not in others.

Before considering the case of explanation in theology we should ponder what counts as explanation. What does a set of beliefs or ideas (the explanans) have to possess in order to "explain" some phenomena (the explanandum). The view of Carl Hempel, whose work is seminal in the field, is that the explanans is a type of argument, and must include a covering-law or law of nature. In this theory, the explanandum is deduced from the law, along with certain other facts such as initial conditions and observational sentences. However, this "received view" has come under serious philosophical attack. For the most part, this view confuses logical connections (in arguments) with the kind of physical or psycho-social connections that we are concerned with in the natural and social sciences. Further, many philosophers have pointed out that equally good deductions can be made from "explanans" that do not explain anything. For example, given a situation in which the morning sun is casting a shadow on a flag pole, we can "explain" the position of the sun, consistent with the received view, by the length of the shadow.

What is missing from the covering law view is a notion of causal connection. Those who were raised with logical positivism tend to have an allergy to metaphysics, even after logical positivism had been overturned. But explanations are always attached to some metaphysical commitments, as David-Hillel Ruben persuasively argues.^{16[16]} Causation is an ineliminable element of scientific explanation.

Many of the various theories of scientific explanation are, like Hempel's, empirical and predictive. On such theories, an explanation is a prediction of how events of that type will turn out. We use explanations, then, to manipulate the outcome of events. The best explanation is "empirically adequate", that is, explains past observed phenomena and allows the manipulation or prediction of future observed

^{15[15]} I would therefore reject the view of W. Pannenberg, Theology and the Philosophy of Science (Philadelphia: Westminster, 1976), and of his student P. Clayton, Explanation from Physics to Theology (New Haven: Yale University Press, 1989), that the social and natural sciences are both hermeneutical, that both seek "coherence," and that these considerations alone serve to fully explicate scientific method. What such a view ignores is specifically the causal element I am emphasizing: an element which is quite different from the concern of "meaning" in hermeneutics. So it is not enough to simply state, as Stepehn Toulmin does (Foresight and Understanding [Bloomington: Indiana University Press, 1961], 81), that natural scientific explanation amounts to placing an event in a context in which it is intelligible. Such an opinion is correct but incomplete.

^{16[16]} Explaining Explanation (London: Routledge, 1990). Ruben also provides an extensive bibliography on this topic.

events.^{17[17]} We are not in fact committed, intellectually, to the acceptance of non-observable entities and relations posited in scientific theories. There are problems with such views. An emphasis on prediction and experiment seems adequate for some types of science, but in many cases explanations are given for events which are past (as in geology or paleontology or cosmology) or singular and unique (as in archeology or history or textual criticism). An explanation can tell us why a certain event occurred, even if it only happened once. An explanation does not have to be predictive.

With respect to the empiricism common in many circles: there is no reason, other than prejudice, to limit ontology to what humans can observe. This seems, in fact, to be rather anthropocentric. Reality is not limited to observable phenomena. Paleontologists posit the existence of non-observed animals, for example, to explain the fossil records. I, for one, believe in dinosaurs. The restriction of explanantia which deserve rational acceptance to observable (or observable-in-principle) things is artificial, and contrary to the actual history of science where previously "unobserved" things have in fact become observed (e.g. germs). The extreme empiricism of such views is an example of the futile attempt to avoid metaphysics in philosophy of science.

One last theory deserves mention: here scientific explanation is understood as any larger story or intellectual framework which "makes sense" of the explananda, or makes them intelligible. The problem here is that this view is too broad: it allows too many frameworks to pass as scientific explanations that are pseudo-scientific or even unreasonable (astrology, for example, or voodoo, or Velikovsky). The weakness of Pannenberg's excellent book, Theology and the Philosophy of Science, lies in his following this overly vague conception of scientific explanation.^{18[18]}

The basic problem with all of these theories can be found in two root issues: (1) the vain attempt to avoid induction in the philosophy of science, and/or (2) the equally bankrupt attempt to describe scientific explanation without recourse to causation. Covering laws, pragmatic usefulness, intelligibility, prediction: all these have a place in scientific explanation, but they are not the whole story, any more than causation is. The addition of induction and causation overcomes the inadequacies of the theories we have just been covering. This leaves us, then, with a view of explanation that is causal and inductive.

Theological Explanation

Is there something like "explanation" of this sort to be found in theology? There certainly are many types of explanation and understanding, as we have just seen. All scholars should agree with the idea that theology can explain things in some sense of the term "explain." Theology can explain why people act the way they do, for example, in the same way that any ideology can be utilized in a social scientific explanation. Theology can also explain the set of beliefs that one finds in a particular religion's tradition, without any commitment to the truth of those beliefs. Our entire discussion of levels of explanation, however, leads to the idea that theology does, or can, explain things in a causal way as well.^{19[19]}

Ludwig Wittgenstein and his followers have been pervasive in arguing that religion is not really any kind of explanation. Even if it is false, religion is not just a simple mistake. Surely this much is true: religion is not an explanation for something.^{20[20]} Religious belief is much more complex than that. Likewise, language is much more complex than the simple notion of conveying information. What also must be said, in the spirit of dialectics, is that language does after all convey information; and that there is an explanatory dimension to religious beliefs. A religious scheme such as astrology, for example, may not be a simple mistake, but it is still mistaken — is it not? Religious believers do recognize the impact of experience and reason upon their belief-systems, and do not always hold on to that system come what may.

^{17[17]} As, e.g., Bas van Fraassen argues in The Scientific Image (Oxford: Oxford University Press, 1980).

^{18[18]} Pannenberg, op. cit., 143-155. I find the same problem with the work of Clayton (op. cit.). Both attempt to subsume causal explanation under the banner of hermeneutical understanding -- a category mistake that results in a mistaken notion of what counts as theological explanation (Pannenberg, op. cit., 326-345).

^{19[19]} This point about causation in theological explanation is also made, in differing ways, by Swinburne, The Existence of God (Oxford: Clarendon Press, 1979) and E. L. Schoen, Religious Explanation (London: Routledge, 1985). Swinburne has been criticized for focusing too much on causal explanation by Rob Prevost, Probability and Theistic Explanation (Oxford: Clarendon Press, 1990).

^{20[20]} See, e.g., D. Z. Phillips, Religion Without Explanation (Oxford: Blackwell, 1976).

So Phillips and company misunderstand the nature of religious belief, when they deny it any explanatory dimension, even though they are correct in asserting that religion is not an explanation of something in the way that, say, Darwinian evolution is. Specifically, certain elements in religion, especially those collected in theologies, do explain elements in the world.

But even if some elements of religion or theology are explanatory, surely we are not looking for a causal explanation, are we? In seeking to answer this question, we turn again to the notion of levels of explanation.

Theology seeks to organize religious beliefs into a satisfactory world-view and explanatory scheme. There is a lot more to theology, of course: but theology does seek to know the truth, and also seeks explanations. As such, theology is concerned with the facts about God: other things are theologically important in their relationship with him.

Theological explanation is similar in some ways to the explanatory schemes of the natural and social sciences. Theology will develop models of the Ultimate Reality, its nature and powers, as well as models of other things in relationship to the divine (e.g., humans, the cosmos, the ecosystem). Theology seeks explanations, and as such it is devoted to the truth, as Pannenberg rightly argues. However, theology always takes place in a religious community. There is no generic theology, only Christian, Buddhist, Muslim theology: the theology of particular religions. Even natural theology occurs within a particular religious tradition. So these twin concerns, truth and community, define the horizon of the theologian. As Tillich wrote:

Theology moves back and forth between two poles, the eternal truth of its foundation and the temporal situation in which the eternal truth must be received.

. . . [F]or the church is the "home" of systematic theology. Here alone do the sources and the norms of theology have actual existence.^{21[21]}

Theological explanation involves causal explanation, but it is not the same kind of causation that one finds in the sciences, any more than sociology per se uses the causal notions found in the natural sciences. Theology can and does use both natural and social causal explanations. Theology can and does involve hermeneutical, ethical, and metaphysical issues from philosophy, and some of these indeed can be understood as a kind of "explanation" (we grant this much to Pannenberg and his followers). But in addition to these things, theology posits a unique God-world relationship (or Ultimate Reality-lifeworld relationship) on the basis of which it seeks uniquely theological explanatory schemes for certain elements of human existence, and certain elements of our knowledge of reality derived from extra-religious sources. Because theology understands God to be an agent, it explains some elements of reality on the basis of divine agency. For example, the Christian doctrine of original sin, if true, is explanatory of certain facts known to us through history, sociology and psychology. The doctrine of karma in Hinduism, likewise, is explanatory if true. Surely the divine does bring about certain facts about the world, if religious explanations are to be accepted as true. Of course, if they are merely interesting or pragmatically useful stories, then the study of religion is reduced to social science, and theological explanation per se cannot occur.

What Theology Learns from Science

If I am on track in my suggestions about the nature of theological explanation, then we need to consider again our view of the theological task. Theology is not merely an exercise in making sense of religious experience and beliefs in a particular community, as some would have us believe. Such an exercise is important, of course, but is really an aspect of the social sciences (witness the "religious studies" departments in most universities). Theology is not just about religious being-in-the world, although it includes that. Theology is about God, and about human beings in relationship to the divine. Theology does not seek to develop only pragmatically useful models, but also accurate models whose pragmatic usefulness is one criterion -- among others -- of their verisimilitude. Theology seeks the truth about the Transcendent, or more modestly, theology seeks adequate, reasonably accurate models and theological principles which

21[21] Paul Tillich, Systematic Theology, vol. I (Chicago: University of Chicago Press, 1951), 3, 48.

are reasonably held to be true. We do not merely seek pragmatically successful God-talk, but we seek to discover the truth about God.

What seems to have happened in American theological circles is this: the source of knowledge has been confused with the subject of that knowledge. This is actually a very easy mistake to fall into. It is surely true that what we know about the divine comes to us through the religious experiences of others and of our own. But this does not imply that the only subject of theology is religious experience. Scientific knowledge (say, in physics) is based upon ordinary human experience but it is not about ordinary human experience. Likewise the rational, explanatory element in religion (which we call theology) is not about religious experience, but about the source and subject of those experiences (God or Ultimate Reality). Theology is about God, too, and not just about the human.

In seeking the truth about the divine, theology needs the other arts and sciences. In developing its models, theories, principles, and postulated causal relationships, it assumes the results of the other disciplines. This would include such fields as philosophy, sociology, physics, history and aesthetics: in short, the whole of the university faculty. No wonder it's so difficult to be a theologian! Theologians do not require a comprehensive view of such fields, of course, any more than a botanist need be a particle physicist. Yet the results and views of these disciplines will shape our understanding of the nature of creation in its relation to the Creator. This is especially true of any large-scale explanations of reality that come from the special sciences. For example, behaviorism in psychology and determinism in philosophy have important theological implications.

What Science Learns from Theology

What is not as often acknowledged by those considering the dialogue between theology and science is that theology should influence, if we are rational, our beliefs in other fields. The special sciences can and should learn from theology, and not just the other way around. If on theological grounds we have good reason to affirm the Free Will Defense, say, then this should cause us to closely examine the evidence for behaviorism and determinism. If two or more theories in another discipline are currently of equal status with respect to their reasonableness, the religious believer is fully justified in choosing that view which is more in consonance with his theological world-view. This means that Peter Berger plays too much the role of "scientific positivist" when he writes:

Questions raised within the frame of an empirical discipline (and I would emphatically consider sociological theory to be within such a frame of reference) are not susceptible to answers coming out of the frame of reference of a non-empirical and normative discipline [i.e. theology], just as the reverse procedure is inadmissible. As such, the argument of this book stands or falls as an enterprise of sociological theorizing and, as such, is not amenable to either theological support or theological critique.^{22[22]}

Such a claim to hermetically seal-off the disciplines from each other is empirically false as an historical hypothesis, and methodologically unsound as a philosophy of science. There is some truth to Berger's pontification: theology, philosophy or ethics does not pretend to tell the scientist what he must believe in terms of his own discipline. The truth must be discovered in each science by the canons of acceptability found within each discipline. Dogmatics does not want to be dogmatic in the negative sense! All I am suggesting is that the results of a more fundamental discipline can be called into question by a higher-level explanatory scheme, and that this can then send us back to the other discipline to argue -- on the basis of accepted scientific evidence and methods within that discipline -- for a different conclusion. This is in fact what happens in sciences from time to time in any case.

Theological, philosophical and scientific evidence are all relevant to answering important worldview questions, and any attempt to hermetically seal-off these disciplines will lead to incoherence. Neither reality, nor human reason, can be so neatly sliced into pieces. For example, determinism is either true or false, and cannot be true "for science" but false "for religion." As realists (even as dialectical realists) we are committed to the unity of reality, and therefore to the unity of truth. There may well be times in which we cannot decide, given the complexity of a problem, what the truth is in a particular case. Scientific evidence and theological conclusions may lead in different directions, at least for the moment.

22[22] The Sacred Canopy (1967; Garden City: Anchor Books, 1990), 179.

Yet the conviction that they must be in harmony is grounded in the fact, long advocated by Christian tradition, that God is the creator of the Universe and the author of revelation. There is one God, one world, and one truth about that world.

Apart from specific conclusions and questions in which theology and science can reinforce each other, or (temporarily) conflict, what can science learn from theology? There are several theological conclusions that are important to the disciplines of the sciences. For example, God is the creator of the world, and She is both rational and good. This has been an important theological datum in the history of Western science. Science itself is good because knowledge is good, when it is used properly and in the service of God. However, we cannot live by science alone. The natural and social sciences are limited. They are unable to answer our deepest needs for meaning, values, and purpose. These are theological or philosophical in nature. So science is important, but not all-important. Science cannot save us. It is itself based upon important assumptions and values which it cannot justify in its own terms but must assume from other disciplines. This, at least, is some indication of what the sciences can learn from theology. Our model, then, is of theology and the sciences having a mutual dialogue, each discipline learning from the other, as we seek a fully adequate philosophy of life that is both true and satisfies our ethical/existential needs.

An Example of Mutual Modification: Theology, Time and Thermodynamics

I would like to give a concrete example that will spell-out the more abstract discussion of the previous section. I have chosen the topic of thermodynamics because of its intrinsic interest, and because of my interest in the philosophy and theology of time.

What is time? This is one of the oldest and most difficult of philosophical conundrums. St. Augustine asked this question, as did many philosophers before him, including Parmenides, Plato, Aristotle and Plotinus. We seem in some ways no closer to knowing the answer to such deep questions than these men of the past. But in one area, formerly known as “natural philosophy” and now called natural science, there has been a great deal of progress in our understanding of the world, including its temporality. Partly this is because science limits itself to quantitative questions and answers. Even in the natural sciences, however, there is no agreement as to the true nature of time.

In this section we will investigate what light natural science (thermodynamics in particular) can cast upon the problem of the nature of time. As a way of exemplifying the model of theology-science dialogue already developed, we will include the integration of theology and science around the topic of time.

Time seems so everyday, so ordinary, and yet at the same time so enigmatic. One of the reasons that the problem of time has proven so intractable involves the many senses of the word. “Time” can mean many things, from a break in the middle of a sporting event, to the so-called “fourth dimension” of our spacetime. Time has many facets to it, and philosophers and scientists have come to study many different aspects of time. For example, there is the question of the “absolute” or “relative” character of time. Does the passage of time reduce to a relationship between events and things, or can we say, with Newton, that “time of itself and from its own nature . . . flows equably without relation to anything external”.^{23[23]} Another important issue in the philosophy of time is this: is “process”, i.e. the passage of time from past, to present, to future, an objective part of the natural world or is it mind-dependent and subjective? Many physicists would answer that process is subjective, and what is fundamental is the geometrical spread of spacetime, which includes all events as equally real, whether or not one would call them “past” or “future” or “present” (pseudo-properties which have no measure and no physical significance). This latter view I call the stasis theory of time (also known as the “tenseless” or “B” theory).

Of the many fascinating issues in the philosophy of time, thermodynamics impinges on two issues: the beginning of time, and the “arrow” of time. Since the time of Origen and Augustine, Christians have asked, “Does time have a beginning?” Is the initial singularity of the Universe (the “Big Bang”) a beginning in time? Such a question raises the distinction between physical time as we know it (what most scientists mean by time, which I call “Measured Time”) and time plain and simple, or what we might call

^{23[23]} Sir Isaac Newton's Mathematical Principles, F. Cajori, ed. (Berkeley: University of California Press, 1947), 6.

“pure duration”.^{24[24]} Measured Time is time as we know it in physics: a measurable, quantitative factor of the universe. Pure duration is what Measured Time is a measure of; time that can “go by” even though no change takes place.

On the plausible assumption that we can distinguish philosophically between time itself and the events that occur in time, the distinction between Measured Time and pure duration allows us to distinguish the question of their beginnings. Does the time of our universe (Measured Time) have a beginning? This is a separate question from, Does pure duration (time in a metaphysical sense) have a beginning? As we shall see, thermodynamics can help us answer the first of these questions, although it leaves the latter untouched.

Thermodynamics is also of some help in answering the question of the “arrow” of time, that is, does time have a “direction” that it always follows? More technically, this is known as the “anisotropy” or “asymmetry” of time.^{25[25]} Space is isotropic: we can move freely in it, apart from some force such as gravity pulling or pushing us in some way. Time is not like that, according to our everyday experience and common sense. Time only goes in one direction: physical systems cannot run backwards against the clock -- or can they? The science of thermodynamics has important lessons for us in our search for an answer to this question.

Thermodynamics

One of the most interesting areas of contemporary physics is thermodynamics. Although studies in quantum mechanics, cosmology or dynamical systems (“chaos”) have received a great deal of attention in the popular press, and in books written for the educated general public,^{26[26]} thermodynamics deserves an equal billing. Particular interest in thermodynamics and its implications has been generated by the work of Ilya Prigogine.^{27[27]} Born in Russia in 1917, Prigogine moved with his family to Belgium, where he was schooled in the “Brussels School” of physical chemistry. A brilliant student, he eventually became the leading researcher at this school. He received the Nobel Prize in 1977 for his work in thermodynamics, and is now widely considered the world’s leading expert in statistical mechanics and thermodynamics. The Center for Statistical Mechanics and Thermodynamics at the University of Texas, Austin is named after him, and he is currently leading research at both Austin and Brussels. The work of Prigogine and his colleagues on the thermodynamics of dissipative structures (systems which exhibit some stability, even though they are far from equilibrium and non-linear) has greatly added to the importance of this science for physics, chemistry and biology.

Modern physics is divided into four areas: classical physics, quantum mechanics, Relativity physics, and thermodynamics. The term “thermodynamics” comes from two Greek words, meaning “heat-movement” and thermodynamics does indeed study heat. Perhaps this area of science is best understood as the transfer of heat and work between and within physical systems. It focuses on such measures as volume, temperature and pressure in order to measure the amount of “work” that a system is capable of, that is, how much free energy it has to work with.

Thermodynamics arose in the 19th century, from the study of heat and energy in steam engines and other “macroscopic” systems. There are four laws of thermodynamics that have arisen from such studies. The Zeroth Law is about temperature, stating that there is such a measure which different types of

^{24[24]} For more on the nature of Measured Time, see A. G. Padgett, God, Eternity and the Nature of Time (London: Macmillan, 1992), 7-18.

^{25[25]} In discussing time and thermodynamics, we should carefully distinguish between the process and stasis theories, which are about the ontological status of “nowness” or “presentness” in the physical universe; and the issue of the anisotropy or “arrow” of time. While the process theorist, who believes that nowness is objective, is committed to the anisotropy of time, the stasis theorist, for whom “past”, “present” and “future” are merely subjective qualities, can consistently assert either the anisotropy or the isotropy of time.

^{26[26]} A good example of this is the best-seller, S. Hawking, A Brief History of Time (New York: Bantam, 1988).

^{27[27]} See his now standard work, From Being to Becoming (San Francisco: W. H. Freeman, 1980).

systems can have in common. The First Law arises from the work of James Prescott Joule, the son of a Manchester brewing family, who discovered the equivalence of heat and work. The basic unity of energy in physics, the “Joule”, is named after him. The First Law states that the total energy remains conserved even when work is done: energy will always be conserved in a physical process, even though it may undergo transformation from free energy to heat.

The Second Law owes its origins to the work of Rudolf Gottlieb, a German physicist born in 1822, universally known as Clausius. He noticed that while heat and work are equivalent, and energy is conserved in the exchange, they are dissimilar in that work can be fully transformed into heat but heat does not on its own turn back into useful energy for work. The Second Law is certainly the most interesting of the four laws of thermodynamics, and the best known, having wide ramifications for our everyday life. It can be stated in many ways. Clausius’ statement was, “Heat does not pass spontaneously from cold to hot”.^{28[28]} A more universal expression of the Second Law is this: for isolated systems, entropy always increases.

The introduction of the term “entropy” leads us into one of the most important concepts in thermodynamics. Since thermodynamics studies heat and energy in systems, entropy has to do with these aspects of physical systems. Although energy is constant over change for an isolated system (the First Law), the form or structure of this energy in the system is not constant. Iron will turn to rust, but rusty iron never spontaneously becomes clean again. An open bottle of perfume will send its scent into the air of a room, but the reverse process never takes place. What is lost in these processes is capacity for useful work; what is gained in each process is entropy. Entropy is difficult to specify, exactly, because its measure differs for different types of systems. But in each case, entropy is at a maximum at thermal equilibrium: the state of a system in which all spontaneous thermodynamic changes are at an end and all free energy has been used up. For example, an isolated system of ice and water is a thermal equilibrium when the ice no longer melts in the water. To take another example, a marble sent spinning around in a bowl is in thermal equilibrium when the marble stops rolling around, and settles to the bottom of the bowl.

According to the Second Law, whenever a change takes place in an isolated system, entropy increases and so the capacity for useful work (“free energy”) decreases. In the words of the title of Lord Kelvin’s classic 1852 paper on the subject, the Second Law concerns “The Universal Tendency in Nature to the Dissipation of Mechanical Energy”. Thus even though energy as a whole is conserved in every change in a system, the capacity for work or useful energy in the universe decreases. The implications of this for our understanding of time is our next subject.

Time and Thermodynamics

Since entropy is always on the increase, it is possible to give an “arrow” or direction to the time dimension. This would not seem to be such a great discovery. Don’t we know the direction of time from our everyday existence? But physicists and philosophers of science have argued that the “direction” of time is in fact an epiphenomenon, something that is not fundamental to physical reality. This is because the classical mechanics which Newton brilliantly formulated, and which were at one time believed to be fundamental to the Universe, are time symmetric. Although equations such as “force is equal to the change in momentum over time” ($F=dp/dt$) have “time” in them, in classical mechanics the same equations can describe the same phenomenon whether t is positive or negative, that is, whether time is going “backwards” or “forwards”. In the simple case of colliding billiard balls (or atoms) the equations stay the same no matter which direction time runs in. It is not possible to tell which direction time has, when attending only to this sort of phenomenon.

The advent of thermodynamics and entropy complicates matters. Suddenly it seemed that such “time-relative” irreversible processes must boil down, ultimately, to time symmetrical equations of classical mechanics. Or so it seemed at one time to scientists dominated by the simplified abstractions of classical Newtonian physics. In more recent times, however, scientists in a number of fields have begun to note the limitations of classical mechanics for our understanding of the rough-and-tumble, complex world of irreversible processes. In quantum mechanics the “collapse” of the Schroedinger equation during measurement is irreversible. Before the measurement, the exact position or energy of the particle is a matter of probability, due to the famous Heisenberg uncertainty principle. After the collapse of the

^{28[28]} The Third Law is basically about reaching zero degrees Kelvin, and will not concern us here.

equation in a measurement, there is an asymmetry in the particle system based on the “before” and “after” of the experimental intrusion of measurement. So measurement introduces irreversibility into sub-atomic physics, even though the equations of quantum mechanics are time-symmetric. In the study of dynamical systems, or “chaos” theory, the smallest of differences in the initial conditions of such complex systems leads to large differences over time (weather is a good example). Our inability to predict the outcome of the system, and the complex interaction between elements of a dynamical system, lead to another kind of irreversible process. In biology, the movement from birth, to full growth, to death, is likewise irreversible.^{29[29]}

The key philosophical issue facing those who reflect upon time in contemporary science is this: which is really fundamental? Shall we view the time-symmetrical physics of wave functions, trajectories, and classical mechanics as truly fundamental, and interpret irreversible processes in light of them? Or should we view irreversible processes such as the increase of entropy as fundamental, and view trajectories, wave functions, and classical mechanics as idealizations and simplifications? There is a growing body of science, lead by Ilya Prigogine and his colleagues, which is arguing that the second view is the correct one.^{30[30]} The general philosophical question of which interpretation one should accept (which I will consider further, below) leads to the issue of the integration of theology and science.

Time and Christian Theology

Given our quest for a systematic Christian worldview, we cannot ignore what theology and the sciences both have to say on a subject. Theology and science need to be integrated, especially at the level of large-scale explanations of the Universe. Time and history are important dimensions of the Universe. To illustrate the manner in which theology and science can be integrated, we begin with theological perspectives on this topic. What exactly are Christians committed to with respect to time? Can we speak properly of the Christian view of time?

Let us recall the many issues that the philosophy of time brought up. The Christian faith is not committed to one view or the other on most of these problems. Whether time is absolute or relative, whether there is a relationship between time and change, whether the process or stasis theory is correct, or even whether Measured Time has a beginning: none of these are essential to the Christian Faith, to the heart of the Gospel. For some thinkers, the last point in particular may come as a surprise. For example, Carl Sagan and Stephen Hawking both assume that “a universe with no edge in space, no beginning or end in time, [has] nothing for a creator to do”. This quotation comes from Sagan's introduction to Hawking's best seller, A Brief History of Time.^{31[31]} In that book Hawking makes the argument that universe is just “there”, adopting the stasis theory of time, and incorporating some speculative elements of quantum gravitational theory to argue that the entire Universe exists as a complete spacetime entity, without need of an initial “bump” of energy from a Creator to get it going. In fact, the Universe is a kind of “free lunch”.

While Sagan and Hawking may be fine scientists, as philosophers and theologians they leave something to be desired. Christian theologians like Thomas Aquinas have persuasively argued that Measured Time could be of infinite duration, and the Christian doctrine of “creation out of nothing” (creatio ex nihilo) could still be true. For the doctrine of creation asserts that the universe is radically contingent: the Creator's will alone is the ground of being for our universe, whether Measured Time has a beginning or not. Unlike Plato's Demiurge in the Timaeus, the Lord of Heaven and Earth did not have any other “stuff” -- other than his own power, love and freedom -- out of which he had to make the world. But we need to note that the priority of God's power and will over any and all other things is a logical or causal priority, not a temporal one. The doctrine of creation out of nothing does not necessarily imply a beginning to time. Rather, it points to the radical dependence of all other beings on the Being of God. After all, where do the laws of nature come from? Where does spacetime come from? Who ordered the delicate balance of forces in the Universe, that brought forth human life? Despite Hawking and Sagan, the

^{29[29]} For a readable survey of these and other topics, see P. Coveney and R. Highfield, The Arrow of Time (London: W. H. Allen, 1990).

^{30[30]} Prigogine, op. cit. and at a more popular level, Prigogine and I. Stenger, Order out of Chaos (London: Heinemann, 1984).

^{31[31]} Hawking, Brief History, x.

metaphysical and scientific fact that the Universe is contingent cannot be dispelled by some magic tricks in theoretical physics.^{32[32]}

Is there some aspect of time, then, which is essential to the Christian faith? I believe there is. The Gospel is committed to the fact that time is linear and has a direction. There is a beginning, middle, and end to human history in Biblical perspective. The Christian doctrines of Creation, Fall, Salvation-history, Christology, Soteriology, and Eschatology imply a linear direction to time and history which is ineliminable from the Christian worldview. Natural religions as well as many of the philosophies of Greece and Rome did not have such a linear view of history. As Mircea Eliade points out in his fascinating book, The Myth of the Eternal Return, “The life of archaic man. . . although it takes place in time, does not record time’s irreversibility”. One of the important (but not unique) contributions of Hebrew thought to Western civilization is a linear conception of history. “Christian thought tended to transcend, once and for all, the old themes of eternal repetition”.^{33[33]} As Hendrikus Berkhof demonstrates at length in his excellent little book, Christ The Meaning of History, the Christian faith is committed to the meaningfulness of the historical process, and to the once-and-for-all quality of Christ’s redemption for all humanity. He rightly noted that “We must thank . . . Israel for our sense that history is goal-directed, and that as such it has meaning”.^{34[34]} The Christian view of time, then, is that it has a direction and a purpose: as such, Christianity is committed to the anisotropy of the temporal process.

The Integration of Thermodynamics and Theology

Is it possible for theology and science to support each other? With care, as long as we avoid leaping to conclusions and a “God of the gaps” mentality that would find God wherever there is some unanswered scientific question, surely there can be some support and even integration between science and theology. I believe that such integration takes place most fully at the level of large-scale explanations. Despite the oft-quoted remarks of Ernan McMullin (who argued that a Big Bang model does not support the Christian doctrine of creation and that the doctrine of Creation does not support a Big Bang model)^{35[35]} I find that theology can support our view of physics and vice versa.^{36[36]} According to the “mutuality model” developed earlier, there needs to be an on-going dialogue between theology and science in which each discipline learns from the other. Of course theology is only interested in the most general results of the special sciences, or what I have called “large-scale” explanations. Science, likewise, must come to its conclusions based on scientific data and methods, not on the basis of religious beliefs. Nevertheless, a coherent worldview is desired in Christian Doctrine (systematic theology), and therefore what we learn from both theological disciplines and the sciences should be woven together into a larger picture. A rational believer who seeks a holistic worldview will not be satisfied with dividing our beliefs into separate boxes. While I agree with Ernan McMullin that science is complete on its own terms (given its methods, purpose, and limitations), this does not mean that the natural sciences are in and of themselves “complete” from a theological or philosophical perspective.^{37[37]} If we are rational, then what we believe as Christians will give shape to our views of natural science, and what we learn from the sciences will shape our theological convictions.

Both disciplines must, of course, come to their own conclusions, based upon their own unique methodologies. I am certainly not proposing we hold to scientific theories because of theology, or let

^{32[32]} For more on creation, contingency and modern science, see the excellent collection, Ted Peters, ed., Cosmos as Creation (Nashville: Abingdon, 1989), and also W. B. Drees, Beyond the Big Bang (LaSalle, Ill.: Open Court, 1990).

^{33[33]} London: Routledge, 1955, citing pp. 86 and 137.

^{34[34]} London: SCM, 1966, 21.

^{35[35]} E. McMullin “Natural Science and Belief in a Creator”, in D. M. Byers, ed., Religion, Science, and the Search for Wisdom (Washington, D.C.: National Conference of Catholic Bishops, 1987), 39.

^{36[36]} Part of the debate here is over the meaning of “support”. McMullin makes it clear (ibid.) that by support he means deductive support (implication, entailment). In this essay, on the other hand, by “support” I mean inductive, indirect support.

^{37[37]} McMullin, “Natural Science”, 14-47.

theology be dictated to by science. Rather, there is room for a broader, more general attempt to put together a holistic worldview that includes what we believe both as Christians and as scientists, especially at the level of very large explanations of reality.^{38[38]} In the case of explanations of time and history, Christian theology clearly supports one particular interpretation of time in current physical science, rather than another plausible and popular view. So the Christian is reasonable in holding to that theory of time which best fits her theology, as long as both theories are equally supported by reason and evidence.

The Direction of Time and Irreversibility. Given that entropy is always on the increase for any changing matter-energy system in our world, the dissipation of systems provides us with a fundamental asymmetry or anisotropy for time. In the section on thermodynamics and time, above, we ended with a dilemma: either irreversible processes are the “real world” and classical dynamics and un-collapsed wave equations are a simplification of it; or the reversible world of classical dynamics and wave equations is fundamental, and thermodynamics is a special, limiting case. What is important to realize is this: in either case, what is at stake is not science itself, but our interpretation of science. In cases such as these, reflective believers are well within their intellectual rights in accepting that interpretation which, all other things being equal [!], is in line with her or his theological and metaphysical worldview. Given the Christian view of linear time essential to our faith, Christian philosophers of science will follow Prigogine, and a growing number of others, in finding the real world to be anisotropic and irreversible in time. At times the “dialogue” between theology and science looks like a monologue, with science doing all the talking. In this case, however, Christian theology should act as a “control belief” in guiding us to the proper interpretation of science.^{39[39]}

The End and Beginning of Time. I begin with the assumption that the universe, or better the Material Universe (since I do hold to non-material objects) is an isolated system. Physical energy and matter are not being exchanged between our Material Universe and some other dimension or universe. The Material Universe, then, contains all the known matter and energy. In such a system, entropy will always increase. This means that the Material Universe, left to its own devices, will come to an end. The Material Universe will some day reach thermal equilibrium: all free energy will be used-up, and no more “work” will take place. Whether we predict another singularity at the end of Measured Time (a “Big Crunch”) or a continual expanse of lifeless particles into empty space (a “heat death”) is not of any significance.^{40[40]} The basic point remains the same, from a thermodynamic perspective: entropy must increase (even if it never reaches an absolute maximum in an ever-expanding universe). The universe will come to an end.

Some scientists are uneasy with this conclusion. There are three objections to applying thermodynamics to the Material Universe of which I am aware. First, some have suggested that thermodynamics is questionable when applied to such large entities as an entire Universe. After all, this science was developed on small steam engines, not huge galactic clusters. In response I would argue that all physical cosmological laws were developed on earth, in the study of small, simple systems. It is an axiom of astronomy and cosmology that the laws of physics apply throughout all time and space in the Material Universe. To try and exempt thermodynamics from such universality is simply an attempt to wiggle out of the problem. According to all we know of physics and astronomy, every single astronomical object will eventually decay, and the resultant matter and energy left over will not have the same capacity for work (free energy) as the original system. Entropy applies to everything in the Material Universe.

Secondly, William Drees has argued against the universal increase of entropy in the Material Universe by suggesting that it is not a “closed” (he no doubt means “isolated”) system, in the sense necessary to apply the Second Law.^{41[41]} The expansion of the Material Universe, he suggests, works as if

^{38[38]} I assume that McMullin would also agree with this last point, given what he says about worldviews at the end of his interesting paper, “How Should Cosmology Relate to Theology?”, in A. Peacocke, ed., The Sciences and Theology in the Twentieth Century (Notre Dame: University of Notre Dame Pr., 1981), 51f.

^{39[39]} For more on “control beliefs” see N. Wolterstorff, Reason within the Bounds of Religion. 2nd ed. (Grand Rapids: Eerdmans, 1984).

^{40[40]} For more on this topic, see S. Frautschi, “Entropy in an Expanding Universe”, Science 217 (1982), 593-599.

^{41[41]} Drees, 32

there were an “environment” into which entropy was carried away, even though there is no environment for the universe. Here I find Drees’ argument rather unclear. Even the radiation given off by the universe, at the edge of its expansion, is also part of the Material Universe. The expansion itself is a form of thermodynamic exchange, increasing always the entropy of the whole (radiation, energy, matter) and decreasing the free energy in the Material Universe. Empty space is not an “environment” in the thermodynamic sense, i.e., something from which energy can be brought into the system, to decrease the (local) entropy of that system. There is, I believe, no philosophical or scientific grounds for doubting the fact that the Material Universe, after billions of years, will come to an end (I count a ceaseless drifting apart of lifeless particles as an “end”).

Thirdly, Drees also states that the Second Law is a purely statistical law. As such, perhaps this universe of low entropy is a (low probability) fluctuation in an otherwise eternal universe in thermal equilibrium.^{42[42]} Such a “fluctuation” would be very, very unlikely, but if the Second Law is merely statistical, still possible. This would allow for the Material Universe to be eternal, while not running counter to the Second Law. Ludwig Boltzmann suggested such a model in the 19th Century, and Hawking’s cosmology, perhaps, is of a similar kind. The problem here lies in interpreting the Second Law in a purely statistical manner. There are real forces at work in the world, which are the ground of the statistics in the Second Law. In a merely statistical interpretation, there is no answer given as to why some states are more probable (act as “attractors”) than others: the fact that some are is merely asserted, rather than explained. As Prigogine wrote on another occasion:^{43[43]}

Dissipation produces entropy. But what then is the meaning of entropy? Over a century ago, Boltzmann came up with a most original idea: entropy is related to probability. . . . It is because the probability increases that entropy increases. Let me immediately emphasize that in this perspective the second law would have great practical importance but would be of no fundamental significance. . . . By improving our abilities to measure less and less unlikely events, we could reach a situation in which the second law would play as small a role as we want. This is the point of view that is often taken today, but it is difficult to maintain in the presence of the important constructive role of dissipative systems.

In other words, while the merely statistical interpretation of entropy is useful and important, it is not metaphysically significant or fundamental. Dissipation, not statistics, produces entropy. “Unlikely” states of affairs, such as “fluctuations” of the age and extent of our Material Universe in an otherwise eternal thermal equilibrium, are not merely unlikely but practically impossible from a thermodynamic perspective.

Given the failure of the above objections, we can conclude that the Material Universe as we know it will come to an end. This therefore implies that Measured Time, the physical time of our universe, must have a beginning. The argument for this conclusion is a simple one. Either pure duration is of infinite or finite extension into the past. If it is finite, then time has a beginning, and thus so does Measured Time. If pure duration is infinite, then Measured Time either has a beginning, or it does not. If we begin to think that it has no beginning (i.e., “began” an infinite time ago), we soon realize that with an infinite past, we should already have reached the end of Measured Time, since the Material Universe is of merely finite duration. But we have not reached the end of Measured Time. So Measured Time must have a beginning (whether pure duration also must have a beginning is another question). Yet even this result (that Measured Time has a beginning) is important: it adds weight to the conclusion, based on results from many areas, that the Material Universe is contingent. Thermodynamics therefore helps support one implication of the Christian doctrine of Creation, namely, that the Universe is contingent.

Conclusions

We have covered a lot of terrain in a hurry. Each major point we have made could be the subject of another article on its own. Still, some progress has been made toward an understanding of the relationship between thermodynamics and Christian theology. Thermodynamics supports the Christian doctrine that time is linear, while Christian doctrine supports the dynamic, irreversible view of fundamental

^{42[42]} ibid. and 227.

^{43[43]} “Irreversibility and Space-time Structure”, in David Griffin, ed., Physics and the Ultimate Significance of Time (Albany, NY: SUNY Press, 1986), 239.

physics. Both disciplines together lead to the conclusion that the Material Universe is contingent, having a beginning in time, and again in this way support each other.

In terms of the relationship between theology and science, we have seen that at least in this small area these disciplines can be integrated, and they can support each other (by “support” I mean indirect, inductive support). Of further methodological interest is this: in two cases *metaphysics* (that is, “large-scale” explanation) has served as an intermediary between theology and science.. Thermodynamics supports the Christian doctrine of creation through its metaphysical implications, while the Christian doctrine of time helps us choose between rival metaphysical interpretations of basic physics with respect to the “direction” of time. Is not metaphysics, then the proper meeting place of theology and science?^{44[44]}

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