IDEOLOGY AND SCIENCE

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1. INTRODUCTION

The notion that not only facts but also personal and communal beliefs contribute to scientific knowledge has become commonplace. It raises two important questions. How can people with very different belief systems work together in science? Can scientific knowledge be trusted if it is shaped and sometimes distorted by beliefs operating in the background of science (background beliefs)? In this essay I explain why background beliefs are required for the construction of theories in science. I argue that background beliefs do not normally distort scientific knowledge because God created an objectively existing reality that resists distortion. Therefore, the background beliefs of scientists do not dictate the content of scientific knowledge. The conclusion is that people with different belief systems including Christians can work together in scientific research.[1]

The role of religious background beliefs in shaping knowledge became an influential research program in The Netherlands through the work of the theologians Abraham Kuyper (1837-1920) and Herman Bavinck (1854-1921), the philosophers Dirk Vollenhoven (1892-1978) and Herman Dooyeweerd (1894-1977), and the historian of science Reijer Hooykaas (1906-1994). This role was not discovered in historical research. Rather it was a normative claim grounded by both Kuyper and Bavinck in the comprehensive character of Christ's redeeming work. The need for a redemption of scholarship followed from the long established notion that human cognitive ability had been affected by the fall into sin (Harrison 2007: 26-27). The conviction that Christ uses people as instruments of redemption promoted the development of a program for the redemption of culture including scholarship. One of the implications of this program was that scientific knowledge has a subjective component consisting of background beliefs that originate in the knower rather than in the non-human world.

While the Dutch research program became internationalized it never became widely accepted. The notion of the subjectivity of science was popularized, however, as the result of two developments independent of the Kuyperian school. First, the issue was also explored in Poland (Fleck, 1935, tr.1979), the United Kingdom (Foster, 1934, 1935-36; Polanyi, 1958) and the United States (Kuhn, 1970). This pioneering work in the history and philosophy of science and medicine led to a recognition of the role of background beliefs in shaping scientific knowledge. It also triggered the downfall of positivism, the view that not only scientific knowledge, but all knowledge depends only on what can be perceived by the senses and established by reason. These developments were independent of the Kuyperian school of Dutch neo-Calvinism and they were not motivated by the religious notion of the redemption of scholarship. Their basis in historical scholarship and their justification by philosophical argument made them more widely acceptable. However, the acknowledgement of a subjective dimension of scientific knowledge led some to the extreme of denying that true knowledge of nature was possible at all (relativism). Nevertheless, orthodox Christians in Europe and North America welcomed the new philosophy of science because it opened up a role for religion in science at least potentially. An engagement between the Kuyperian and Kuhnian schools ensued. Few Christians, however, showed an

[1] A word on terminology. I will be using the term background beliefs loosely as a synonym for presupposition, worldview, control belief, ideology and presumption. Whatever differences there are between these terms, I will ignore them because they are irrelevant for this essay in which a background belief is a belief one needs before one can even start to think about the full range of realities from God and the world to fermions, frogs and feelings.

awareness of the relativism implied particularly in Kuhn's views.

The notion that background beliefs shape science is now common currency. It has been variously interpreted. At one end of the spectrum we have the sociology of knowledge school. Its members hold that truth about nature depends largely or completely on the communal agreement of scientists (subjectivism), not on nature itself. The other extreme is represented by what is left of the logical empiricists also known as the positivist school. For logical empiricists truth about nature is gained by observation and reason with the understanding that the outcome depends solely on the object being explored and on the proper use of logic (objectivism). Some Christians have joined the sociology of knowledge school, not because they want to acknowledge the social dimension of knowledge acquisition, but because it allows them arbitrarily to deny the truth of those parts of science that are threatening to them. They reason as follows. If the content of scientific theories is influenced substantially or even completely by background beliefs, then this levels the playing field between say naturalism and theism. They do not realize that this move is very costly from a Christian perspective. For one, truth about nature is made to depend completely on the beliefs of the community with the most power. For another – and implied in the previous point – truth no longer depends on what exists objectively as created by God. Is it possible to acknowledge the role of background beliefs in science (subjectivity) and avoid turning background beliefs into the sole source of knowledge of nature (subjectivism)?

The purpose of this essay is to review some of the relationships between background beliefs and scientific theories and explanations that have been uncovered. I take for granted that normally background beliefs are needed for the construction of theories in the natural sciences (Brooke 1991, Brooke, Osler and van der Meer 2001). Examples are given in section 4 below. But I argue that this does not justify the view that science consists of a collection of arbitrary opinions or that relativism reigns supreme in science. My argument is developed in five steps.

> Step 1: In Section 2 I begin with the doctrine of creation and point out that from a Christian perspective, scholars have the moral duty to oppose background beliefs that distort their understanding of natural phenomena. For this to be possible, background beliefs must be detachable from the explanations they support.
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> Step 2: In Section 3 I describe examples from the history of science showing that there are standard ways of detecting distortion by background beliefs (3.1), that it is logically possible to separate such background beliefs from scientific explanation (3.2), and that in their work scientists in fact do oppose their background beliefs (3.3).
> Step 3: In Section 4 I explain how background beliefs can have a constructive role in science and under what conditions they can be either discarded or accepted as permanent components of a theory.
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> Step 4: In Section 5 I locate scientific knowledge as one kind of knowledge among others such as everyday, common-sense knowledge, knowledge by acquaintance, skills knowledge, and faith knowledge. I show that while science needs to build on such non-scientific kinds of knowledge, it is limited in that it cannot itself produce non-scientific knowledge.
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> Step 5: In Section 6 I conclude that background beliefs are needed in the acquisition of knowledge of nature and that they can play their role without distorting scientific knowledge.

2. THE MORAL DUTY OF SCIENTISTS

Two of the less desirable uses of background beliefs have been in the promotion of relativism and in the distortion of scientific knowledge. A Christian response to such abuse of background beliefs must begin with the notion that scholars have a moral obligation to identify and avoid relativism and distortion. This applies especially to Christians since they believe that God created an objectively existing reality that they are obliged to understand with integrity. For them it is a religious duty to glorify God in the work of his hands. This cannot be done if one denies that humankind has access to this creation. Such a view maintained by those who believe that knowledge of nature is a pure mental construction and truth is achieved when all the parts of this construction are mutually consistent (*anti-realists*). Access to knowledge of nature is also denied by those who believe that such knowledge cannot be attained at all (postmodern *relativists*). Therefore, the majority of scientists irrespective of their religious commitments are *realists*. That is, they believe that true knowledge of nature consists of knowledge that corresponds to nature. For who would want to spend a lifetime attempting to understand something that does not exist? Scientific realists do not deny that in coming to understand nature humans contribute their beliefs, but they insist that reality decides whether a belief becomes knowledge. Like everyone else, however, scientists are also familiar with failure and error. Christians have additional reasons to be sensitive to the imperfection of knowledge, for they recognize it as a consequence of their finitude and of living in a world affected by the fall. Thus Christian and non-Christian scientists alike tend to be *critical realists*. A Christian's sensitivity to the danger of self-deception is a gift that equips one to be a good scientist. But sensitivity to self-deception is not enough. A range of measures is employed to guard against distortion by background beliefs in science. One of these measures uses the convergence of different lines of evidence on the same explanation or theory, which will now be discussed.

3. KEEPING DISTORTION OUT OF THEORY

3.1. Independent Lines of Evidence

A theory or explanation that is supported by evidence contributed by several independent scholars is better protected against distortion than one supported by a single scholar. This is a matter of common sense. News agencies give most credence to consistent reports that have been independently confirmed. When different reports agree amongst each other about an event irrespective of the reporters, the event is taken to be *true*. Likewise, patients decide to undergo medical treatment with more confidence when a second opinion agrees with the first. When a diagnosis is consistently given by different independent physicians who identify the same cause, this is taken to point to the *true* cause of the disease. The principle applied in such cases is that if the same event is reported by different journalists or the same symptoms reported by different physicians, the report is taken to be true because it does not depend on the reporters. Rather the report corresponds to reality. The expression 'independent lines of evidence' refers to the fact that the content of the reports does not depend on the reporters. The reports are identical because they originate in a single event reported by different individuals.

The principle of independent lines of evidence applies also in more complex circumstances where, instead of simply seeing the same thing, two journalists see different things but infer the same cause. Likewise two physicians can infer the same cause of a disease from two different sets of observations. For instance, a psychiatrist can attribute insomnia and depression to an abnormally low activity of the thyroid gland. A radiologist can attribute weight gain and an abnormally low level of thyroid hormone to an underperforming thyroid gland. When this happens it is taken to be a stronger confirmation for the existence of the inferred cause – the malfunctioning thyroid – than in the simple example. In the simple case two journalists report the same observation. In the complex case two physicians not only infer the

same cause from different observations, but they also make the observations using different methods. One has two different lines of evidence observed by two different people pointing to the same cause. In other words, the existence of the cause, though inferred, is independent not only of the persons doing the inferring, but also of the differences between what is observed and of the method by which the observations were made.

This complex case is analogous to what is meant by independent lines of evidence in science. There are two reasons why the background beliefs of scholars do not easily enter the natural sciences today. First, the number of scholars contributing different pieces of the puzzle is large. This communal character of research ensures that members of the research community do not share personal background beliefs so that the latter do not enter the explanation they are contributing to. However, they do share whatever background beliefs characterize their research community or tradition, and these communal background beliefs may influence their scholarship.

The second reason concerns communal background beliefs and why they can be excluded from science. Since the development of an explanation may take a long time, the contributing scholars live in different eras and, therefore, tend to belong to different research traditions. Thus, while in the first case scholars belonging to the same research tradition share its background beliefs, this is not likely to be the case with scholars from different historical periods. Therefore, taking these two reasons together, a convergence of evidence on the same theory or explanation is most likely due to the fact that the explanation is correct. The alternative – that all participants distort the evidence in the same direction by contributing the same background beliefs is simply not believable.

Below I will explain why personal as well as communal background beliefs are open to questioning (Sections 3.2 and 3.3). But let us first look at some examples of convergence of different lines of evidence on the same explanation in the natural sciences. We'll take physics first and focus on the contributions of Galileo, Kepler, Newton and Laplace to the theory of mechanics. Galileo (1564 – 1642) developed descriptions of the parabolic path of a projectile and of the relation between speed, time and distance traveled by a body that falls with uniformly accelerated motion. Kepler (1571 – 1630) formulated mathematical laws for planetary motion. Isaac Newton (1643 – 1727) unified the work of Galileo and Kepler and expanded it in the three laws of motion first published in his *Philosophiæ Naturalis Principia Mathematica* on July 5, 1687 (http://csep10.phys.utk.edu/astr161/lect/history/newtongrav.html). The first law states that every body persists in its state of rest or of uniform motion, that is motion with constant speed in a straight line, unless it is compelled to change that state by forces impressed on it. This means that in the absence of a net force, the centre of mass of a body, either is at rest or moves at a constant velocity. The second law states that a body of mass m subject to a force $\boldsymbol{F}$ undergoes an acceleration $\boldsymbol{a}$ that has the same direction as the force and a magnitude that is directly proportional to the force and inversely proportional to the mass, i.e., $\boldsymbol{F} = m\boldsymbol{a}$. Alternatively, the total force applied on a body is equal to the time derivative of linear momentum of the body. Finally, the third law asserts that the mutual forces between two bodies are equal, opposite and collinear. This means that whenever a first body exerts a force $\boldsymbol{F}$ on a second body, the second body exerts a force $-\boldsymbol{F}$ on the first body. $\boldsymbol{F}$ and $-\boldsymbol{F}$ are equal in magnitude and opposite in direction. This law is sometimes referred to as the action-reaction law, with $\boldsymbol{F}$ called the "action" and $-\boldsymbol{F}$ the "reaction".

Newton used his three laws to explain the motion of many physical objects and systems including those studied by Galileo and Kepler as well as the fall of an apple from a tree (http://news.cnet.com/8301-1023_3-10438960-93.html). For example, in the third volume of the text, Newton showed that these laws of motion, combined with his law of universal gravitation [$\boldsymbol{F} = Gm_1 m_2 / R^2$ or $\boldsymbol{F} = m\boldsymbol{g}$ for earth], explained Kepler's laws of planetary motion. Further included in Newton's unifying

account were Galileo's descriptions of the parabolic path of a projectile and the relation between speed, time and distance traveled by a body that falls with uniformly accelerated motion. Finally, the mathematical description of planetary orbits in Newtonian mechanics was simplified by Lagrange (1736 – 1813) and given a historical explanation by Pierre-Simon Laplace (1749 – 1827). Laplace postulated that the solar system had started as a nebulous cloud which gradually separated into rings, each of which in turn eventually coalesced to form the planets. This explained why the planets moved approximately in the same plane and direction. The simplification was taken by many to imply that divine corrections were no longer required to keep the planets in orbit as Newton had thought. Together Lagrange and Laplace had shown how the solar system could stabilize itself.

The point is that Galileo was a Catholic, Kepler a Protestant Platonist, Newton a Unitarian Deist and Laplace an Atheist. Despite these differences in personal religious and metaphysical background beliefs they contributed to the development of mechanics. Kepler's commitment to Platonism caused him to expect planetary orbits to be perfect circles. Famously, it took him more than thirty years to come to grips with their elliptical shape. Laplace was an atheist and his nebular hypothesis was designed to replace references to purpose and design with those to the operation of physical laws. But note that this motivation plays no role in the question of truth which depends on the facts about our solar system. This illustrates that physical reality resists being distorted by the background beliefs of individual contributing scholars. On the other hand, they shared a view of the cosmos as a machine. But this only moves the question of how they could contribute to the theory of mechanics from the level of theory to that of background belief. What calls for explanation is how they could share a mechanical view of the cosmos given their different background beliefs. This will be explained in Section 3.2.

We'll next consider a more technical example from modern physics provided by Dr. Arnold Sikkema. According to theory, the sun is powered by nuclear fusion. How do we know this? This claim is what one could call a high-level theory under which several unrelated models and theories are brought together. Each model and theory in turn employs several lower-level models and theories. Finally, each of the latter is supported by converging lines of evidence. So we don't have just one theory on which different lines of evidence converge. We have a network of such convergences. At the most directly experimental level an abundance of evidence gives strong support to a limited number of theories and models. The latter all point with great clarity toward substantiating the theoretical claim that the energy of the sun is produced by nuclear fusion. The number of contributors of all this evidence runs in the thousands. But it is not only the sheer number that ensures diversity of background beliefs. The scientists also lived in different places and times, and in nearly every case they were confronted with completely unexpected results with which they had to grapple, and which were significantly resisted by the scientific community at large. Here are some details:

1. Models of gravitational / radiation balance in stars including the sun are based on:
1.1. Newton's theory of gravity, which is confirmed to high precision through solar system observations and through lab experiments
1.2. The mass and size of the sun, which are determined through distance ranging, the theory of gravity, trigonometry, the speed of light, and the length of the year.
1.2.1 The speed of light is routinely measured and relied upon both in the labs and in the wider solar system, and is well understood in terms of classical electromagnetic theory and the electrical and magnetic properties of the vacuum.
1.3. A theoretical understanding of radiation pressure based on electromagnetic theory and Einstein's theory of special relativity (to understand momentum of particles of light), and confirmed through thousands of unrelated experiments.
2. Models of the interior of the sun, confirmed through helioseismology and consistent with the

conditions required for nuclear fusion.

3. Models of nuclear fusion consistent with Einstein's theory of special relativity to relate mass and energy, and more generally high-energy particle theory, both of which are confirmed through thousands of unrelated experiments and billions of independent unrelated collision events analyzed in particle colliders all around the world.
4. Coherence with astrophysical explanations of observations of relative abundances of the chemical elements throughout the universe, as observed via spectral analysis of stars, interstellar matter, and galaxies. The spectral analysis uses standard laboratory practices of wave optics, and probes the gas emission and absorption of electromagnetic radiation, which is well understood using quantum chemistry.
5. Coherence with the measured rate of detection of solar neutrinos along with the later experimental confirmation of neutrino oscillations which resolved an anomaly that lasted three decades
6. Consistency with a wide range of applications of stellar astrophysics, such as the models of end states of stars in which nuclear fusion plays a well understood role even in the extreme conditions of supernovae, including the production of neutrinos.

In addition, there is the clear failure of every alternative scientific model considered (such as earlier suggestions that the sun is powered by chemical processes) to allow for the observed radiative energy output, stability, spectrum, resonances, etc.

The third example is from geology. We'll take the theory of plate tectonics. This theory explains how the continents on Earth are formed by the breaking apart of a single continent into fragments that moved away from each other to form the currently known continents. A small selection of independent lines of evidence includes the geometric fit of the displaced continents such as between West Africa and the eastern coast of South America, the similarity of rock ages and Paleozoic fossils in corresponding rock strata between continents, deep trenches in the ocean floor where one plate descends under another plate (troughs), mountain ranges in the sea floor midway between continents (mid-ocean ridges), and seashells on mountaintops due to uplift of crust in collision zones. Furthermore, sea floor spreading explains movement of continents. Along the length of a mid-ocean ridge new magma from deep within the Earth rises up and erupts in hydrothermal vents or smokestacks to create new oceanic crust. A video of a smokestack can be seen at http://www.ceoe.udel.edu/deepsea/level-2/geology/vents.html. This process pushes continents away from each other and from the ridge. Some lines of evidence supporting this explanation include radioactive dates, fossil studies, and earth magnetism. Radioactivity-based rock ages are similar in equidistant bands symmetrically centred on the mid-ocean ridge. The age of the rocks increases as their distance from the mid-ocean ridge increases. Also, identical fossils are found in bands equidistant from the ridge. This shows that a particular band of crust shared a similar history as its corresponding band of crust located on the other side of the ridge. Just as similar age bands and fossil bands exist on either side of a ridge, studies of the magnetic orientations of rocks reveal bands of similar magnetic orientation that are equidistant and on both sides of a mid-ocean ridge. This list is very incomplete yet its abundance is sufficient to make the point of independent lines of evidence. For more evidence, see http://en.wikipedia.org/wiki/Plate_tectonics#cite_ref-17, http://www.physicalgeography.net/fundamentals/10i.html, http://www.visionlearning.com/library/module_viewer.php?mid=65, and http://earthsci.org/education/teacher/basicgeol/platec/platec.html.

The final example is from biology. The theory of biological species formation enjoys several instances of independent confirmation. For instance, studies of the history of over one hundred fruit fly species on the Hawaiian Islands show a remarkable fit between geological, biological and geographical lines of evidence. Geological studies of plate tectonics show that the Pacific Plate moves northwestward over a

stationary hotspot in the core of the earth. The hotspot melts the plate moving above it spawning a series of volcanic islands as it goes (see http://en.wikipedia.org/wiki/Hawaiian_Islands). Thus the oldest island is expected and found at the extreme northwest tip of the submarine mountain chain, 2,400 km from Hawaii near Kamchatka Peninsula (Eastern Russia) (http://maps.nationalgeographic.com/maps/atlas/pacific-ocean-geophysical.html). This evidence from plate tectonics correlates with evidence from isotope ratios of ^{40}Ar / ^{39}Ar showing that oldest islands by argon dating are also the smallest, i.e., the most eroded and are located in the northwest as expected. The youngest islands are the largest and located as predicted in the southeast (e.g., Hawaii). These two lines of geological evidence are matched by three independent lines in biology. By and large the same genealogy of fruit fly species has been obtained from comparison of morphological characters, DNA sequences and chromosome mutations. Finally, looking at the geographic location of the different species we see that the phylogenetically youngest species of *Drosophila* are found on the geologically youngest islands of the Hawaiian Archipelago because they were the last to be colonized by the fruit flies (see a summary of the work of H.L. Carson online at http://www.bio.ilstu.edu/Edwards/HawaiianDrosophila/CarsonTree.htm as well as of O'Grady *et al.* (2001), online at http://www.biomedcentral.com/1471-2148/1/6). In sum we have a correlation among the history of mutations in their chromosomes, the geographic distribution of their species, the time sequence in which the islands surfaced above sea level as a result of volcanic action and the direction of continental drift. This involves five independent lines of evidence. This research program started in 1963 and is continuing. The list of contributors runs into the hundreds and includes people from different cultures around the globe. Their background beliefs are not known, but one can be sure that such an international cast of characters holds a diversity of background beliefs. Yet they all agree on a common reconstruction of the natural history of Hawaiian fruit flies. As in the previous examples, this agreement is likely underwritten by broad agreement about scientific methodology both general and discipline-specific. But, as before, this moves the question of how they could contribute to the natural history of Hawaiian fruit flies from the level of theory to that of background belief. The question is how they could share this history despite their differences in background beliefs. This will be explained in Section 3.2.

3.2. Background Beliefs *Can* be Separated from Scientific Explanation

What happens if different lines of evidence do not converge on the same explanation? Apart from distortion by background beliefs there are many other technical reasons why this might have happened. We will ignore all of them in order to focus on the question whether theories can be made independent of background beliefs. So let us assume that the failure of convergence is due to distortion by background beliefs. Can this be undone? In this section I argue that background beliefs can be disconnected from theory. The key point is that a background belief does not dictate a theory. Nor does a theory dictate a background belief. This is because there is no simple necessary (logical) link between belief – Christian or otherwise – and scientific explanation.

3.2.1. Mutually inconsistent theories under the same religious background belief

For one, a theory does not dictate a background belief. Otherwise mutually inconsistent theories could not be subsumed under the same theistic background belief. But they can. For instance, the background belief that God created animals with a purpose – the purpose to reproduce, for instance – has had at least two mutually exclusive interpretations (Fig. 1). If, with the Tübingen physiologist Carl Friedrich Kielmeyer (1765-1844) we add the hypothesis that God acts via natural law it follows that God has created organisms with the capacity to generate their own purposes. On the other hand, if with the French zoologist Georges Cuvier (1769-1832) organisms are seen as depending directly on God for their purpose, it follows that organisms receive their purposes from outside of themselves when they were created. Thus, in conjunction with the shared background belief that God created animals with a purpose,

different assumptions on how God acts in the world – by natural law or by intervention – lead to different explanations for purposeful behaviour of animals. Purposeful behaviour is generated internally by the organism if God creates by natural law, but externally if organisms are created without this internal capacity. The reason why two mutually exclusive explanations can be derived from the same background belief in the Creator lies in the different views of how God acts in the world. If theories dictated background beliefs then one theory would be associated with just one background belief.

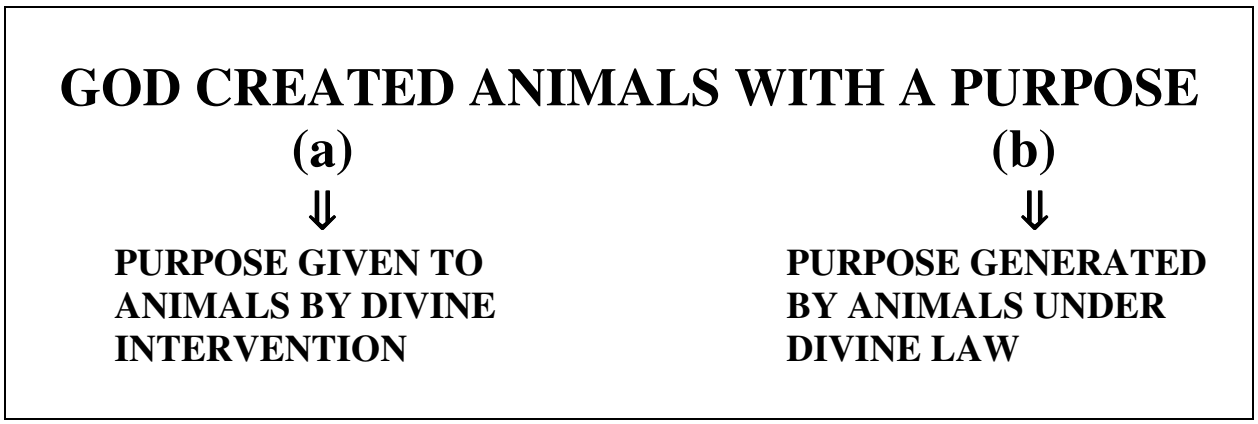

Figure 1. Mutually inconsistent theories (a) and (b) can be subsumed under the same background belief. The background belief that God created animals with a purpose can be specified in at least two different ways. (a) Adding the hypothesis that God acts by intervention makes the purposeful organization of animals directly dependent upon continuous divine intervention. It follows that organisms receive their purposes directly from outside of themselves. (b) By adding the hypothesis that God acts via natural law it follows that he has created organisms with the capacity to generate their own purposes. That is, organisms receive their purposes indirectly from outside of themselves.

The second example of mutually exclusive theories under the same background belief is from astronomy. Isaac Newton (1642-1727) had developed a mathematical description of the planetary orbits. The description implied that a planet would gradually leave its orbit. To prevent this Newton believed God would intervene from time to time to make a correction in the orbit. Gottfried Wilhelm Leibniz (1646-1716) objected that this was not in keeping with God's perfections. God is all-knowing and so he would have foreseen this problem by creating a planetary system without the need for intervention. Later, Pierre-Simon Laplace (1749-1827) would improve on Newton's mathematics making divine intervention superfluous. But that is beside the point I want to make, which is this. Both Newton and Leibniz believed that God is the all-powerful and all-knowing Creator of the cosmos. But they disagreed on the need for divine intervention in the planetary system because they emphasized different attributes of God (Fig. 2). Newton emphasized divine omnipotence. This meant that God was free to create what he willed, leading Newton to emphasize intervention. In contrast, Leibniz stressed that God is omniscient. An all-knowing God can anticipate all the implications of what he wanted to create before he had created it so that there was no need for corrections afterward. Again, two mutually exclusive planetary theories can be subsumed under the same theistic background belief. The difference between the planetary theories lies in the different emphases Newton and Leibniz placed on the attributes of the Creator – the freedom to create or the foreknowledge of what would happen in the products of his creative action.

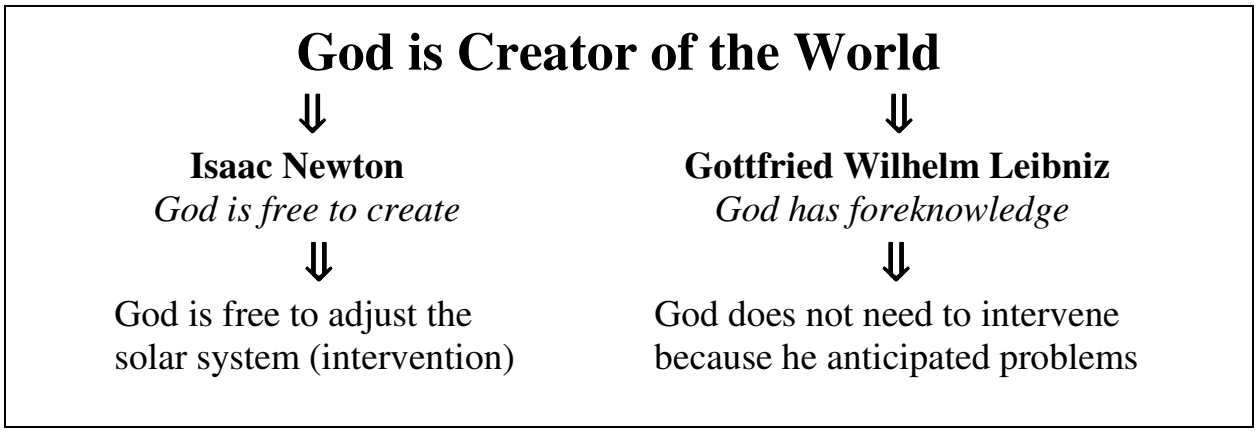

Figure 2. Newton and Leibniz disagreed on the need for divine intervention in the planetary system because they had different ideas on how divine omnipotence is manifested in divine action.

3.2.2. The same theory under mutually exclusive background beliefs

While mutually inconsistent theories can be subsumed under the same religious background belief, the converse is also possible. Different background beliefs can provide presuppositions for the same theory. This would not occur if background beliefs dictated theories. A case in point involves materialism and Christianity. Christian teleomechanism is a view held by a number of nineteenth century German biologists. They believed that organisms were designed by God as a human engineer designs machines, namely with a built-in purpose. Both materialism and Christian teleomechanism have been made more specific in order to support the theory that organisms generate their own purposes (Fig. 3). Materialists, who believe that the purposive behaviour of organism is real and not only apparent, made their background belief more specific by adding the hypothesis that matter has the potential to produce purposive organisms. Christians specified their belief in the Creator by adding that God designed organisms with a purpose. In other words, the purposiveness of organisms can be derived from non-religious as well as religious background beliefs by the addition of suitable hypotheses. Therefore, the theory that organisms generate their own purposes is logically independent of the background belief that God has created things for a purpose. Moving in the opposite direction from theory to background belief, this means that the purposiveness observed in organisms can be interpreted in religious and non-religious ways.

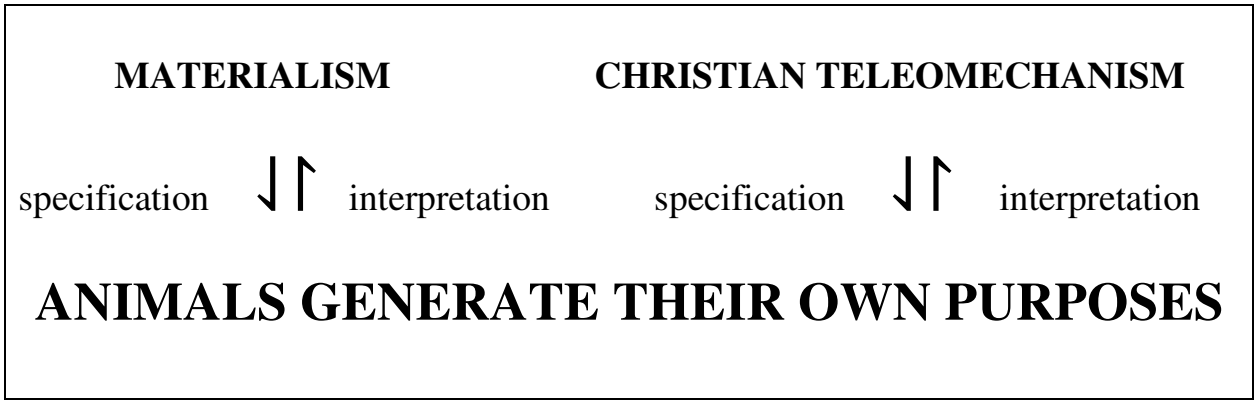

Figure 3. The same theory under mutually exclusive background beliefs

3.2.3. Interim conclusion

To conclude, a particular philosophical or religious belief operating in the background of science cannot dictate or entail a particular theory in a simple way because the theory is connected with many other assumptions. The examples show that, logically, a theory or explanation can be separated from its background belief. This is possible because background beliefs of a high level of generality need to be made specific before they can be tested. This specification is achieved by adding hypotheses to the background belief. Since the added hypotheses can be replaced, background beliefs do not simply dictate explanations of natural phenomena. This takes care of the scientific relativism implied if religious and other background beliefs dictated scientific explanations. Different religious background beliefs can be made consistent with the same observations and explanation by adding different hypotheses.

It follows that Scriptural presuppositions do not dictate a kind of scholarship with a uniquely Christian content. The difference between two kinds of scholarship remains limited to the background beliefs of scientists. In the history of science this conclusion is supported by the existence of schools of thought in science. In physics there are different interpretations of quantum physics. In biology, gradualism and punctuated equilibrium represent different schools of evolutionary theory. In geology, uniformitarianism and catastrophism are different interpretation of earth history. Scholars in different traditions have different background beliefs, but they share observations and explanations. Likewise, Christians and non-Christians can share observations and explanations because science is rooted in an objective reality.

Conversely, a particular theory or explanation in science does not dictate a particular worldview or philosophy. Unfortunately, the complexity of the relationships between worldviews and theories and the associated complexity of separating ideology from science provides a cover for those who abuse theories for the promotion of ideologies. Preachers of a secular religion such as Carl Sagan, Richard Dawkins and Daniel Dennett have not done sober science a favour by promoting an aggressive anti-Christian atheism in the name of science. Christians need to learn to see through this abuse of science if they do not want to throw out the baby of science with the bath water of ideology. Otherwise, they will have failed their God-given calling to glorify the Creator in his creation. Sober atheists can see through the charade as their critique of Richard Dawkins shows. The Canadian philosopher and religious skeptic Michael Ruse commented recently: “I am indignant at the poor quality of the argumentation in Dawkins, Dennett, Hitchens, and all of the others in that group [of atheists]” (http://blog.beliefnet.com/scienceandthesacred/2009/08/why-i-think-the-new-atheists-are-a-bloody-disaster.html). It is unfortunate that many Christians have been unable to distinguish between the science and the background belief.

3.3. Individual Scientists Have Kept their Background Beliefs out of their Theory

The examples just described focus on the logical aspect of connections between background beliefs and theories in science. They show that from a logical point of view the two can be disconnected by adding additional assumptions. This looseness of connection between background belief and theory also applies to the work of scientists at a personal level as will be shown with two sets of examples.

First, one reason not to worry about distortion by background beliefs is the phenomenon of repeated independent discovery. For instance, in ancient Chinese culture the scarcity of written records caused mathematicians often to rediscover or re-invent earlier achievements (VanBrummelen 2001). In Western Europe, the laws of Mendel in genetics were rediscovered independently in 1903 by three geneticists. This is analogous to four different reporters confirming the same event. Clearly, the content of such reports or discoveries does not depend on the background beliefs of the discoverer. This excludes a possible distortion by background beliefs at the individual level.

The discovery of the same mathematical and scientific knowledge in different and isolated cultures excludes distortion due to shared background beliefs such as found in research programs and schools of thought. For instance, mathematical knowledge discovered independently in Western Europe and ancient China includes the binomial theorem, the solution of n^{th} roots and polynomial equations via Horner's method, the earliest use of negative numbers, combinatorial analysis, Gaussian elimination for the solution of systems of linear equations, solutions of indeterminate integer equations, algebra with infinite series and finite-difference interpolation methods (VanBrummelen 2001). Further, in physics Newton's first law (the law of inertia) apparently occurred to several different natural philosophers and scientists independently. The inertia of motion was described in the 3rd century BC by the Chinese philosopher Mo Tzu, and in the 11th century by the Muslim physicists Alhazen (Salam 1984) and Avicenna (Espinoza 2005: 141). The 17th century philosopher René Descartes also formulated the law, although he did not perform any experiments to confirm it (Descartes 1644: §§ 36-39). These scholars are separated by many centuries as well as by deeply different cultural values. They could not have shared background beliefs that might explain their convergence on the same discovery.

Back to the distorting role of background beliefs held by individuals. The second set of examples is from the history of racism which involves the interaction between society and genetics. I will focus on the social and individual background beliefs of the geneticists Karl Pearson (1857-1936), Ronald Fisher (1890-1962) and John Haldane (1892-1964). All of them resisted the temptation of allowing their personal background beliefs to distort their scientific knowledge.

Pearson is a founder of modern statistics. His statistical approach to human genetics has been shown to be motivated by biological problems and not by the ideology of eugenics which he held strongly. Fisher is a founder of population genetics. He showed how difficult it would be to eliminate harmful genes from a human population despite the fact that this was the ideal of the eugenics movement which he endorsed. Finally, Haldane developed important parts of the theory of natural selection despite his suspicions of the eugenics movement which wanted to apply artificial selection to purify the human race (Bowler and Morus 2005: 433-34).

These scholars did not allow their work in genetics to be distorted by their background beliefs even though the two were contrary to each other. The point is twofold. The theory of biological evolution does not dictate eugenics theories or practices. Further, the theory is not evil just because some ideologues abused it for their evil purposes. Such a conclusion would be as unwarranted as characterizing the internet as evil because some terrorists post recipes for bomb making. This becomes even more obvious by considering that the theory of biological evolution actually worked against racism in at least two ways. First, the genetic theory of natural selection undermined the idea that parallel evolution of different human races would produce or had produced different human species. It did so by pointing out that races had not been separated long enough to have become different human species. Second, the genetic theory of natural selection emphasized the genetic unity of all humans by pointing out that all humans have a common ancestor. In that way it opposed discrimination based on race.

So far, I have argued that a Christian has the responsibility to remove distortion by background beliefs from science, that the communal nature of research in science helps guard against such distortion, that the removal of distortion is possible from a logical point of view, and that individual scientists have developed explanations and theories that went against their personal background beliefs. Distortion, however, is a derailment of the normal and generally constructive role of background beliefs. What is this role and how can background beliefs fulfill it without encouraging relativism?

4. THE CONSTRUCTIVE ROLE OF BACKGROUND BELIEFS

Normally background beliefs help construct good theories and explanations. A good theory goes beyond the data otherwise it could not explain anything (For details, see van der Meer 2000). Background beliefs contribute the part of a theory that goes beyond the data. Scientists are free to take any suitable background belief from their cultural context. Take, for instance, Galileo's theory of the tides. (http://www.pbs.org/wgbh/nova/galileo/mistake.html). He came upon it one day as he observed the movement of water in a gondola in Venice. As the gondola moved forward the water in it sloshed backwards piling up at the stern. Galileo thought the tides might be water piling up on a global scale. Picture the orbit of Earth moving around the sun once a year. At the same time Earth is also rotating daily anti-clockwise around its axis. Now draw an imaginary line connecting the centre of the sun with that of Earth. This line intersects the circumference of Earth at two points; one towards the sun (B) and the other (A) away from the sun opposite (B). At (A) the direction of Earth's orbit around the sun coincides with that of its axial rotation. With the two movements reinforcing each other, Galileo reasoned that water in the oceans would pile up at the trailing end of Earth just like it did in the gondola: high tide. At (B) the two movements would occur in opposite directions, one cancelling out the other and no water would accumulate. In fact water would flow to the other side: low tide. So far the theory based on a background belief borrowed from everyday life in Venice. Now let us consider the implications of this theory. For instance, Earth rotates around its axis in 24 hours. So Galileo's high tide moves around the globe in 24 hours and so does his low tide. But anyone living near the sea knows that there are two high tides per day. The background belief received no support from observation and had to be replaced.

I wrote that scientists are free to use any suitable background belief, but that is where the freedom stops. In theory construction, the support from a background belief can become permanent only if this belief corresponds with observation and with other well-established theories. Only then is it rational and justified to accept the background belief as true knowledge. Therefore, normally background beliefs do not distort scientific knowledge into a collection of arbitrary opinions (subjectivism). Nor do they make true knowledge of nature impossible (relativism). This is illustrated by the subsequent history of the theory of the tides which led to the true theory as we have it today.

Scientists are called to construct their theories in the closest possible correspondence with an objectively existing reality. If a background belief does not become knowledge, it will have to make place for a better alternative. Failure to do so is one of the reasons why the constructive role of a background belief can turn into a destructive one distorting the truth. The transformation of an open-minded attitude towards a theory to a close-minded one can be a gradual one as the case of Galileo demonstrates. Scientists are human and they do not easily part with their work. There can be many reasons for this reluctance. Let us look at an example.

Galileo and his contemporaries were aware of the shortcomings of his theory of the tides because there are two daily high tides at Venice instead of one, about twelve hours apart. Galileo dismissed this anomaly as the result of several secondary causes, including the shape of the sea, its depth, and other factors (Finocchiaro (1989), pp.127–131 and Drake (1953), pp. 432–6). While these were valid reasons for retaining his theory, Galileo had a far weightier reason to do so. His theory explained the tides as the result of the daily and annual movements of the earth. If true, the theory of the tides would become evidence for his theory of a planetary system with the sun in the centre. The latter was the crowning achievement of Galileo's career and the reason for his conflict with the church. The stakes were high. But in the end these personal and social interests made no difference. Observations shaped the understanding of the tides as we have it today. Already during Galileo's lifetime his colleague, the astronomer Kepler

had suggested that the moon was one of the causes of the tide and it is part of the explanation today (http://www.sjsu.edu/faculty/watkins/tides.htm). This shows how the communal character of scientific research screens out personal preferences.

When we look at the history of a theory such as the theory of the tides we see that the recruitment by science of support from culture may go through cycles. When a theory needs to be reconstructed a new background belief may be required again. Thus background beliefs need to be replaceable. They cannot be held dogmatically because at one point or another they will start to distort scientific knowledge.

The kind of background beliefs that are recruited to support a theory depend on local cultural and historical circumstances. From the Middle Ages through the Early Modern Era the Christian religion was an obvious source of background beliefs because the European culture was largely Christian. In current pluralistic Western societies a wide variety of other sources provide supporting background beliefs.

Background beliefs that function dogmatically are not the only ones inadmissible in science. God also cannot be part of a scientific explanation. This is in part because asserting that God created volcanoes, for instance, while true, would not explain where volcanoes are located or why they erupt. Scientific explanation has the narrow goal of finding material causes by learning from experience and God just is not a material cause because this would turn Him into a creature. Rather God is the Creator of all material causes. In this way a scientist is like the farmer in Isaiah 28: 23-29 for whom learning from experience is the same as receiving knowledge from the Lord. Further, if God were to be a part of an explanation, this would mean that God would be treated as if He were a variable to be manipulated by an experimenter. To treat God that way would be blasphemous and, therefore, totally unacceptable from a Christian standpoint. Finally, is it not appropriate to explain material phenomena in terms of material causes because God made them of matter?

5. SOME LIMITATIONS OF SCIENCE

So far I have argued that background beliefs are required for the construction of scientific explanation and that the two can be separated because they are not logically connected. But logical relationships between background beliefs and science are not the only relationship at issue. Mary Hesse (1985: 108) observed that

> Those (like philosophers) whose business is logic and argument are too prone to neglect the fact that there can be very important tendencies and plausibilities among ideas which are less than strict entailment, but which are highly influential upon thought, and are not simply exorcized by pointing out that they are not logically conclusive. We should look very carefully at such tendencies to see how far we ought to be pushed for good reasons to accept them, and how far we ought to resist them.

In other words, there is another kind of background belief that needs to be considered. It is the kind Abraham Kuyper had in mind when he spoke about the antithesis between the "two cities" of Augustine, Christianity and the world. He was pointing to the influence of background beliefs at a higher level of generality and farther removed from observation and theory than the background beliefs we have discussed so far. Two well-known examples of such high-level beliefs are naturalism and empiricism. The most incisive critique that has been leveled against them is that they are self-destructive.

The meaning of naturalism depends on one's view of nature. If nature is seen as purely material, then naturalism stands for materialism – the view that reality is made of nothing but matter. As Socrates argued long ago, materialism fails to account for non-material realities such as intentionality and

morality. For one, it is not able to explain the logic in a process of reasoning from assumptions to conclusions because the rules of logic are non-material realities. For another, materialism incapable of accounting for the reasons that motivate the person who makes the argument – the intentionality behind the reasoning. This means that materialism is incapable of accounting for the reasoning – scientific or otherwise – that goes into justifying itself. Finally, a denial of the reality of these non-material aspects of materialism means that it is self-destructive. There have been two responses broadly speaking. For one, materialists have denied that logical reasoning and the laws of logic are non-material realities or that they exist independent of material processes in the brain. All one can do is acknowledge that here we have two irreconcilably opposing philosophies. But, someone might counter, some forms of *naturalism* acknowledge non-material realities. Here another problem emerges. All forms of naturalism exclude God. This has given rise to a fatal critique of naturalism when combined with biological evolution, a critique that was first raised by Charles Darwin himself. In a letter to William Graham, July 3rd, 1881, Darwin wrote: "With me, the horrid doubt always arises whether the convictions of man's mind, which has been developed from the mind of the lower animals, are of any value or at all trustworthy. Would any one trust in the convictions of a monkey's mind, if there are any convictions in such a mind?" Philosopher Alvin Plantinga has developed Darwin's doubt into a logically rigorous argument to the effect that naturalism is self-defeating when combined with evolutionism. Briefly the argument goes like this. Naturalists claim that there is no God guiding the evolutionary process. If so, then our cognitive faculties have developed to maximize survival, not truth. It follows that any conclusion we reach about the world is untrustworthy, including the claim that evolution is true. Therefore naturalism joined to evolution (and everything else) is self-defeating and must be given up (Plantinga 1993: Chs. 11-12). For us to trust our own beliefs, we must believe that God exists, and that if evolution occurred God must have guided it.

Naturalism is different from the background beliefs we have discussed so far in two related respects. First, naturalism cannot become true knowledge of nature because its claim to universal validity cannot be supported scientifically. There is no observation or experiment that could support naturalism. This is another way of saying that naturalism is a philosophy or pseudo-religion that lies outside the competence of the natural sciences to confirm or deny. Second, it would be self-destructive for naturalism to use additional hypotheses in order to make specific claims about reality as is the case for the first category of background beliefs we discussed. The point of naturalism is to make an unspecific claim to universal validity. Making this claim more specific would destroy its universality. This universality implies that naturalism dictates the content of scholarship and reveals its all-encompassing pseudo-religious character. Christians and other theists characteristically reject the universality of naturalism by acknowledging that there is more to God's creation than just matter. But they would also acknowledge the material nature of part of this creation and recognize that it is appropriate to refer to material causes in accounts of material phenomena. This stance inevitably carries with it a recognition of the limitations of science – a recognition that the natural sciences deal with the material dimension of reality.

Empiricism is the belief that the only things humans can know are the things that can be experienced by the senses. Knowledge of nature cannot be had from visions, hallucinations or mere reflection. It must be based on sense perception. But we have already seen that scientific enterprise also requires the ability to argue about what is true and false. This ability cannot be established by science itself because truth and error are abstract realities. They cannot be perceived by the senses. Also from this angle it can be seen that science has needs that it cannot provide itself. Universal claims to the effect that sense perception can supply those needs are self-destructive as in the case of naturalism. The implication of this limitation of science is, that it cannot produce knowledge about things that are not perceivable such as values and God. Yet there are many who ignore this limitation. One such value is the notion that sense perception is the only valid method of acquiring knowledge. Others hold that if God can be known it must be by sense experience. Surprising as this may seem, this is how the controversial protestant theologian H.M. Kuitert

(1924-present) put it: all that can be known about God is known from below by experience, not from above by revelation. This is an example of how one kind of knowledge – empirical knowledge – has become the standard for all knowledge (empiricism). Empiricism fails because it ignores other ways of knowing such as knowing by acquaintance, knowing by witness, knowing by authority, knowing by faith, tacit knowledge, self-knowledge and knowledge from memory.

Thus empiricism and naturalism are similar in that the universality of their claims lead to self-destruction. It is the universality of their claims that make both of them different from the first category of background beliefs whose claims could be limited by adding specifying hypotheses. But empiricism is different from naturalism in that it is not a background belief about the character of reality, but about the way in which reality comes to be known. Therefore, it does not make sense to discuss whether empiricism might become true knowledge of nature as we did in the case of naturalism.

In general one finds two basic attitudes toward such high-level kinds of background beliefs as naturalism and empiricism. There are those who take scientific knowledge as the standard for all knowledge – a distortion known as scientism. For instance, the co-discoverer of the structure of DNA, Francis Crick, wrote that "The knowledge we have already makes it highly unlikely that there is anything that cannot be explained by physics and chemistry."(Crick 1966: 14, 98). The other group believes that there are other kinds of knowledge and respects the limitations of science. The Australian philosopher of science Alan Chalmers writes: "In addition to what is typically regarded as scientific knowledge, we have everyday, common-sense knowledge, we have the knowledge possessed by skilled craftsmen or wise politicians, the knowledge contained in encyclopaedias or stored in the mind of a quiz show expert, and so on." (Chalmers 1992: 25). Further, the British philosopher Mary Midgley asserts, "Science cannot stand alone. We cannot believe its propositions without first believing in a great many other startling things, such as the existence of the external world, the reliability of our senses, memory and informants, and the validity of logic. If we do believe in these things, we already have a world far wider than that of science." (Midgley 1992: 108).

In conclusion, we now have two kinds of background beliefs. There are background beliefs that can become true knowledge about nature and, thereby, become part of scientific knowledge. These background beliefs make limited claims about realities that can be perceived by the senses. But there are other background beliefs such as naturalism and empiricism. They do not rely on sense perception and, therefore, cannot become part of scientific knowledge. These background beliefs make universal claims about reality. That means that science cannot produce or justify this second class of background beliefs. This class must be acknowledged as containing philosophical or religious interpretations of scientific knowledge.

6. CONCLUSIONS

I began with the doctrine of creation and pointed out that, from a Christian perspective, scholars have the moral calling to oppose distortion in their understanding of natural phenomena. This is possible because there is an objectively existing creation, there are standard ways of detecting distortion of scientific knowledge by background beliefs (3.1) and because such background beliefs can be detached from scientific explanation (3.2). Next I showed that in their work scientists in fact do oppose their personal background beliefs (3.3). By and large, practicing scientists are thoughtful people who can distinguish between appropriate and inappropriate use of background beliefs. They understand that while background beliefs are required for the construction of fruitful scientific theories, background beliefs can be employed beyond appropriate boundaries. The difference between what is appropriate and

inappropriate is a matter of judgment and this is where cultural influences play a role. Authors have abused this situation to promote various non-scientific agendas cloaked with the authority of science. It is hard for the general public to separate the chaff from the wheat. This includes many Christians who have mistaken the need for such judgment calls as an opportunity to dismiss uncomfortable scientific knowledge on account of background beliefs, as if there was no objectively existing creation that can resist distortion. Instead they should engage in evaluating scientific knowledge in light of the facts of the matter and the roles, if any, of background beliefs. Inappropriate roles of background beliefs can be recognized when people claim that their background belief has universal validity and this results in self-destruction. The most recent example of many such assessments is *Absence of Mind* by Marilynne Robinson (2010). This stance of critical realism is what underwrites the reliability of the planes we fly in, the medical procedures that heal us, and the computers we use. The practical success of the natural sciences gives confidence that scientists are in touch with reality and that their explanations and theories are not easily distorted by the background beliefs they bring to their work. Christians can interpret this state of affairs as the result of an objectively existing created reality that resists distortion. No one can escape the force of this reality. This means that Christians can work with non-Christians in the enterprise of science. When there is a conflict of background beliefs they can appeal to the limitations placed by objective reality upon scientific knowledge and / or to the limitations of scientific knowledge itself.

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