PERSPECTIVES on Science and Christian Faith

JOURNAL OF THE AMERICAN SCIENTIFIC AFFILIATION

In This Issue …

"The fear of the Lord
is the beginning of Wisdom."
Psalm 111:10

VOLUME 67, NUMBER 3 **SEPTEMBER 2015**

(US ISSN 0892-2675) (CPM #40927506)

Perspectives on Science and Christian Faith

Perspectives on Science and Christian Faith
(USPS 28-3740, ISSN 0892-2675) is published quarterly by American Scientific Affiliation, 218 Boston Street Suite 208, Topsfield, MA 01983. Periodicals postage paid at Topsfield, MA, and additional mailing office. POSTMASTER: Send address changes to: Perspectives on Science and Christian Faith, 218 Boston Street Suite 208, Topsfield, MA 01983.

Manuscript Guidelines

The pages of *Perspectives on Science and Christian Faith (PSCF)* are open to original, unpublished contributions that interact with science and Christian faith in a manner consistent with scientific and theological integrity. A brief description of standards for publication in *PSCF* can be found in the lead editorial of the December 2013 issue. This is available at www.asa3.org under publications → PSCF → index. Published papers do not reflect any official position of the American Scientific Affiliation.

1. Submit all manuscripts to: **James C. Peterson, Editor, Roanoke College, 221 College Lane, Salem, VA 24153.** E-mail: jpeterson@roanoke.edu. Submissions are typically acknowledged within 10 days of their receipt.
2. Authors must submit **an electronic copy of the manuscript formatted in Word** as an email attachment. Typically 2–3 anonymous reviewers critique each manuscript considered for publication.
3. Use endnotes for all references. Each note must have a unique number. Follow *The Chicago Manual of Style* (16th ed., sections 14.1 to 14.317).
4. While figures and diagrams may be embedded within the Word text file of the manuscript, authors are required to also send them as individual electronic files (JPEG or TIFF format). Figure captions should be provided as a list at the end of the manuscript text. Authors are encouraged also to submit a sample of graphic art that can be used to illustrate their manuscript.

ARTICLES are major treatments of a particular subject relating science to a Christian position. Such papers should be at least 2,000 words but **not more than 8,000 words in length**, excluding endnotes. An abstract of 50–150 words is required. Publication for such papers normally takes 9–12 months from the time of acceptance.

COMMUNICATIONS are brief treatments of a wide range of subjects of interest to *PSCF* readers. Communications **must not be longer than 2700 words**, excluding endnotes. Communications are normally published 6–9 months from the time of acceptance.

BOOK REVIEWS serve both to alert readers to new books that appear significant and to engage these books in critical interaction. When a subject area editor selects a book for review, the book is then offered to a scholar with the best match in expertise. ASA/CSCA members who would like to be considered as potential reviewers are welcome to express interest to the book review coordinating editor for inclusion in the reviewer database. Publishers may also contact the book review coordinating editor if they are not sure which subject area reviewer would best consider a particular book.

- **Patrick Franklin** (patrick.franklin@prov.ca): book review coordinating editor; subject areas: ethics, philosophy, and theology.
- **Arie Leegwater** (leeg@calvin.edu): cosmology, history of science, mathematics, and physical sciences.
- **Sara Sybesma Tolsma** (stolsma@nwciowa.edu): biology, environment, genetics, and origins.
- **Heather Looy** (heather.looy@kingsu.ca): anthropology, neurology, psychology, and sociology.
- **Derek Schuurman** (dschuurman@cs.redeemer.ca): computers, engineering, and technology.

The viewpoints expressed in the books reviewed, and in the reviews themselves, are those of the authors and reviewers respectively, and do not reflect an official position of the ASA.

LETTERS to the Editor concerning *PSCF* content may be published unless marked not for publication. Letters submitted for publication **must not be longer than 700 words** and will be subject to editorial review. Letters are to be submitted as electronic copies. Letters accepted for publication will be published within 6 months.

ADVERTISING is accepted in *PSCF*, subject to editorial approval. Please address inquiries for rates or further information to the Managing Editor. The ASA cannot take responsibility for any orders placed with advertisers in *PSCF* and does not imply endorsement by carrying the ad.

A Sense of Place

James C. Peterson

Just before this editorial went to press, ASA/CSCA was gathered in Tulsa for our annual meeting. It was clear from the twenty-four-hour flames at the towered center of campus and at the front fountain of our main meeting hall, that we were both in oil country and at a place that seeks to honor the dynamic presence of the Holy Spirit. Place deeply shapes us. Our opening article on how we should treat human embryos is by D. Gareth Jones of the University of Otago, the oldest university in New Zealand. He brings a perspective informed by the Commonwealth, particularly down under, but has done his homework to address the specific experiences, literature, and legislation in the United States. Dialogue gains from insights far and near, but always eventually is played out for each of us in a specific context.

The next piece addresses fracking wherever it occurs, but particularly from the experience of the shale fields in Pennsylvania. The production of oil and gas there has been revived by this new technology, but local well water, in some cases, has been contaminated. Bruce Beaver, at Pittsburgh's Duquesne University, sees fracking as worth the risk when it is rightly controlled. It is then less damaging than the alternatives of burning coal or making power too costly. For a time, he argues, it is our best available energy source to support people and the environment.

Our third article comes from Wilton Bunch in the deep south of Alabama, where he teaches at Samford University. That is a place of ecumenical intersection, particularly between the locally prominent Baptist, Reformed, and Wesleyan traditions. It lends itself to hearing from and challenging responses to the often-voiced question of how to think about and pastorally respond to a world that is God's, and yet has piercing suffering. The author has had reasons to feel that challenge acutely, and draws from part of how we do science, to address it.

Michael Tenneson, David Bundrick, and Matthew Stanford then advocate a typology for how science and Christian faith relate to each other. They test it in places that they know well, such as with Assembly of God pastors and students.

Jean Claude Parlebas reports from France, a place proudly all its own. At our 2014 annual meeting, we gathered delegates primarily from the jointly sponsoring American Scientific Affiliation, Canadian Scientific and Christian Affiliation, and the UK's Christians in Science. Parlebas reminds us that the interaction between science and Christian faith is fruitful in the French-speaking world as well. He focuses, in particular, on the past and present impact of Blaise Pascal. Pascal was a man of his place and time, from whom can still learn in our place and time.

Our book reviewers write in this issue from Massachusetts, British Columbia, and Alberta, and there is a letter to the editor from the northern plains of Alberta as well. This editorial is being written amidst the Blue Ridge Mountains that overlook Roanoke, Virginia. What a privilege to listen to and learn from the people and situations of so many places. We can then contribute back to that wide dialogue, yet part of our contribution and so much of our application will be local with all the unique concerns and nuance that such entails. Our Lord came for us in all places, but to be truly human, started in a particular place, as we always do as well. ✦

James C. Peterson, *editor*

In Vitro Fertilization and the Destruction of Embryos

D. Gareth Jones

D. Gareth Jones

The emergence of in vitro fertilization in the late 1970s and early 1980s was met by mixed responses within Christian circles. These varied from outright hostility amid fears that human life as we know it was threatened, to guarded acceptance of the major procedures. The destruction of embryos was integral to the development of in vitro fertilization as demonstrated by the initial work of Robert Edwards in the UK. This destruction continues as procedures are improved to protect the interests and well-being of future children. For many Christian commentators, the centrality of embryo destruction in abortion, and subsequently in the debate over embryonic stem cells, has overshadowed debate on the loss of embryos during in vitro fertilization. Consequently, the tension between protecting embryos on the one hand and accepting the legitimacy of in vitro fertilization for infertile couples remains unresolved for many Christian commentators. In order to highlight the issues involved, the arguments of a range of commentators are assessed. These include those of contributors to God and the Embryo, *the political debate in the US during the Bush era, Ted Peters, the Vatican, the Christian Medical and Dental Associations, Edwin Hui, John Wyatt, and Richard Higginson. It is concluded that Christians can be open to the blessings of scientific developments such as in vitro fertilization, as long as their limitations and possible misdirections are taken into account in decision making.*

In vitro fertilization (IVF) appears to be generally accepted by the Christian public,[1] and yet it is a phenomenon that has elicited considerable debate within Christian circles. Many within these circles viewed the emergence of IVF in the late 1970s and early 1980s as a mixed blessing.[2] For some, it was a threat to human life and to fundamental Christian values about the meaning of human life.[3] For others, it was a challenging new development in the reproductive technologies, but one that could assist those confronted by issues of infertility.[4] Over subsequent years, there have continued to be subtle undertones of tension between science and faith over how to respond to the intrusion of these technologies into the very intimate areas of human begetting.[5]

What was surprising is that the churches and most theologians (with the exception of Paul Ramsey) had shown practically no interest in this whole realm throughout the 1960s and 1970s, a period when all the essential scientific studies leading to IVF were taking place.[6] None of this work had been carried out in secret. Moreover, Robert Edwards, the reproductive physiologist who almost single-handedly brought developments in human beings to fruition, wrote extensively on the ethical repercussions of IVF.[7] He longed for debate with politicians, philosophers, theologians, and policy makers, but to no avail. IVF lay in the future; it was of very little interest compared with abortion and overpopulation.[8]

However, once the first IVF babies were born, the scene changed. It became clear

Gareth Jones *is Emeritus Professor in the University of Otago, Dunedin, New Zealand. He is associated with the Department of Anatomy and the Bioethics Centre at that University and can be contacted at gareth.jones @otago.ac.nz.*

that these children were largely healthy and were not seriously malformed. An unlikely technique had become the hope of many infertile couples longing for a child. In the UK, the 1984 report of the Warnock Committee of Inquiry set the path for UK legislation, and many of its recommendations—contentious as some of them were—proved crucial for debate and subsequent legislation in that country.[9]

At long last the churches and Christian organizations woke up and realized that something dramatic had occurred, something for which they were ill-prepared. Having spent years arguing for protection of the fetus in the context of abortion, they were now confronted by the very early embryo in the context of IVF. Unfortunately, few had expertise in embryology, and they now came face-to-face with embryological terms such as blastocyst, inner cell mass, and primitive streak. However, even now there are far more Christian statements on the destruction of embryos in the production of embryonic stem cells and even on cloning than on their destruction in IVF.[10]

IVF and the Destruction of Embryos—Scientific Background

In considering the relationship between IVF and the destruction of embryos, it is vital to inquire whether IVF can be completely separated from their destruction. This scientific consideration has immense implications for ethical and theological debate on IVF in its simplest forms, namely, within the husband-wife relationship and even without the production of embryos surplus to the requirements of such a couple.

In order to be able to study human development, sufficient embryos had to be obtained, and this meant that IVF had to be a viable procedure in humans. By the mid-1960s successful IVF had been achieved in rabbits,[11] hamsters,[12] and mice.[13] In 1969, research on the pH of the insemination medium for human sperm led to the crucial paper that demonstrated the fertilization in vitro of human oocytes.[14] Enormous interest focused on the normality of the embryos produced by IVF, since this work was highly controversial within scientific circles as well as among the general public and media.[15] All the work carried out by Edwards and collaborators prior to 1969 had been on mice, rabbits, or rats.[16] From the 1970s onward, attention was directed far more onto human oocytes. However, this move from laboratory animals to humans was demanding scientifically and clinically. Against the background of his previous work on the reproductive biology of the mouse, Edwards and gynecologist Patrick Steptoe made a series of discoveries that demonstrated that 16-cell stage human embryos could be obtained in vitro. They then started to transfer these back into women. Unfortunately, a large number of initial attempts led to short-lived pregnancies, since the hormone treatments being used disturbed implantation of the embryo in the uterus, resulting in spontaneous abortions. It was a change in the hormone treatment protocol that led to the first successful pregnancy in 1976.[17] Unfortunately, the embryo had implanted ectopically in the Fallopian tube and the pregnancy had to be terminated. Further modifications led to the birth of the first healthy baby in 1978.[18] For an overview, see the announcement accompanying the award of Edwards's Nobel Prize in 2010.[19]

This brief outline demonstrates that IVF in human beings would not have eventuated in the absence of a considerable amount of highly innovative research using human tissue. This has continued unabated over subsequent years since research using human embryos is intimately woven through every aspect of IVF.[20] It is an ethical requirement that the procedures used are as effective and safe as possible, since as pointed out by ethicist Ronald Green, "we wrong a future child by carelessness or neglect in our reproductive conduct."[21] This does not eliminate the need for previous animal research, but it recognizes the limitations of animal models (interestingly, some recent developments in the artificial reproductive technologies [ARTs], such as the widespread introduction of intracytoplasmic sperm injection [ICSI], may have moved too rapidly into the clinical arena). Nevertheless, ongoing research on human embryos is essential if IVF is to take adequate notice of the interests and welfare of future children, an outworking of theological concerns as much as of general ethical ones.

IVF and the Destruction of Human Embryos—Abortion

Against this scientific backdrop with its reliance upon embryo destruction, one might expect responses to IVF to be closely aligned to viewpoints on abortion. Strong opposition to abortion might be

expected to lead to opposition to IVF based on an embryo-protection stance stemming from the concept that "human life begins at conception."[22] Many have viewed this stance as relevant for the abortion debate, since it draws a line in the sand at fertilization, beyond which no prenatal human life is to be sacrificed. It is a means of protecting all life before birth and gives practical expression of the notion that all human life is sacred—from its earliest manifestations onward.

The anti-abortion rhetoric, however, only infrequently took note of IVF. What is interesting is that the major anti-abortion campaigns (within the evangelical constituency) came to a head in the 1970s and 1980s, at a time when IVF was being developed but before any serious interest in IVF was shown by the same evangelicals. With attention focused on abortion, IVF entered mainstream medicine relatively undetected, at least in public debate. However, by now, IVF was locked into the anti-abortion mindset for a large number of evangelicals, on the ground that "human life begins at conception."

Nevertheless, some Christian writers took note of IVF. Following the release of the Warnock Committee of Inquiry Report in the UK in 1984, there was an outpouring of criticism of what was viewed as the permissive and liberal agenda of the Report. However, this was six years after the birth of the first IVF child in 1978, a period during which well over 1,000 children had already been born using IVF in the UK. And so these commentators, lamenting what they saw as the intrusion of secular forces into the reproductive realm, were writing long after the biotechnology revolution had become established.

However, even this response tended to be submerged beneath more general concerns at other biotechnological developments (both real and highly speculative). Hence, far more attention was directed at cloning, stem cell research, genetic possibilities (the new genetics), eugenics, embryo research, and prenatal diagnosis, than at IVF.[23] Some recognized that opposition to the destruction of embryos had implications for IVF, and some were openly negative toward IVF, but opposition was muted compared with opposition to possibilities such as cloning and eugenics.

Almost total emphasis upon the moral value of the embryo has been the driving force behind sentiments such as these, stemming in large part from opposition to abortion. Arguments repeatedly encountered in the evangelical literature elevate the status of the embryo to one in relationship with God, an image bearer of God, an innocent human being with an inviolable right to life, a neighbor and fellow traveller.[24] Such an elevated status leaves no room for the deliberate destruction of embryos. These arguments are principally found in opposition to abortion and research on embryos rather than in discussions on the practice of IVF.

There are exceptions. Jennifer Lahl considers IVF to be tantamount to abortion.[25] Albert Mohler also recognizes this and rightly comments that if embryos are destroyed in IVF, it is, from his perspective, a troubling procedure. He writes:

> Far too many evangelicals seem to turn a blind eye to this reality. While we celebrate the birth of a child and the gift of life, we cannot blind ourselves to the harsh and grotesque reality that this technology also means the destruction of human life.
>
> Many evangelicals fail to see what many proponents of human embryonic stem cell research have noted—a glaring inconsistency in condemning the destruction of human embryos through stem cell research, while ignoring or dismissing the destruction of embryos in IVF clinics.[26]

However, they tend to limit their concern to the production of surplus embryos in IVF programs, without explicitly acknowledging that embryo destruction is implicit within IVF from its earliest stages through to the present. To quote Mohler again: "At a bare minimum, Christian couples must commit to the implantation of all embryos, and the selective reduction of none."[27]

It is surprising that he does not go further than this and condemn IVF outright. It is true that he considers that IVF cannot be encouraged, since in his eyes it amounts to "the wanton destruction of human life, and is morally and medically indefensible."[28] This is what one would expect of someone for whom the termination and disposal of human embryos in IVF "is a reminder that the gruesome reality of the Third Reich is never far from us."[29]

Some commentators have noted that evangelicals have readily accepted IVF, in contrast to abortion and stem cells, by adopting a variety of compromise positions that allow them to accept this means

of family-building.[30] One has even argued that it is legitimate to freeze embryos as long as they are not subsequently destroyed.[31] Others though object. Lahl argues that "if embryos are human lives, it is time for Christians to be consistent about their moral objections and unite against IVF."[32] These, however, are minority voices, even within those sections of evangelicalism strongly opposed to abortion and the general thrust of the ARTs.

Limitations of the Abortion Model

Roe v. Wade (1973) in the USA and the Warnock Report (1984) in the UK each galvanized the evangelical communities. In their different ways, each was seen as a step too far, but in each case the issues were depicted as a contrast between extremes: pro- or anti-abortion, pro- or anti-IVF. However, while the former fits neatly into the pro-choice versus pro-life paradigm, it is difficult to express the IVF situation in these categorical terms. For most, whatever their doubts about IVF and the destruction of embryos, the end-result is in no way comparable to the end-result of abortion.

The language of "silent holocaust" that has been featured on occasion in the abortion debate sits uneasily with IVF.[33] Even if the destruction of embryos is regarded as a holocaust, the arrival of a baby hardly fits this picture. Hence, there is immediate tension. Even if babies are thought to be the creatures of the doctors who were in part responsible for bringing them into existence, the future child/individual is hardly going to be treated as some form of "not-quite-human" creature (there is no evidence that this is the case in the IVF literature[34]). And where does God fit into this alarming picture, since he cannot have been excluded simply because there has been human assistance in bringing beings into existence? No such concerns are raised over standard obstetric care, even when this involves scans throughout gestation, bed rest, technologically dependent treatment in neonatal intensive care units for very preterm infants, or hormonal treatment before and after fertilization. In many of these instances, the birth of a live child would not have eventuated had there been no technological assistance.

This ambivalence toward IVF reflects differences between abortion and IVF. For those who view the destruction of embryos as being akin to the destruction of postnatal human beings, abortion is an unmitigated evil under all (or most) circumstances. By contrast, IVF is not entirely evil since the intended end result is a much-wanted child. While abortion may be deemed life destroying, IVF is—in the main—life affirming, as long as a balance is attained between the life-destroying aspects of embryo destruction and the life-affirming element in the birth of a child. It is easy to accept completely or reject completely a position such as abortion, but with IVF there is not this simple solution. This does not provide justification for IVF, but it demonstrates the limited relevance of the abortion model.[35]

Abortion is associated with feelings of relief or grief because of the absence of a child. IVF is (if the procedure works as hoped) accompanied by joy at the presence of a child. This child has all the potential and aspirations of any other human being, and is as much a child of God as one conceived without technical assistance. In no way does this invalidate concerns based upon the potential reductionism of a technological approach like IVF, but it does look to a broader framework than one predicated by opposition based solely on an anti-embryonic-destruction mentality.

IVF and the Destruction of Human Embryos—Stem Cells

One strand within the abortion debate, namely, that the protection of embryos is paramount and that human beings should not interfere with what God has or has not given, has had repercussions in other areas. Consequently, when the debate on stem cells entered the public arena in 1998,[36] the therapeutic prospects held out for embryonic stem cells (ESCs) elicited many responses from Christian commentators. While these varied in content and direction, a negative reaction emerged time and again on the ground that this would involve the destruction of embryos.[37] The debate on ESCs was part of the wider debate on embryo research, although much of the latter had a very strong orientation toward stem cells, as demonstrated by the regulations governing embryo research in many jurisdictions.[38] Surprisingly, even in this debate, little attention was paid by Christian writers as well as others to the role of embryo research in the development and ongoing sustenance of IVF.

God and the Embryo

This is illustrated by the edited volume, *God and the Embryo*, published in 2003.[39] With the subheading, "Religious Voices on Stem Cells and Cloning," it was a response to the newly developing debate on embryonic stem cells. As such, greatest attention was paid to stem cells with limited attention to cloning. Inevitably, the status of the embryo underlying these debates constituted one section of the book. While the contributors came from a variety of disciplines and theological backgrounds, little attention was paid to IVF, even though it represented a well-attested reproductive procedure of considerable relevance to the theological debate on embryos and ESCs.

However, Ronald Cole-Turner, one of the editors, was puzzled that views on embryo research were not always reflected in positions on IVF.[40] He commented that one might have expected that anyone who permits couples to create multiple embryos for reproductive purposes might also allow scientists to carry out research on embryos. From this he deduced that greater value is being placed on reproductive freedom than on scientific freedom. His conclusion was that

> we have created an incoherent body of policies that permits abortion, privatizes and thereby ignores in vitro fertilization, prohibits public funding for embryo research and thereby avoids any federal role in overseeing it, but permits privately funded research to do whatever it wants.[41]

While this was written within a specifically American context, its thrust can be generalized to ethical and theological debate elsewhere.

Also of relevance was Cole-Turner's further comment that many religious organizations have accepted IVF without comment, but object to the creation of embryos for research purposes. This acceptance of IVF was, in his eyes, so routine that their members could choose to utilize it almost as if faith played no role in the decision.[42]

The only contributor in the *God and the Embryo* volume to engage with IVF is Gene Outka, philosopher and Christian ethicist, who writes against a background of the widespread acceptability of IVF within society, and hence a procedure that has to be addressed as a fait accompli.[43] While writing within the context of ESCs, he confronts in detail how we treat surplus embryos in IVF programs as well as embryos created explicitly for research purposes. In sketching an approach to these embryos, he refers to the concept of perpetual potentiality, and the "nothing is lost" principle. This leads him to regard research on embryos, including excess embryos, as something in which one acquiesces only reluctantly and hesitatingly. He looks forward to the day when there will be no need to destroy embryos and when it will be possible to reprogram adult stem cells. His position allows him to distinguish between creating embryos for research and employing them for research. While he rejects the notion that abortion and ESC research are morally indistinguishable from murder, neither does he consider that they are morally indifferent actions. They are to be judged by the benefits they might bring to others.

Outka, therefore, represents a carefully nuanced theological position, in which the links between abortion, IVF, ESCs, and embryo research are elaborated and assessed. His "middle" position between "right" and "left" on the necessity of ESC research takes seriously both theological and scientific challenges and possibilities, and accepts that IVF is an integral player within this whole realm.

Political Debate in the United States

In the United States, the debate surrounding ESCs took an unusual turn when it entered the world of politics. While this was not ostensibly for theological reasons, there seems little doubt that the stance adopted by then President George W. Bush was to the liking of many Christians. On August 9, 2001, he spoke to the nation about ESC research, when he declared that "embryonic stem cell research is at the leading edge of a series of moral hazards."[44] He announced that the use of NIH (federal) funds would be permitted for research on an estimated sixty stem cell lines already in existence as of that date. These lines must have been derived from embryos surplus to the requirements of IVF programs. No new embryos could be destroyed in deriving ESCs using federal funds.

The aim of this dictate was to encourage respect for human life while exploring the promise and potential of stem cell research in finding cures for debilitating diseases. Unfortunately, the stem cell lines already in existence, plus additional ones potentially eligible for federal research funding, failed to live up to ethical

standards set by the Food and Drug Administration (FDA).[45]

Regulations governing ESCs fall into four dominant positions. These were designated A to D by Towns and Jones.[46] Position A encompasses countries that prohibit all embryo research and therefore the extraction of ESCs. Position B confines the use of ESCs to those currently in existence, in that they were extracted prior to a specified date, thereby prohibiting the extraction of ESCs and utilization of ESCs derived in the future. Position C allows for the use and ongoing isolation of ESCs from surplus IVF embryos from IVF programs. Position D allows the creation of human embryos specifically for research via both fertilization and somatic cell nuclear transfer (SCNT). In 2006, the Hinxton Group, an international consortium on stem cells, ethics and law, again identified four groups: Prohibitive (equivalent to A), Restrictive Compromise (B), Permissive Compromise (C), and Permissive (D).[47] The classification adopted by the European Science Foundation is similar, but omits a position B equivalent.[48] The groups are Very Restrictive (corresponding to A), Permissive (C), and Very Permissive (D), with further categories of Restrictions by Default (where legislation is not explicit, but national practices are quite restrictive in practice), and Unlegislated (where there is no legislation on human ESCs).

It is not the intent of this article to delve into where different countries fit into these categories, except to state that the position adopted by President Bush in 2001 was that of B. What is relevant for present purposes is to compare Positions A and B. Position A (Prohibition) exemplifies the stance that human life commences at fertilization, allowing nothing to be done to the embryo that is not in its best interests. Such a stance would also be expected to disapprove of IVF, the production of surplus embryos, and the derivation of ESCs from these embryos. Its emphasis is entirely on harm done to embryos, rather than on benefits that might accrue from research using ESCs. It neglects any interests beyond those of the very early embryo, including those of persons with fertility problems.

The intention of position B (Restrictive Compromise) was to allow some research on human embryos, while aiming to protect embryos. This was achieved by allowing research only on stem cell lines already in existence, since the embryos from which these lines had been extracted had previously been destroyed. The destruction of any further embryos was forbidden. This compromise position took note of the plight of people with severe degenerating conditions who could, possibly, benefit from scientific advances.[49] However, these restrictive ESC guidelines fail to protect the large numbers of embryos destroyed daily by IVF procedures in fertility clinics. This is the nub of the conflict as I see it. While the debate was on the production of ESCs, it applies just as forcefully to the destruction of embryos in IVF.

Position B is an attempt to allay the fears of those who see embryo research as commodifying the human embryo, while appeasing those who wish to pursue the therapeutic potential ESCs offer. As a result, this position gives the appearance of upholding an absolute position on the inviolability of the embryo while allowing a moderate amount of research to occur using already derived material. However, ethical inconsistency arises from the ongoing creation and destruction of embryos produced in the IVF programs that exist in most countries.[50]

Christian commentators are generally found within positions A–C, with very few opting for the most permissive position represented by D. The reality, however, is that in practice few reject IVF as demanded by position A, even if they bestow full moral value on embryos from fertilization onward. Most fall by default into category C no matter how problematic this appears to them. I return to specific examples in the section Confronting IVF.

Sacred Cells?

Another contribution to unpack the subtle relationships between the various dimensions within the reproductive technologies is that of Ted Peters. In a provocatively titled book, *Sacred Cells? Why Christians Should Support Stem Cell Research*, written in 2008 with Karen Lebacqz and Gaymon Bennett, Peters employs three ethical frameworks: (1) embryo protection, (2) human protection, and (3) future wholeness.[51] Official Roman Catholicism and many sectors within evangelical Protestantism are identified within an embryo protection framework with its pro-life, anti-abortion stance. The (then) President's Bioethics Council and Leon Kass are seen as major exponents of the human protection position that stresses the dangers of "playing God" and of excessive technological prowess. The authors, Peters,

Lebacqz, and Bennett, advocate the third framework, with its emphasis on exploiting possible medical and associated benefits that may accompany stem cell and allied research.

For Peters, Lebacqz, and Bennett, the embryo protection position serves to reiterate the abortion debate. For them, this position depends on genomic novelty, constituting as it does the bulwark for indicating the presence of a unique individual, ensoulment, and with it a moral claim based in the will of God. Accompanying this position are closely aligned variants, such as the assertions that it is better to be safe than sorry and that all blastocysts are sacred. In this instance, the ethical principle that comes to the fore is nonmaleficence—of embryos in this instance. The authors contend that the same applies with the human protection framework, when it is nature (DNA) and culture that require protection. Beneficence comes into play only when emphasis is placed on human flourishing and the vision for a better future. The authors view this possibility in theological terms. For them, humans are called to be created co-creators, possessing the talent for creative transformation. This future-oriented ethic lies at the heart of their positivity toward stem cell research, but they are careful to replace the hype so often surrounding this research with hope—genuine theological hope in the future. They are emphatic with their assertion that "the promise of redemption tells us that our future is not restrictively determined by our past."[52]

Once again the ability to accept IVF and stem cell research depends upon a view of the human embryo. For Peters, one should not confine one's attention to the embryo's genetic origins, since this omits God's eschatological call to become who we are destined to be.[53] This is closely allied with gifts given us by God, namely, our creativity as human beings, the glimpse we have been given of God's promised future, and our ability to make decisions for the good. From this, stem his major themes. The first is dignity that is ultimately conferred by God; this in turn is relational in character and is derived from destiny and not origin. A second characteristic of Peters's position is that, since the spotlight is no longer directed exclusively onto the early embryo, the principle of beneficence can be included in ethical calculations. This allows him to examine all other groups that might benefit from a greater understanding of the embryo, emanating possibly from research on the embryo. Third, the promise contained within this future vision can only be brought about by creativity, something that Peters sees as fundamental to human existence.[54]

These principles allow Peters considerable liberty in allowing embryo manipulations, not as ends in themselves, but guided by the beneficence argument. The good of others in the community may on occasion trump the good of embryos. It is within this context that IVF is to be seen, allowing both the procedure itself and research on surplus embryos from such programs.

Confronting IVF

While, in my view, much discussion about IVF has been distracted by debate about abortion and, more recently, stem cells, there have been attempts to address IVF in its own right. In this section, I shall cover a range of responses to illustrate how different segments of the Christian church have reacted.

Vatican Stance

The first is that of the Vatican with its definite positions on interference with the earliest stages of human development. This was first enunciated in the 1987 instruction *Donum Vitae*[55] that condemned the voluntary destruction of human embryos obtained in vitro for research purposes.[56] Researchers are, it asserted, usurping the place of God, since they are choosing which embryos will be allowed to live and which will be "sent to death"; "defenceless human beings," it asserted, are being "killed." IVF was condemned since it was seen as giving to biomedical scientists power over the life and identity of embryos, "leading to the domination of technology over the origin and destiny of the human person." These positions were reiterated with a few minor amendments in 2008 with the instruction, *Dignitas Personae*.[57]

The importance of referring summarily to these official positions from the Vatican is to acknowledge the consistency of logic within them. This is not to accept their assumptions or directions, which incidentally have been criticized by a range of Roman Catholic ethicists,[58] but to show how a particular view of the moral significance of the moment of conception may lead to opposition to abortion, artificial contraception, embryo research, the freezing of embryos and

oocytes, IVF, ICSI, preimplantation genetic diagnosis (PGD), and any donation of embryos. *Dignitas Personae,* in particular, seeks to defend the dignity of the human embryo on the grounds of its being personal from conception onward. Embryos are sacrosanct, leading to the simple conclusion that there is to be no technological interference or human control over embryos or any aspect of the reproductive processes.

Two North American Contributions

The Christian Medical and Dental Associations (CMDA) set out its position on IVF and allied ARTs in 2010.[59] Taking into account that this was over thirty years since the first IVF birth, there had been ample time for reflection on the variety of relevant issues and principles.

CMDA accepts that many ARTs may be an appropriate expression of humankind's God-given creativity and stewardship under certain circumstances. The principles guiding this position are

- Fertilization resulting from the union of a wife's egg and her husband's sperm is the biblical design;
- Individual human life begins at fertilization;
- God holds us morally responsible for our reproductive choices;
- ART should not result in embryo loss greater than natural occurrence.

In light of these principles, CMDA considers that a number of procedures are consistent with God's design for reproduction. These include

- Artificial insemination by husband (AIH),
- Adoption, including embryo adoption,
- IVF with wife's egg and husband's sperm, and
- Cryopreservation of sperm or eggs.

The following are thought to be morally problematic:

- Introduction of a third party (any use of donor egg or sperm),
- Gestational surrogacy, and
- Cryopreservation of embryos (on condition that all frozen embryos will eventually be transferred back to the genetic mother).

The following are deemed inconsistent with God's design for the family:

- Discarding or destroying embryos,
- Uterine transfer of excessive number of embryos,
- Destructive experimentation with embryos,
- True surrogacy,
- Routine use of PGD, and
- PGD done with the intention of discarding or destroying embryos.

This statement demonstrates very nicely the conflicting tensions that have to be negotiated by those prepared to accept IVF and who start from the premise that individual human life—and one imagines, individual moral value—commences at fertilization. This leads to the view that embryo loss should not exceed that encountered in natural fertilization. This is a valid conclusion, but since up to 70% of embryos are lost naturally (although estimates over the years have varied substantially),[60] this leaves considerable leeway in IVF. For instance, if twelve embryos are produced following ovarian stimulation, three are lost following embryo transfer, two lead to successful pregnancies and the remaining seven are discarded (or used in research), then the percentage lost is less than 60%. These figures can, of course, be adjusted endlessly, but they indicate that the loss of embryos in IVF, even with the production of embryos surplus to the requirements of the IVF program, may not be too far removed from that encountered naturally.

The prohibition of discarding or destroying embryos is meant to protect embryos, as is opposition to PGD with its greater destruction of embryos than in IVF alone. Opposition to research on embryos, including surplus embryos, is intended to serve the same purpose. However, acceptance of IVF itself entails acceptance, albeit unwittingly, of embryo destruction, both during the early years in which IVF was being established as a viable procedure and also in ongoing research (see section, IVF and the Destruction of Embryos—Scientific Background). In view of this, one is led to ask whether the prohibition encountered in this statement is as helpful ethically and theologically as suggested.

An allied consideration is raised by the acceptance of "embryo adoption," once again one imagines

as a means to preventing the destruction of surplus embryos. However, this involves donating an embryo from one couple to another, something that goes against a procedure considered to be morally problematic, namely, the introduction of a third party into the marital relationship.

While making these critical points, I wish to acknowledge the legitimate concerns underlying the statement and its various provisions. They take seriously the moral value to be ascribed to prenatal human life, and they seek to uphold the importance of the family. They also wish to make use of the benefits arising from technological interventions in reproduction to assist those with fertility problems. However, in my estimation, they downplay the nature of IVF and the scientific research that underpins it, research that has implications for the value we ascribe to human embryos.

Another significant contribution to this debate is that of Edwin Hui with his 2002 book, *At the Beginning of Life: Dilemmas in Theological Bioethics*.[61] For Hui, the human embryo is a human person from conception onward and hence is to be treated with the respect granted to persons.[62] This leads him to the view that any form of embryo manipulation violates an ethic of personhood and compromises the integrity of the embryonic community.[63] In line with this stance, he contends that any embryo research not for the benefit of the embryo in question cannot be endorsed as moral. This includes the use of surplus embryos in IVF programs since they have been made to represent "redundant" human lives.[64] From this it follows that one should protest against IVF as well as other forms of the ARTs and surrogacy.

Definitive as this position appears, his chapter on IVF is devoted to concerns that center on potential harm to embryos, potential physical and psychological harm to resulting children, and adverse effects on couples, with further concerns based on the medicalization and commercialization of IVF and allied procedures. While each of these is ripe for serious analysis (many follow-up studies have been conducted on families with IVF-conceived children), it is interesting that the intimate link between IVF and embryo research is not highlighted as the dominant reason for categorizing IVF as morally untenable.

Two English Contributions

John Wyatt, a respected British commentator on bioethical issues, deals at length with issues at the beginning of human life in his book, *Matters of Life and Death*.[65] His aim is to express a biblically informed position on issues encountered before and after birth, starting from a high view of human life including that of the embryo. As a pediatrician he is well aware of clinical realities and of the suffering caused by infertility and congenital abnormalities, and by the good that can be brought about by the use of medical technology. How then does he cope with the conflicting demands of a high view of the embryo and the potential benefits of IVF? Wyatt contends,

> It is at fertilization that the particular configuration of the human genome is created. It is at fertilization that the image of Adam is passed on to the next generation. Even the early embryo is a being "in Adam."[66]

In light of this, "an appropriate response is to vote in favor of protection and against intentional destruction" of the embryo.[67]

Since, in his view, the creation order posits that sex is the unique way of constructing a baby, ideally there should be no separation between this and its procreative aspects. But he concedes that IVF can be accepted when used to assist an infertile couple to have a child genetically related to them. The logic here is that this is bringing together what the Fall has separated. Nevertheless, he remains troubled by many facets of IVF, namely, its intrusive nature, the production of spare embryos, and its dependence upon many years of embryo research. His conclusion is that

> IVF may be acceptable for a married couple provided that no spare embryos are created, but that the possible negative consequences need to be very carefully considered before embarking on this course.[68]

This is a nuanced and human response to a taxing situation. However, it fails to address some crucial considerations. The destruction of embryos in the early stages of the development of IVF and in its ongoing clinical modifications is bypassed. No technology, least of all IVF, can rely on scientific understanding and concepts lying ten, twenty, or

thirty years in the past. This is especially so when the health and well-being of future children is at stake. Embryos have been and will continue to be destroyed as long as IVF is employed. For many this is not a major problem, but it should be for those who regard embryos as vulnerable human beings to be protected and defended. If embryos are "one of us," loved by God as we are, and to be protected as the most vulnerable and innocent of humans, it is imperative to provide cogent reasons why IVF might on occasion prove acceptable, even with substantial stipulations and provisos.

One writer who did tackle the apparent discrepancy head-on was Richard Higginson.[69] He attempted to balance the demands of what he thought was the wrongness of the initial work carried out on embryos against what might be the legitimacy of some research on spare and defective embryos in the present. He reached the conclusion that there is nothing intrinsically wrong with IVF for couples eager for a child and incapable of conceiving in any other way, but he was also aware of the pitfalls associated with regarding IVF children as products. A valuable insight of his was that it is unreasonable to expect a higher standard of IVF procedures than that found in natural fertilization.[70] In expressing the matter in this way, he cast doubt on the idealism so often shown by those who view embryos as practically sacrosanct—they are flagrantly dispensable in nature, with numerous embryos routinely lost in bringing each new individual into existence. While this provides neither ethical nor theological guidelines for what should or should not be done with or to embryos in the laboratory or clinic, it is a salutary reminder of the fragility of embryos.

Should Christians Positively Embrace IVF?

A degree of positivity toward scientific and technological innovations in the reproductive area will mean being prepared to acknowledge explicitly that it is acceptable to destroy embryos under certain circumstances, and to encourage research on (surplus) embryos. This in turn acknowledges the role of science in alleviating disease and in rectifying what may have gone amiss during development.

Christians should be open about the blessings of scientific investigations in spite of distressing misdirections by those longing to remodel humanity according to their own self-centered aspirations or ideals. Everything that is possible in science should not be undertaken. And societies, including Christian communities, can decide that they do not wish to be involved on ethical grounds. Similarly, those with ethical objections to research on human embryos are under no obligation to utilize IVF, and probably should not do so. All of us draw lines at one point or another. What is crucial is that we clearly assess the grounds on which those choices are being made.

In any assessment of IVF, the driving impetus is to ask what might be most pleasing to God. Phrasing the predicament in these terms points to the centrality of Christ and to biblical directives emphasizing humility, an ethic of responsibility, and stewardship of God's creation. It demands a close examination of one's motives in wanting a genetically related child of one's own as opposed to remaining childless, wanting a child without a genetically debilitating condition, fostering children, or adopting children in dire need.

The welfare of families, family relationships, and individuals should be central, stressing the significance of marriage. This is central to Christian life in society, since it throws the focus onto the significance of humans in the eyes of God—as his beings and, for Christians, as his people. Whatever limits are imposed flow from this framework. The welfare of embryos will not be ignored, but they are no longer the only consideration. ✦

Notes

[1]Pew Survey March 21–April 8, 2013, "Abortion Viewed in Moral Terms: Fewer See Stem Cell Research and IVF as Moral Issues," Pew Research Religion and Public Life Project, http://www.pewforum.org/2013/08/15/abortion-viewed-in-moral-terms/. According to this survey, 12% of Americans consider IVF to be morally wrong; 33%, morally acceptable; 46%, not a moral issue (Protestants: 13% morally wrong; 31% morally acceptable; 45% not a moral issue).

[2]Princeton theologian Paul Ramsey was at the forefront of Protestant response in the 1970s, with his opposition to IVF based in part on his concern that the experiments were being imposed nontherapeutically on the child-to-be without its consent, with the added problem that a damaged human being may be the end-result. See Paul Ramsey, *Fabricated Man* (New Haven, CT: Yale University Press, 1970), 113; see also P. Ramsey, "Shall We 'Reproduce'? 1 The Medical Ethics of In Vitro Fertilization," *Journal of the American Medical Association* 220, no. 10

(1972): 1346–50; "Shall We Reproduce? 2 Rejoinders and Future Forecast," *Journal of the American Medical Association* 220, no. 11 (1972): 1480–85; and P. Ramsey, *On In Vitro Fertilization*, AUL Studies in Law and Medicine 3 (Chicago: Americans United for Life, 1978), reprinted in Stephen E. Lammers & Allen Verhey, eds., *On Moral Medicine* (Grand Rapids, MI: Eerdmans, 1987), 339–45, p. 341.

[3]Examples are provided by O. O'Donovan, *Begotten or Made?* (New York: Oxford University Press, 1984); T. F. Torrance, *Test-tube Babies: Morals, Science and the Law* (Edinburgh: Scottish Academic Press, 1984); N. M. de S Cameron, "The Christian Stake in the Warnock Debate," in *Embryos and Ethics*, ed. N. M. de S. Cameron (Edinburgh: Rutherford House Books, 1987), 1–13; O. R. Johnston, *Warnock "Weighed and Found Wanting"* (London: CARE [Christian Action Research and Education], 1984).

[4]W. O. Spitzer and C. L. Saylor, eds., *Birth Control and the Christian* (Wheaton, IL: Tyndale House, 1969); also L. P. Bird, "Dilemmas in Bioethics," in *Horizons of Science,* ed. C. F. H. Henry (New York: Harper and Row, 1978), 131–55. Also D. Gareth Jones, "Making New Men: A Theology of Modified Man," *Journal of the American Scientific Affiliation* 26 (1974): 144–54.

[5]Of many examples, consider R. Higginson, *Whose Baby? The Ethics of In Vitro Fertilization* (Basingstoke, UK: Marshall Pickering, 1988); Edwin C. Hui, *At the Beginning of Life: Dilemmas in Theological Bioethics* (Downers Grove, IL, InterVarsity Press, 2002); John Wyatt, *Matters of Life and Death: Human Dilemmas in the Light of the Christian Faith*, 2nd ed. (Nottingham, UK: Inter-Varsity Press, 2009).

[6]See R. G. Edwards, B. D. Bavister, and P. C. Steptoe, "Early Stages of Fertilization In Vitro of Human Oocytes Matured In Vitro," *Nature* 222 (1969): 632–35; and R. G. Edwards and P. Steptoe, *A Matter of Life: The Story of a Medical Breakthrough* (London: Hutchinson, 1980).

[7]R. G. Edwards and D. J. Sharpe, "Social Values and Research in Human Embryology," *Nature* 231 (1971): 87–91. Also R. Edwards, "Fertilization of Human Eggs In Vitro: Morals, Ethics and the Law," *The Quarterly Review of Biology* 49 (1974): 3–26; R. G. Edwards, "Reminiscences on Learning about Morals and Ethics in Biomedicine," *Reproductive BioMedicine Online* 14, Suppl. 1 (2007): 7–11.

[8]R. V. Short, "Review of *Our Future Inheritance: Choice or Chance?*," *Journal of Medical Ethics* 1 (1975): 107–8. See also Robert Edwards's own description in R. Edwards, *Life before Birth: Reflections on the Embryo Debate* (London: Hutchinson, 1989).

[9]Mary Warnock, *Report of the Committee of Inquiry into Human Fertilisation and Embryology* (London: HMSO, 1984).

[10]Brent Waters and Ronald Cole-Turner, eds., *God and the Embryo: Religious Voices on Stem Cells and Cloning* (Washington, DC: Georgetown University Press, 2003); Ted Peters, Karen Lebacqz, and Gaymon Bennett, *Sacred Cells? Why Christians Should Support Stem Cell Research* (Lanham, MD: Rowman and Littlefield, 2008).

[11]M. C. Chang, "Fertilization of Rabbit Ova In Vitro," *Nature* 184, Suppl. 7 (1959): 466–67.

[12]R. Yanagimachi and M. C. Chang, "Fertilization of Hamster Eggs In Vitro," *Nature* 200 (1963): 281–82.

[13]D. G. Whittingham, "Fertilization of Mouse Eggs In Vitro," *Nature* 220 (1968): 592–93.

[14]Edwards, Bavister, and Steptoe, "Early Stages of Fertilization In Vitro of Human Oocytes Matured In Vitro."

[15]Edwards and Steptoe, *A Matter of Life*; Edwards, *Life before Birth*.

[16]See M. H. Johnson, "Robert Edwards: The Path to IVF," *Reproductive BioMedicine Online* 23 (2011): 245–62.

[17]P. C. Steptoe and R. G. Edwards, "Reimplantation of a Human Embryo with Subsequent Tubal Pregnancy," *Lancet* 1, no. 7965 (1976): 880–82.

[18]P. C. Steptoe and R. G. Edwards, "Birth after the Reimplantation of a Human Embryo," *Lancet* 2, no. 8085 (1978): 366.

[19]The Nobel Committee for Physiology or Medicine, 'Human In Vitro Fertilization,' The Nobel Assembly at Karolinska Institutet, 2010, http://www.nobelprize.org/nobel_prizes/medicine/laureates/2010/advanced-medicineprize2010.pdf.

[20]R. L. Gardner and M. H. Johnson, "Bob Edwards and the First Decade of *Reproductive BioMedicine Online*," *Reproductive BioMedicine Online* 22 (2010): 103–21.

[21]R. M. Green, *The Human Embryo Research Debates: Bioethics in the Vortex of Controversy* (New York: Oxford University Press, 2001), 74.

[22]See discussion in Jonathan Dudley, *Broken Words: The Abuse of Science and Faith in American Politics* (New York: Crown Publishers, 2011). Responses to the claims made by Dudley that evangelical perspectives on abortion have changed have been provided by Mark Galli, editor of *Christianity Today*, in M. Galli, "'When Evangelicals Were Pro-Choice'—Another Fake History," *Christianity Today* (October 31, 2012), http://www.christianitytoday.com/ct/channel/utilities/print.html?type=article&id=99109; and also in M. Galli, "Does It Matter That Evangelicals Became Prolife Recently?" *Christianity Today* (November 7, 2012), http://www.christianitytoday.com/ct/2012/november-web-only/does-it-matter-that-evangelicals-became-prolife-recently.html.

[23]An example is provided by C. W. Colson and N. M. de S. Cameron, eds., *Human Dignity in the Biotech Century: A Christian Vision for Public Policy* (Downers Grove, IL: InterVarsity Press, 2004).

[24]D. Atkinson, "Some Theological Perspectives on the Human Embryo," in *Embryos and Ethics,* ed. N. M. de S. Cameron (Edinburgh: Rutherford House Books, 1987), 43–57. Further examples of these stances are given by N. M. de S. Cameron and others in *Embryos and Ethics*.

[25]Lahl's views are quoted in N. S. Riley, "What About IVF? The Embryo Technology That Evangelicals Don't Oppose," Boston.com, October 10, 2010, http://www.boston.com/news/science/articles/2010/10/10/what_about_ivf/.

[26]A. Mohler, "'A Rather Unexpected Aspect of IVF'—Over a Million Human Embryos Destroyed in Britain," AlbertMohler.com, January 10, 2008, http://www.albertmohler.com/2008/01/10/a-rather-unexpected-aspect-of-ivf-over-a-million-human-embryos-destroyed-in-britain/.

[27]A. Mohler, "Christian Morality and Test Tube Babies, Part Two," http://www.faithtalk970.com/1396390/.

[28]Mohler quoted in B. Allen, "Southern Baptist Leader Says In-Vitro Fertilization Immoral," Ethicsdaily.com, January 16, 2008, http://www.ethicsdaily.com/southern-baptist-leader-says-in-vitro-fertilization-immoral-cms-12151.

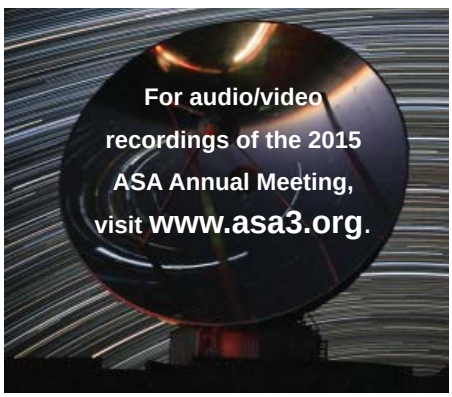
[29]Mohler, ibid.

[30]Riley, "What about IVF?

[31]Referred to in Riley, "What about IVF?

[32]Lahl quoted in Riley, "What about IVF?
[33]J. Powell, *Abortion: The Silent Holocaust* (East Lansing, MI: Tabor Publishing, 1981).
[34]H. Bos and F. van Balen, "Children of the New Reproductive Technologies: Social and Genetic Parenthood," *Patient Education and Counseling* 81 (2010): 429–35.
[35]Ellen Painter Dollar, *No Easy Choice: A Story of Disability, Parenthood, and Faith in an Age of Advanced Reproduction* (Louisville, KY: Westminster John Knox Press, 2012).
[36]J. A. Thomson, J. Itskovitz-Eldor, S. S. Shapiro, M. A. Waknitz, J. J. Swiergiel, V. S. Marshall, and J. M. Jones, "Embryonic Stem Cell Lines Derived from Human Blastocysts," *Science* 282 (1998): 1145–47.
[37]See overview in D. Gareth Jones, "Responses to the Human Embryo and Embryonic Stem Cells: Scientific and Theological Assessments," *Science and Christian Belief* 17 (2005): 199–222.
[38]There are a number of categorizations, all of which have much in common. One recent example is that of the European Science Foundation, *Human Stem Cell Research and Regenerative Medicine: Focus on European Policy and Scientific Contributions* (Strasbourg, France: European Science Foundation, 2013).
[39]Waters and Cole-Turner, eds., *God and the Embryo*.
[40]Ronald Cole-Turner, "Religion Meets Research," in *God and the Embryo*, ed. Waters and Cole-Turner, 7–18.
[41]Ibid., 16.
[42]Ibid.
[43]Gene Outka, "The Ethics of Human Stem Cell Research," in *God and the Embryo*, ed. Waters and Cole-Turner, 29–64.
[44]George W. Bush, "On Stem Cell Research," in *The Stem Cell Controversy: Debating the Issues*, 2nd ed., ed. M. Ruse and C. A. Pynes (Amherst, NY: Prometheus Books, 2006).
[45]Erica C. Jonlin, "Differing Standards for the NIH Stem Cell Registry and FDA Approval Render Most Federally Funded hESC Lines Unsuitable for Clinical Use," *Cell Stem Cell* 14 (2014): 139–40.
[46]C. Towns and D. G. Jones, "Stem Cells: Policy and Ethics," in *The Stem Cell Controversy*, ed. Ruse and Pynes, 329–41.
[47]Hinxton Group: An International Consortium on Stem Cells, Ethics and Law, *World Stem Cell Policies,* accessed May 28, 2014, http://www.hinxtongroup.org/wp_ao_map.html.
[48]European Science Foundation, *Human Stem Cell Research and Regenerative Medicine*.
[49]Towns and Jones, "Stem Cells: Policy and Ethics."
[50]A. N. Anderson, L. Gianaroli, R. Felberbaum, J. de Mouzon, and K. G. Nygren, "The European IVF-Monitoring Programme (EIM), for the European Society of Human Assisted Reproductive Technology in Europe, 2001. Results Generated from European Registers by ESHRE," *Human Reproduction* 20, no. 5 (2005): 1158–76.
[51]Peters, Lebacqz, and Bennett, *Sacred Cells?*
[52]Ibid., 76.
[53]These ideas are developed further in Ted Peters, *Playing God? Genetic Determinism and Human Freedom* (New York: Routledge, 2003). Also in Ted Peters, "Embryonic Persons in the Cloning and Stem Cell Debates," *Theology and Science* 1, no. 1 (2003): 51–77.
[54]See further discussion in Jones, "Responses to the Human Embryo and Embryonic Stem Cells."
[55]Congregation for the Doctrine of the Faith, *Donum Vitae: Instruction on Respect for Human Life in its Origin and on the Dignity of Procreation* (United States Conference of Catholic Bishops, 1987).
[56]A much greater level of detail and analysis is provided by D. Gareth Jones, "Christian Responses to Challenging Developments in Biomedical Science: The Case of In Vitro Fertilisation (IVF)," *Science and Christian Belief* 26 (2014): 143–64.
[57]Congregation for the Doctrine of the Faith, *Dignitas Personae (The Dignity of a Person): On Certain Bioethical Questions* (United States Conference of Catholic Bishops, 2008).
[58]Examples of such ethicists are: Richard McCormick, Kevin Kelly, Celia Deane-Drummond, and Ann-Marie Mealey. See R. A. McCormick, *How Brave a New World? Dilemmas in Bioethics* (London: SCM Press, 1981), 147–48; K. Kelly, *Life and Love: Towards a Dialogue on Bioethical Questions* (London: Collins, 1987); C. Deane-Drummond, "Bodies in Glass: A Virtue Approach to Ethical Quandaries in a Cyborg Age through a Recovery of Practical Wisdom," in *A Glass Darkly: Medicine and Theology in Further Dialogue,* ed. D. G. Jones and R. J. Elford (Bern: Peter Lang, 2010), 61–79; A. M. Mealey, "*Dignitas Personae*," in *A Glass Darkly: Medicine and Theology in Further Dialogue,* ed. Jones and Elford, 111–29.
[59]Christian Medical and Dental Associations (CMDA), *Assisted Reproductive Technology Ethics Statement*, April 29, 2010, accessed December 22, 2014, http://cmda.org/resources/publication/assisted-reproductive-technology-ethics-statement.
[60]Of the many relevant publications, see J. J. Schlesselman, "How Does One Assess the Risk of Abnormalities from Human In Vitro Fertilization?," *American Journal of Obstetrics and Gynecology* 135 (1979): 135–48; S. Shapiro, E. W. Jones, and P. M. Densen, "A Life Table of Pregnancy Terminations and Correlates of Fetal Loss," *Millbank Memorial Fund Quarterly* 20 (1962): 7–45. For a pro-life perspective, see C. O. Tollefsen, "What We Should Do about Natural Embryo Loss," *Public Discourse*, December 16, 2008, http://www.thepublicdiscourse.com/2008/12/103.
[61]Hui, *At the Beginning of Life.*
[62]Ibid., 233.
[63]Ibid., 236.
[64]Ibid., 228.
[65]Wyatt, *Matters of Life and Death.*
[66]Ibid., 502 (iBooks).
[67]Ibid., 494 (iBooks).
[68]Ibid., 304 (iBooks).
[69]Higginson, *Whose Baby?*
[70]Ibid., 107.

ASA Members: Submit comments and questions on this article at www.asa3.org→FORUMS→PSCF DISCUSSION.



Should We Frack?

Bruce Beaver

Bruce Beaver

This article examines the role of hydraulic fracturing (fracking) for natural gas production as a bridge fuel to a more sustainable future. The basic science, technology, risks, and benefits of fracking will be explored.

Christian Call to Care for Our Neighbors

As Christians we are called to seek the common good of our neighbors, both domestically and internationally. Pope Francis stated to the May 21, 2014, audience in Rome, "Creation is a gift, it is a wonderful gift that God has given us, so that we care for it and we use it for the benefit of all, always with great respect and gratitude." Care for our neighbors must take into account creation and our relationship to "the least of these" (Matthew 25:40). The common good is served by the development of safe, clean, and affordable energy sources for the enhancement of the quality of life for all, especially for "the least of these."

Realization of clean and affordable energy for all will require significant global financial investment over decades to develop and implement because the world has over one billion impoverished people. This situation also has an additional complication: namely, coal-fired electricity generation is dirty but inexpensive, while wind and solar are clean energy sources but expensive. Also, nuclear energy is moderately priced and clean, but the public is afraid of this technology. In the light of these complexities, what is the most loving way for Christians to advocate for clean and affordable energy for all?

The future global energy portfolio must address energy poverty and criteria pollutants (soot, smog, ozone, nitrogen and sulfur oxides, and toxic metals) in the short term and carbon emissions in the long term. Currently, technologies that address carbon pollution at a global scale (carbon capture and sequestration, wind and solar) are not economical. Therefore, since conserved energy is the cheapest and cleanest energy, conservation should play an immediate large role in the developed world. In the short term, to address the serious problem of criteria pollution, rapid global development of natural gas reserves by fracking (and, in the longer term, by nuclear power expansion) is necessary to replace the ~40% of global electricity generated from coal-fired facilities. This strategy acknowledges that coal-fired plants can be converted to gas-fired plants more rapidly than nuclear facilities can be constructed. In this manner, gas-fired power can serve as a bridge fuel for a few decades until a global gas/nuclear/wind/solar smart grid can be economically developed and deployed, and the public learns to trust nuclear energy.

Energy Conservation for the Rich and Energy Development for the Poor

The role of energy in global development and its importance for an adequate standard of living must be explored. The

Bruce Beaver *is Professor of Chemistry, Duquesne University, Pittsburgh, Pennsylvania. He reviews most research articles and research proposals on fuel oxidation, and is on the editorial board, for the Journal of Petroleum Engineering. In addition, he has consulted on fuel oxidation issues with various energy companies, additive companies, the US Air Force, the US Department of Energy, the US Navy, the Australian Navy, and litigious lawyers.*

United Nations Development Programme has developed a semi-quantitative measure of overall material quality of life called the human development index (HDI). This index is composed of quantitative measures of "average national life quality" based upon three indicators: (1) life expectancy at birth, (2) per capita income, and (3) mean years of schooling. HDI values are reported every other year and range from 0 to 1 with a 2012 value (latest data) of 0.71 being the median value for the 187 ranked countries. Some examples of country values are (global HDI rank/HDI value) USA (#3/0.94), China (#101/0.70), South Africa (#121/0.63), India (#136/0.55), and Mozambique (#185/0.33).

An interesting presentation by David Larrabee at the 2014 ASA/CSCA/CiS Annual Meeting discussed the relationship between HDI and national per capita total energy consumption.[1] Some of this data is presented in table 1. He made three important points. First, above a per capita energy consumption of approximately 145 kWh/day, there is no correlation between HDI and energy use. For instance, Germany and Canada have similar HDI values yet very different per capita energy consumption. This suggests that ~145 kWh/day might be a good global target for how much energy the less-developed world will need for an adequate standard of living. Currently, the median per capita global total energy consumption is about 60 kWh/day. The 145 kWh/day value also sets a target for the developed world in terms of per capita energy conservation.

Secondly, below 145 kWh/day, there is a weak correlation with the HDI and energy consumption: generally, the lower the per capita energy consumption, the lower the HDI. Most interestingly, with very low per capita energy consumption (<20 kWh/day), there is a strong correlation: small increases in per capita energy consumption significantly increase HDI values. These data suggest that a program focused upon electrification of the most energy-impoverished regions will rapidly increase the global standard of living.

Table 1. National Human Development Index (HDI) versus Per Capita Total Energy Consumption. Data are for 2010 and from the presentation by David Larrabee at the 2014 ASA/CSCA/CiS Annual Meeting in Hamilton, ON.

Country	HDI	kWh/person/day
Norway	0.938	330
USA	0.902	254
Canada	0.888	310
Germany	0.880	145
Mexico	0.750	100
China	0.663	58
South Africa	0.600	40
India	0.519	15
Mozambique	0.284	5

The third interesting point was Larrabee's invitation to do a personal energy audit. This is the first step in addressing energy conservation in the developed world. The monthly electric bill is the best place to start since it measures a portion of our energy consumption. For example, my family's monthly electric bill allows convenient comparison of our electricity use to the values in table 1. Our highest electric bill typically reveals an average electricity consumption of 11 kWh/day/person that is about double the average per capita total energy use for Mozambique. However, comparing my family's daily electric usage with the per capita US total average energy consumption (11/254 x 100) accounts for only about 4% of total energy consumption.

According to the US Energy Information Agency (EIA), 40% of US energy consumption in 2011 was for electricity generation. This involves electricity used for residential, commercial, and industrial purposes. My household per capita daily electricity consumption represents only 10.2% of the US per capita daily electricity consumption of 102 kWh/day. Where is the rest of my family's per capita energy consumption?

Most electricity use in the US is for commercial and industrial purposes. Therefore, the largest portion of my "true" per capita electric "bill" (102 – 11 = 92 kWh/day) is for the electricity used to make items such as appliances, food, automobiles, tires, computers, cell phones, and other commodities of modern life. The American love affair with the automobile accounts for 27%, or 69 kWh/day, of the per capita US energy use. The missing 33% or about 84 kWh/day/person of US energy use must be accounted for by consuming products containing non-electrical energy from industries such as petrochemicals, refining, paper, construction, mining, pharmaceuticals, and heating. This analysis of my family's energy use reveals that a significant amount of our energy use was invisible to me. I was only aware of my transportation, home

heating, and electrical energy consumption which accounts for only about one-half of the US per capita energy consumption.

This simple analysis of my family's per capita electric bill and its relationship to the average total per capita energy use illustrates two important points about US energy. First, not much electricity (and other energy) is required for the basic necessities of life: heat, cooling, lighting, clean cooking, refrigeration, food processing, clean water, and sanitation. Second, a typical US middle-class lifestyle could be reconfigured to use significantly less electricity without a significant decrease in lifestyle. Much electricity is used to convert natural resources into the materials used to construct buildings. Larrabee suggests that simply buying a slightly smaller house and delaying non-essential replacement of cars and electronic devices such as cell phones, computers, and TVs could save significant amounts of energy without significantly lowering our standard of living. Obviously, increased use of mass transit would also significantly decrease energy consumption.

At the other end of the energy spectrum are 1.2 billion people in the developing world without electricity, according to the World Bank. Most of these people live in India and sub-Saharan Africa. The previous discussion suggested that not much energy is needed to provide the basic necessities of life for the world's poorest. However, if providing this energy is linked to sustainable energy development, it will delay the poorest from obtaining these necessities. A review of World Bank energy projects over the last few years shows that only about 10% of the ~$9 billion spent annually on energy projects involved fossil fuels. At the current rate of World Bank-financed electricity development and estimated population growth, by 2030, there will still be over 1 billion people without electricity and 2.7 billion still without clean cooking capabilities. To address this issue by 2030 will require a significant increase in annual electrification expenditures.[2]

Table 2 presents estimates for the average US electricity costs for differing generation technologies. It is assumed that the facility will be generating electricity by 2019 and has a life cycle of thirty years. Although these estimates are for the US, it seems logical that the relative ranking for electricity costs for the differing technologies should be similar globally. However, global fossil-fuel prices will be a major variable that can change electricity prices and the commercial viability of the various technologies. For instance, only in the US is natural gas inexpensive; fracking increases the gas supply which makes gas-fired power plants economically viable. In addition, it has been suggested that the costs reported in table 2 for wind and solar have been significantly underestimated.[3]

To illustrate the complexity of green energy economics, we will examine a recent paper by Delucchi and Jacobson that addressed the feasibility of providing energy (electric power, transportation, and heating/cooling) with wind, water, and solar (WWS) power.[4] In this peer-reviewed paper, the authors examined the electric power needs of California over two years (2005 and 2006) to explore the feasibility of WWS power to meet minute-to-minute energy demand. To this energy-demand curve they then computationally deployed an imaginary electric grid with a capacity of wind (73.5 GW), water (26.4 GW hydroelectric), solar (26.4 GW of concentrated solar power and 28.2 GW of rooftop photovoltaic power), geothermal energy (4.8 GW), and a natural gas reserve (24.8 GW). The geothermal capacity is a base load (i.e., constant) energy source and was set at the maximum commercially available for California. It should be noted that geothermal energy production is commercially viable only in areas that are near tectonic plate boundaries; these result in the hot earth mantle being near the surface, as in California. Wind and sun are variable energy sources, whereas hydropower is a dispatchable energy source that can quickly adjust to meet fluctuating electric demand. In this study, the magnitude of hydropower available was limited

Table 2. Average US Levelized Cost Estimates (fuel and construction costs) for Electric Generation Rates in 2019. Subsidies have been excluded from cost estimates. Data from http://www.eia.gov/forecasts/aeo/electricity_generation.cfm.

Capacity Factor (%)	Technology	2012$/MWh
85	Conventional Coal	95.6
87	Gas-Fired Adv. Comb. Cycle	64.4
90	Advanced Nuclear	96.1
35	Wind	80.3
25	Solar Photovoltaic	130.0
20	Solar Thermal	243.1
53	Hydro	84.5
93	Geothermal	47.9

to the current amount allocated to California from the Pacific Northwest.

Based upon the weather records for 2005 and 2006, Delucchi and Jacobson were able to estimate daily, minute-by-minute, energy production curves for wind- and solar-energy sources. They were then able to dispatch hydropower appropriately in their model to balance grid-energy needs. It was found that 99.8% of the time, the model grid was able to meet the power demand of the WWS grid. However, over the course of two years, there were ~36 hours when the model needed electricity generation (~12 GW) from the natural-gas backup facilities. This amount of energy requires ~50 (500 MW each) gas-fired power plants on idle such that they can quickly power up to meet surging electricity demand.

This example of the hypothetical California WWS grid that needs ~50 natural gas power stations on standby to stabilize the grid against inevitable significant power fluctuations is very expensive. In essence, two power systems are needed to run simultaneously while being intricately balanced to keep the grid stable. In the real world, the ~50 natural gas power plants would need to be financed by a surcharge on the WWS electric bills.

Currently, countries that have significant amounts of solar/wind capacity in their grid, such as Germany at ~20%, are able to stabilize the grid inexpensively with their significant fossil-fuel capacity. However, incorporating greater than ~20% wind/solar capacity adds significant expense because of extra required dedicated dispatchable fossil-fuel capacity needed for standby unless special geographic conditions are readily available. Such is the case in Denmark which has ~20% wind capacity and is able to balance its grid by interfacing with the massive hydro-capacity in neighboring Norway and Sweden. When the wind is strong in Denmark, excess electricity is sent to the neighboring countries for immediate consumption while hydroelectric generation is decreased appropriately. When not enough wind energy is generated in Denmark, the neighbors increase hydroelectric production to dispatch to Denmark. This system is expensive and results in Denmark having the highest residential electric rates in Europe.[5]

There are many other significant issues with the Delucchi and Jacobson paper[6] and with green energy economics[7] that are beyond the scope of this article.

Addressing the other energy sources in table 2, commercial-scale geothermal and/or hydroelectric generation, where viable, has, by and large, already been deployed. Table 2 suggests that of the remaining commercial-scale technologies for electricity generation, gas-fired advanced combustion-cycle generators and nuclear are the most economical, and they are cleaner than coal technologies. Gas-fired power generation has an advantage over nuclear in that it can be deployed faster.

However, gas-fired power plants are only economically viable when natural gas is plentiful and consequently inexpensive. For instance, India is using only ~25% of available natural gas capacity because of a domestic shortage. A lack of infrastructure to import enough liquefied natural gas (LNG) to fuel all gas-fired generators has resulted in coal-fired power plants providing most of India's power.[8]

Coal is a dirty fuel. Globally, coal-fired power generates ambient particulate matter pollution that has been linked with 2.7 million premature deaths in 2012, according to the World Health Organization.[9] An additional 4.3 million deaths occurred due to indoor air pollution from cooking and heating. Of the ambient particulate matter deaths, 620,000 occurred in India while 1.2 million occurred in China. To address these deaths, China is implementing a plan to build facilities in rural western China that will convert coal into synthetic natural gas (SNG) to fuel new SNG-fired power stations in eastern urban areas. When fully implemented in ~2020, this will allow the closing of a significant number of urban coal-fired facilities, which will significantly improve urban air quality. This plan will also make it easier to capture the very significant amounts of CO_2 that are generated in the coal gasification/SNG generation process when carbon-capture and sequestration becomes economically viable.

It has been estimated that the carbon footprint of each of China's SNG power stations will be about seven times that of a similar natural gas-fired power station.[10] Rapidly developing China's shale gas potential would be much better than expanding the SNG process beyond 2020 in terms of both criteria pollution (soot, smog, ozone, nitrogen and sulfur oxides, and toxic metals) and carbon pollution perspectives. However, because of difficulties recently encountered in economically developing China's deep massive shale gas reserves, with 68%

more technologically recoverable gas than the US, it was announced that only half of the 2020 shale gas goal will be met. This new natural gas goal is set at 1.1 trillion cubic feet (tcf), while, for perspective, in 2012, the US produced 24 tcf. China has recently sought assistance from US companies in developing their shale gas potential.[11] In order to understand the problems that must be solved in developing China's shale gas reserves, horizontal drilling and hydraulic fracturing will be explored.

What is Fracking?

To properly answer this question, we must develop an understanding of conventional and unconventional drilling shown in figure 1. Conventional oil and gas development can be imagined with a vertical well, drilled thousands of feet below the surface to pierce geological formations that contain crude oil and/or natural gas. This is visualized in figure 1 by the left well, which is drilled into a conventional non-associated gas formation. A non-associated gas formation does not contain any oil while an associated gas formation contains both oil and gas. Conventional wells can tap formations that are *permeable*, that is, the residual hydrocarbons readily flow through the formation from high pressure to lower pressure at the wellhead. The well borehole contains concrete reinforced steel pipe to support the integrity of the well. The top portion of the well shaft is much thicker (not shown) due to additional layers of steel pipe and concrete designed to protect well water from contamination by the drilling process. Well water is typically less than one thousand feet below the surface while oil and gas deposits are typically deeper. The portion of the steel pipe in the hydrocarbon-rich geological formation must be punctured (perforated) to allow the hydrocarbons and brine to flow to the surface. Brine is concentrated salt water that is typically a natural component of hydrocarbon-containing geological formations.

Not all of the wells drilled in the world, as described above, are commercially viable. The cumulative expenses are significant: geological and drilling technology, labor, steel pipe, concrete, legal expenses,

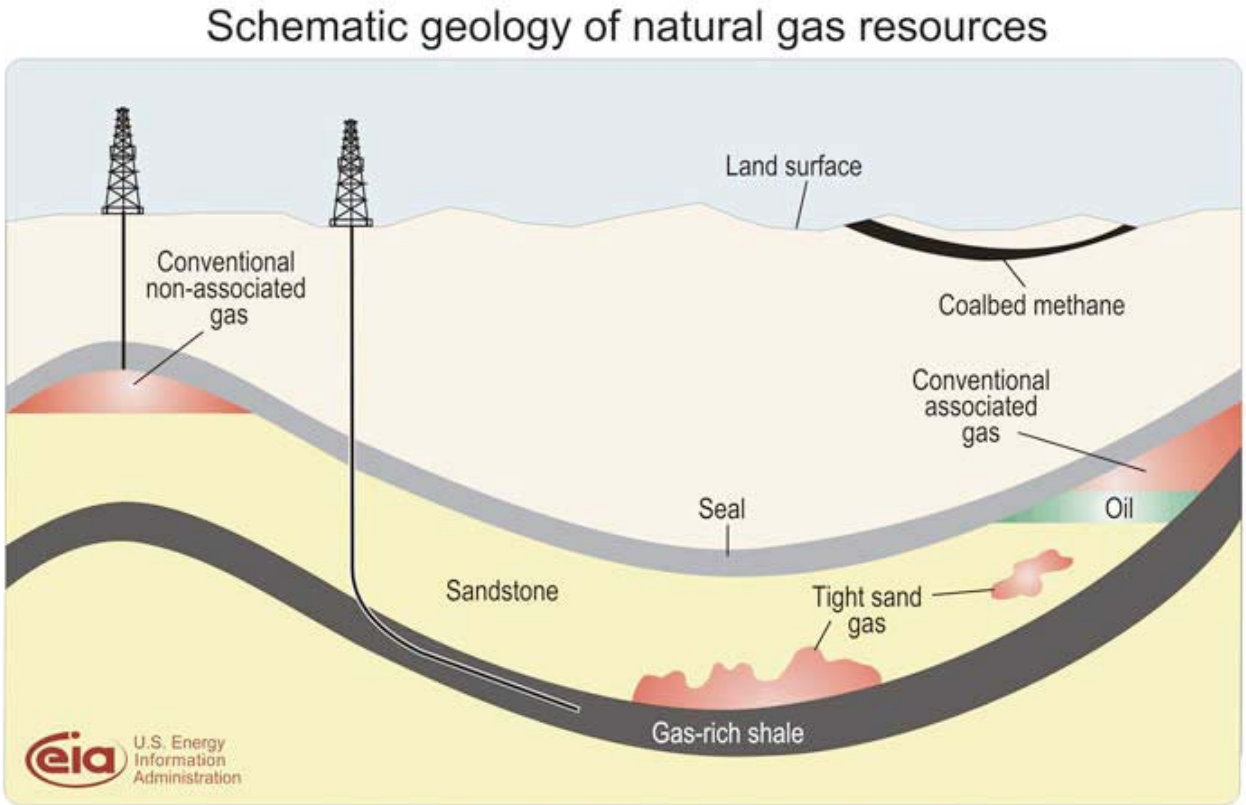


Figure 1. A generic depiction of conventional and unconventional gas wells.
Source: http://www.eia.gov/todayinenergy/detail.cfm?id=110.

landowner royalties, taxes, and establishing the infrastructure required to move oil and gas to market. The critical component necessary for commercial viability in the above well description is sufficient *permeability* in the geological formation to allow the oil and gas to flow at a rapid rate. However, vast amounts of hydrocarbon reserves are trapped in geological formations with poor permeability. To address the lack of permeability, Halliburton Company performed the first hydraulic fracturing in 1949.[12] The first high-volume fracturing was performed in 1968 by Pan American Petroleum. In 1965, a US Bureau of Mines publication wrote that

> Many fields are in existence today because of these fracturing techniques for, without them, many producing horizons would have been bypassed in the past 15 years as either barren or commercially nonproductive.[13]

Being unable to tap nonpermeable reserves would probably have caused a global energy crisis in the 1960s, which would have drastically slowed economic development. Recall that it was 1950 through the 1970s when the world made significant progress in feeding the growing population. Cheap oil contributed to this agriculture green revolution in food production. Fracking enabled abundant crude to flow from conventional wells, helping to keep nominal global prices low (<$40/barrel) through 2002 except during the geopolitical events in the 1970s.

Going back to the previous description of gas production in the vertical wellbore in figure 1, the details of hydraulic fracturing involve (1) injecting high-pressure water through the perforated steel pipe of the wellbore to induce fractures in geological formations, (2) forcing these fractures open to significantly increase the surface area of the formation in contact with the wellbore, and (3) inserting into these induced fractures a proppant, such as sand, to hold the fracture open after the hydraulic pressure is relaxed.

The mixtures used to fracture wells are typically composed, by volume, of ~90% water, ~9% proppant, and ~1% chemicals. The role of the water is to facilitate fracturing and expanding the geological formation surface area; the proppant inserts into the fractures to maintain their integrity after the pressure is released. The roles of the chemicals are many. First, the viscosity of the water is increased in order to keep the proppant sufficiently dispersed to allow the proppant to become embedded in the fractures with the water. Second, when the fracture process is complete, "breakers" are introduced to decrease the viscosity of the fracturing fluid. The fracturing fluid along with brine, referred to as flowback water, readily flows to the surface (owing to the viscosity decrease) as the hydrocarbons are released from the formation. Third, an assorted array of services provide lubricity, corrosion inhibition, plus antiscalant and antibacterial functions.

The tremendous pace of research and development in the oil-field chemicals industry has resulted in decreasing toxicity of fracturing chemicals, with a simultaneous increase in performance. For instance, Halliburton has developed CleanStim, a fracturing fluid formulation that employs chemicals used in the food industry. In a recent public relations stunt, twenty drilling executives sipped on CleanStim (without the antibacterial) to emphasize its lack of toxicity.[14]

It has only been since 2004 that the oil and gas industry has had the technology to perform directional drilling on a commercial scale. George Mitchell is credited with developing horizontal (i.e., unconventional) drilling combined with hydraulic fracturing to start the commercial development of the Barnett Shale in Texas.[15] Unconventional drilling is depicted in the right-hand wellbore in figure 1. Unconventional wells typically go down at least one mile before drilling one or more miles horizontally. Hydraulic fracturing of the geological formation is required to stimulate enough hydrocarbon production to make drilling such massive wells economically viable.

A great example of the potential role of unconventional gas in promoting cleaner energy is found in current developments in the Indian natural gas market.[16] It was previously mentioned that India was using their natural gas power at only 25% capacity because of a shortage of domestic natural gas. The Indian government just started coupling the price of domestic natural gas with international markets. In the short term, this move has doubled Indian gas prices; in the long term, this move will allow industry to develop India's shale gas reserves with unconventional drilling which will produce domestic natural gas much cheaper than imported LNG,

which is currently priced at over $12 per million BTU. In the long term, this move will significantly improve India's air quality.

Developing China's unconventional resources has many technology problems and economic issues that must be addressed. First, China's gas reserves tend to be found at levels deeper than those in the US, which tend to be less than 10,000 feet. Fracking in deep deposits needs advanced proppant technology that can survive high pressures and temperatures. This technology has been developed in the US and involves the use of ceramic proppants that are coated with special polymers.[17]

Second, China has a freshwater shortage that will limit the capacity to frack deep wells with millions of gallons of freshwater. Fortunately, fracking in the dry regions of the US has forced the development of technology that uses minimal freshwater or no water at all. Fracking with minimal freshwater involves reusing ~20% of the produced water, water that returns to the surface after fracking, and blending it with brine. This mixture is then used to frack the next well.[18] In Texas, brine is obtained by drilling brine wells on-site. Also, special additive chemistry was developed to allow the gelling agents, surfacants, and antifriction, antiscalant, and antibacterial additives to function properly in saltwater.[19] In regions where brine is unavailable, fracking can be done by using nitrogen, CO_2, or propane instead of water. However, this technology is more expensive and also more dangerous.

Fracking has a good safety record, but, as with any human enterprise, accidents do happen. For instance, in June 2014, an explosion and fire occurred during a Halliburton fracking operation in Ohio.[20] The explosion was caused by a bursting hydraulic hose which sprayed oil unto a hot engine causing the initial fire. Fortunately, no serious injuries were reported, but an estimated 70,000 fish were killed when fracking chemicals and produced water flowed into a tributary of Opossum Creek to the Ohio River. If this site had been fracking with propane rather than water, most certainly many deaths and injuries would have occurred.

Deep gas wells fracked with brine water containing polymer-coated ceramic proppants will be an expensive operation, requiring high gas prices to make the operation economically viable. According to the US Energy Information Administration (EIA), imported LNG in China was priced at over $14 per million BTU's in October 2014. This high price is an incentive for launching an extensive shale gas-drilling program to increase domestic Chinese natural gas. Such a program could significantly decrease Chinese natural gas prices. Use of the latest technology developed in US gas fields could result in the Chinese gas wells being more productive than US wells. The trick is to find the "sweet spot" in the shale deposits prior to drilling and fracking, which can result in a ten-fold increase in gas production. The state of the art in oil- and gas-prospecting technology uses 3D microseismic imaging to look for the geological fingerprints of sweet spots. This technology exploits the capacity of seismic waves to become distorted in low-density environments such as microcavities that contain oil and gas. Currently, Chinese drilling companies are planning to work with prospecting companies such as Halliburton and Schlumberger, both pioneers in "sweet spot" technology.[21] Finally, the economics of Chinese gas wells should look better in the future as US companies are currently developing "cross-unit drilling" techniques that are significantly lowering well costs.[22] Collaboration between Chinese and major global energy companies has great potential to increase domestic natural gas production with concomitant coal displacement in power generation resulting in reduced future criteria and carbon emissions in China.

Environmentally Responsible Fracking?

In 2011,*The Future of Natural Gas* was published. This report is an in-depth interdisciplinary MIT panel report chaired by Ernest Moniz, the current Secretary of Energy. This report states,

> With over 20,000 shale wells drilled in the last 10 years, the environmental record of shale gas development has for the most part been a good one. Nevertheless, it is important to recognize the inherent risks of the oil and gas business and the damage that can be caused by just one poor operation; the industry must continuously strive to mitigate risk and address public concerns.[23]

Table 3 presents data from major gas drilling incidents that were widely known based upon media coverage between 2005 and 2009. About half of the incidents that occurred were damaging to ground

(well) water, natural gas intrusions because of deficient well casings.

In 2012, the Royal Society and the Royal Academy of Engineering published a peer-reviewed analysis of fracking. The review examined the risks of unconventional drilling from the perspective of water management issues, well integrity, fracking-induced seismicity, and natural-occurring radioactive materials. The review states,

> The health, safety and environmental risks associated with "fracking" … can be managed effectively in the UK as long as operational best practices are implemented and enforced through regulation. Hydraulic fracturing is an established technology that has been used in the oil and gas industries for many decades.[24]

Consistent with this view is a 2014 peer-reviewed article by Susan Brantley and colleagues detailing a thorough analysis of Pennsylvania records on shale gas development water issues from 2008 through 2012.[25] During this period, more than 6,000 wells were drilled and more than 4,000 were completed (i.e., fractured). Brantley et al. estimate that approximately twenty gas wells unambiguously contaminated well water while thirty large spills also occurred. Most of the well-water contamination incidents occurred in the eastern part of the state and involved faulty well casings that permitted methane migration into water wells. This occurred in 0.24% of the gas wells developed. The most famous incident occurred in 2009 in Dimock, PA, where a faulty well casing resulted in increased methane levels in residential wells in eighteen homes.[26] Because of these water well contaminations, the industry has improved the safety protocols required (i.e., enhanced well casings) when drilling permeates drinking water formations to prevent possible water contaminations.

Table 3. Major Widely Known Gas-Drilling Incidents between 2005 and 2009. Source: Table 2.3 in Moniz et al., "The Future of Natural Gas: An Interdisciplinary MIT Study."

Type of Incident	Number Reported	Fraction of 43 Total Incidents
Groundwater contamination by natural gas or drilling fluid	20	47%
On-site surface spills	14	33%
Off-site disposal issues	4	9%
Water withdrawal issues	2	4%
Air Quality	1	2%
Blowouts	2	4%

The Dimock incident stimulated research efforts that culminated in three significant recent publications. A peer-reviewed publication by Duke University researchers suggested that methane found in some sampled wells had isotopic carbon 13 and deuterium signatures consistent with thermogenic methane as opposed to biogenic (microbial) methane.[27] This result suggests the possibility of methane migration from the very deep Marcellus shale entering shallow water wells. A more recent study examining over 1,700 predrilling water samples suggests that the thermogenic methane detected in the Duke study was not derived from the Marcellus shale but from shallow hydrocarbon-containing geological strata that are in direct contact with certain water wells.[28] The most recent report was from the US Geological Survey which suggests that some water wells in parts of eastern Pennsylvania, in regions with no gas drilling activity, contain thermogenic methane from geological strata above the Marcellus shale along with elevated concentrations of some brine components (strontium, barium, arsenic, bromide, chloride, sodium).[29] All of this work illustrates the importance of predrilling drinking water sampling and that additional research is required.

Recent concerns have been raised over fugitive methane emissions since the greenhouse gas (GHG) potential of methane is significantly higher than that of CO_2. Larry Cathles and colleagues, in a peer-reviewed argument, suggest that this fear is unfounded, since fugitive methane emissions are less than 3% of natural gas production from well to customer.[30] In addition, Cathles has also provided very interesting modeling data that suggest a possible role for natural gas in improving our future global carbon footprint.[31] Three different scenarios for future fossil-fuel consumption profiles were examined. These scenarios all assume that between 2005 and 2105 the global energy system will grow to provide for the estimated future ~10 billion inhabitants, each with a European level of energy consumption (7 kW per capita or ~74 terrawatts globally/yr or ~168 kWh/day per capita).

The first scenario, "business as usual," increases global energy consumption 2.1% per year until 2055,

utilizing primarily a mix of fossil fuels. The global energy growth rate increases only 1.2% per year over the next fifty years with declining fossil-fuel use and increasing use of noncarbon energy sources. The second scenario assumes flat petroleum consumption and rapid displacement of coal by natural gas in electricity generation for the first fifty years. In the second fifty years, both gas and petroleum are rapidly replaced by noncarbon energy sources. The third scenario involves the first fifty years with gas and petroleum consumption constant and coal being rapidly replaced by noncarbon energy. In the second fifty years, gas replaces petroleum. The global carbon footprints of these three scenarios over one hundred years were calculated to be 1268, 935, and 544 gigatons carbon (GtC), respectively. Since the Industrial Revolution, global anthropogenic carbon emissions are estimated to be about 600 GtC.

It is believed that limiting cumulative anthropogenic carbon emissions to one trillion tons is necessary to keep future average global temperature increases about 2°C above pre-industrial temperatures.[32] Only in Cathles's third scenario is the carbon budget in line with a ~2°C temperature increase. We previously saw in the analysis by Delucchi and Jacobson that massive deployment of noncarbon energy at this time is not economically feasible.[33] Cathles's second scenario is more economically feasible, in that there is time to optimize the noncarbon energy systems; however, the higher carbon budget for this scenario increases future average global temperature by ~3°C. It is estimated that the "business as usual" scenario will drive global temperatures to ~4°C above pre-industrial temperatures.

It can be argued that the US has inadvertently set out on Cathles's second scenario. According to the US EIA, shale-gas displacement of coal-fired electricity generation has already resulted in a 10% decrease in US GHG emissions between 2005 and 2012. For comparison, GHG reductions in the EU were 14%, while Germany observed 4% in the same time frame.[34] In September 2014, the US EPA released the fourth annual GHG emissions report, which found 2013 methane emissions from the petroleum and natural gas industry down 13.3% from 2008.[35] This is in spite of a 400% expansion in drilling and fracking activity since 2008. The largest component of this decrease has been a 73% reduction in emissions from fracking.

However, tracking GHG emissions is more complicated than the above-cited EIA data suggest. To illustrate this, table 4 presents a comparison of select national CO_2 emissions with data for total GHG emissions when imports and exports are considered. Table 4 succinctly summarizes what has happened globally in the last ten years with respect to carbon pollution on a per capita basis. The selected five countries represent the world in 2001; the first three European countries represent developed countries that were the first to address carbon pollution. For instance, Norway has had a carbon tax since 1991 while Germany and Denmark are currently global leaders in alternative energy deployment. In 2001, these countries had CO_2 emissions about half that of the US. China represents the less-developed world, which is currently committed to economic development, and in 2001 only emitted about one-third of the per capita CO_2 of the European countries. In the

Table 4. Select National CO_2 Emissions in 2001; Total National Greenhouse Gas (GHG) Emissions in 2001, including Imports and Exports; and Select National CO_2 Emissions in 2010.

Country	National fossil fuel CO_2 emissions in 2001[a] (metric tons per capita)	Total national GHG emissions including imports and exports in 2001[b] (metric tons per capita)	National fossil fuel CO_2 emissions in 2010[a] (metric tons per capita)
Denmark	9.2	15.2	8.3
Germany	10.4	15.1	9.1
Norway	9.1	14.9	11.7
United States	19.7	28.6	17.6
China	2.7	3.1	6.2

[a]Per capita CO_2 emission data is from the World Bank and is only from fossil fuel development, consumption, and cement manufacturing.
[b]This data is from Hertwich and Peters, "Carbon Footprint of Nations: A Global, Trade Linked Analysis," and includes estimates of total per capita national greenhouse gas (GHG) emissions (CO_2, CH_4, N_2O, fluorinated gases) at the point of consumption, including those from imports and exports.

middle column are estimates for these countries with respect to total climate emissions.[36] These estimates include emissions from GHG's and address CO_2 at the point of consumption in terms of global trade. The significant per capita increases were observed in climate emissions for the top four.

Clearly, in 2001 Chinese imports were not "exporting" western climate emissions. However, this picture changed somewhat by 2007 with 22% of China's carbon footprint attributable to exports.[37] A similar trend is observed in the 2010 CO_2 emissions data for Norway, which increased 28% from 2001. Since 97% of Norway's electricity is hydroelectric, the bulk of this CO_2 emissions increase is from oil and gas production and manufacturing. Norway's main exports are hydrocarbon fuels, refined metals, chemicals, machinery, ships, and fish.[38] Production of five out of six of these products requires significant CO_2 emissions.

Although the data in table 3 and the discussed studies suggest that the environmental record of the oil and gas industry is relatively good, it must continually improve to gain the popular support required for further development. In 2013, the Center for Sustainable Shale Development (CSSD) in Pittsburgh, PA, was started to promote enhanced environmental standards. The goal of this organization is to work with all stakeholders (industry, government, and the environmental community) to help industry working in the Marcellus Basin increase standards for field engineering and environmental control activities by adapting transparent, objective, continuous improvement processes. These best practices involve the entire range of gas operations. CSSD will use these standards to facilitate third-party inspections to verify that those audited are meeting these best standards. These standards are generally more rigorous than those required by state environmental agencies. In April 2014, Chevron was the first company to be certified. For instance, the standards for groundwater protection include the following:

1. Zero discharge of waste water until adoption of treatment standards
2. Greater than 90% waste-water recycling
3. Closed loop containment of drilling fluids to minimize water use during drilling
4. Double-lined water impoundments with leak detection
5. Groundwater monitoring both pre- and post-operation
6. Casing and cement standards
7. Disclosure of well stimulation fluids
8. Spill response and public notification plans

The standards for air pollution include the following:

1. Removal of hydrocarbons from flowback and produced water before storage
2. Reduced emission completions
3. Emissions standards for drilling rigs, frack pump engines, compressor engines, trucks
4. Condensate tank emissions control

The key to successful shale development involves increasing stakeholder trust by developing and adopting objective continuous improvement processes.

Can Global Unconventional Energy Development Promote "Cleaner" Human Development?

The development of unconventional (horizontal) drilling and hydraulic fracturing has revolutionized the global energy landscape in just ten years. This technology has enabled the economic development of deep, thin, geological formations containing oil and gas. It has significantly increased oil and gas reserves in the US and transformed the global energy landscape in amazing ways. Ten years ago, the prospect of global peak crude-oil production was a serious economic issue facing the US economy, the world's largest consumer of crude. However, application of unconventional drilling techniques to shale-oil formations in North Dakota and Texas has led the International Energy Agency (IEA) to predict that the US will soon be the world's largest producer of crude oil, surpassing both Russia and Saudi Arabia. In addition, British Petroleum projects that by 2030 the world will use 30% less petroleum than in 2011 because of enhanced fuel efficiency standards and increased use of renewable energy and natural gas. Rapid global displacement of coal by natural gas in power generation also has the potential to improve urban air quality and further limit carbon emissions.

The transformation of the US energy landscape by unconventional drilling and fracking can be expanded internationally to provide natural gas as a bridge fuel. However, this must be done carefully and prudently to minimize the extent of wanton economic development. Global development ideally should be coupled with a version of the Roman

Catholic Church's vision of human development. Wolfgang Grassl points out that from such a vision each human is called to a vocation "to be more" in terms of emotional, spiritual, educational, health, and economic spheres.[39] This is referred to as *authentic human development* to distinguish it from mere economic development, which if left unchecked by healthy spirituality, becomes destructive.

William Oddie explains this in a different manner in an interesting essay on *Laudato Si'* (Praise Be to You) as follows:

> So how are the poor to cease to be poor? Only as a result of their economic development. As Charles Moore asked on Saturday: "Why is the developed world rich? The answer lies in the name: it developed more than other places. Development happens by uniting the resources of the earth with the capacities of the human brain and the institutions of human society. The resulting innovations are driven by energy, the cheaper the better. Hence the overwhelming historic (and present) importance of fossil fuels."[40]

From this perspective, it is useful to reflect upon Pope Benedict XVI's encyclical *Caritas in Veritate* (Charity in Truth), which focuses on the problems of global development and progress toward the common good. The Pope writes,

> Charity in truth, to which Jesus Christ bore witness by his earthly life and especially by his death and resurrection, is the principal driving force behind the authentic development of every person and of all humanity. Love—*caritas*—is an extraordinary force which leads people to opt for courageous and generous engagement in the field of justice and peace. (p. 1)

Benedict points out that the "Truth" of humanity's transcendent vocation to progress "drives us to do more, know more, and have more in order to be more" (p. 16).

Benedict also reminds us that

> Technology, viewed in itself, is ambivalent. If on the one hand, some today would be inclined to entrust the entire process of development to technology, on the other hand we are witnessing an upsurge of ideologies that deny *in toto* the very value of development, viewing it as radically anti-human and merely a source of degradation. This leads to a rejection, not only of the distorted and unjust way in which progress is sometimes directed, but also of scientific discoveries themselves, which, if well used, could serve as an opportunity of growth for all. The idea of a world without development indicates a lack of trust in man and in God. It is therefore a serious mistake to undervalue human capacity to exercise control over the deviations of development or to overlook the fact that man is constitutionally oriented towards "being more." (p. 14)

I pray God will be with us as we help, in our own small ways, to bring God's mercy, justice, prosperity, and peace to all. ✦

Notes

[1]David Larrabee, "Personal Lifestyle Implications of a Globally Just and Sustainable Future," presentation, The ASA/CSCA/CiS 2014 Annual Meeting, McMaster University, Hamilton, ON, July 28, 2014, Windows Media Audio, http://resources.asa3.org/FMPro?-db=asadb49.fm4&-format=%2fasadb%2fdetail3.html&-lay=layout1&-sortfield=first%20author&source%5foccasio=2014%2bAnnual%2bMeeting&-lop=or&-max=2147483647&-recid=36068&-find=.

[2]Estimates to electrify the world's poorest by 2030 require more than a five-fold increase in current spending. See International Energy Agency, "Energy for All: Financing Access for the Poor," first presented at the Energy for All Conference in Oslo, Norway, October 2011, http://www.worldenergyoutlook.org/media/weowebsite/energydevelopment/weo2011_energy_for_all.pdf; "World Bank Group Energy Lending Focuses on Poorest Regions—Boost in Renewable Energy Financing," *The World Bank*, September 9, 2014, http://www.worldbank.org/en/news/feature/2014/09/05/boost-in-world-bank-renewable-energy-lending; "Energy Overview," *The World Bank*, September 22, 2014, http://www.worldbank.org/en/topic/energy/overview#1; and B. Tenenbaum, C. Greacen, Tilak Siyambalapitiya, and J. Knuckles, *From the Bottom Up: How Small Power Producers and Mini-Grids Can Deliver Electrification and Renewable Energy in Africa* (Washington, DC: The World Bank, 2014), https://openknowledge.worldbank.org/bitstream/handle/10986/16571/9781464800931.pdf?sequence=1.

[3]It has been suggested that the price of wind and solar power has been greatly underestimated. See "Analysis: Solar and Wind Power Costs Are Huge Compared to Natural Gas Fired Generation," Watts Up with That?, blog entry by guest blogger, September 6, 2014, http://wattsupwiththat.com/2014/09/06/analysis-solar-wind-power-costs-are-huge-compared-to-natural-gas-fired-generation/. The International Energy Agency estimates that global deployment of renewable energy at a scale to limit carbon emissions enough to affect climate change by 2050 will require spending several trillion dollars per year until 2050. See "Taking on the Challenges of an Increasingly Electrified World," IEA press release, Seoul, Korea, May 12, 2014, http://www.iea.org/newsroomandevents/pressreleases/2014/may/name,51005,en.html. For reference, the US economy contains ~27% of global economic

activity and had an estimated value (GDP) of ~$17 trillion in 2013. In 2013, the US federal government spent $3.8 trillion.

[4]M. Z. Jacobson and M. A. Delucchi, "Providing All Global Energy with Wind, Water, and Solar Power, Part 1: Technologies Energy Resources, Quantities and Areas of Infrastructure and Materials," *Energy Policy* 39 (2011): 1154–69, http://web.stanford.edu/group/efmh/jacobson/Articles/I/JDEnPolicyPt1.pdf.

[5]European Commission Eurostat, "Electricity and Natural Gas Price Statistics," data from May 2015, http://ec.europa.eu/eurostat/statistics-explained/index.php/Electricity_and_natural_gas_price_statistics.

[6]Several links to detailed critiques of Jacobson and Delucchi are provided in "How Far Can Wind, Water, and Solar Take Us?" City Atlas New York, http://newyork.thecityatlas.org/lifestyle/how-far-can-wind-water-and-solar-take-us/.

[7]It was reported in November 2014 that Google internally funded the RE<C program, "which aimed to develop renewable energy sources that would generate electricity more cheaply than coal-fired power plants do." After four years of study, between 2007 and 2011, Google terminated the program because it was concluded that the appropriate technology to achieve this goal does not exist. See details, Ross Koningstein and David Fork, "What It Would Really Take to Reverse Climate Change," posted November 18, 2014, http://spectrum.ieee.org/energy/renewables/what-it-would-really-take-to-reverse-climate-change. For a detailed discussion of the problems associated with the German green energy experience, see Will Boisvert, "Green Energy Bust in Germany," http://www.dissentmagazine.org/article/green-energy-bust-in-germany. For problems with Danish wind power, see James Kanter, "Obstacles to Danish Wind Power," http://www.nytimes.com/2012/01/23/business/global/obstacles-to-danish-wind-power.html. For problems associated with the cost of wind energy transmission, see Barry Brook, "Critique of 'A Path to Sustainable Energy by 2030,'" November 3, 2009, http://bravenewclimate.com/2009/11/03/wws-2030-critique/. A recent paper has found that the cost of electricity from solar and wind are at least ten times greater than from nuclear, hydro, coal, or gas. See D. Weißbach, G. Ruprecht, A. Huke, K. Czerski, S. Gottlieb, and A. Hussein, "Energy Intensities, EROIs (Energy Returned on Invested), and Energy Payback Times of Electricity Generating Power Plants," *Energy* 52 (2013): 210–21; and D. Weißbach, G. Ruprecht, A. Huke, K. Czerski, S. Gottlieb, A. Hussein, "Reply on 'Comments on "Energy Intensities, EROIs (Energy Returned on Invested), and Energy Payback Times of Electricity Generating Power Plants.' Making Clear of Quite Some Confusion," *Energy* 68 (2014): 1004–1006.

[8]US Energy Information Administration, "India: Overview," June 26, 2014, http://www.eia.gov/beta/international/rankings/#?prodact=53-1&cy=2014; and R. K. Singh and D. Chakraborty, "India Starts Auction of Gas Imported for Idle Power Plants," BloombergBusiness, May 12, 2015, http://www.bloomberg.com/news/articles/2015-05-12/india-starts-auction-of-imported-fuel-for-gas-fired-power-plants.

[9]T. K. Burki, "Twice as Bad: New Estimates for Mortality from Air Pollution," *The Lancet Respiratory Medicine* 2, no. 5 (2014): 355. See also Global Burden of Disease Study 2010, The Lancet, December 13, 2012, http://www.thelancet.com/themed/global-burden-of-disease.

[10]C. J. Yang and R. B. Jackson, "China's Synthetic Natural Gas Revolution," *Nature Climate Change* 3 (2013): 852–54.

[11]Collin Eaton, "U.S. Takes a Crack at China's Tough Shale," *Houston Chronicle*, August 15, 2014, http://www.houstonchronicle.com/business/energy/article/U-S-fracturing-takes-a-crack-at-China-s-tough-5691345.php. For a discussion on the costs of shale extraction in China, see "China Natural Gas Growth Faces Hurdles," *Financial Times*, August 7, 2014, http://www.ft.com/intl/cms/s/0/c92559c6-ed6e-11e3-8a1e-00144feabdc0.html#axzz3JiA5lFOH.

[12]For an excellent presentation of hydraulic fracturing, see "Hydraulic Fracturing 101," http://www.halliburton.com/public/projects/pubsdata/Hydraulic_Fracturing/fracturing_101.html. See also the primer developed by the American Petroleum Institute, "Hydraulic Fracturing Primer: Unlocking America's Natural Gas Resources," http://www.api.org/policy-and-issues/policy-items/hf/hydraulic-fracturing-primer.

[13]R. F. Zaffarano and J. D. Lankford, "Petroleum and Natural Gas," *Mineral Facts and Problems*, Bulletin 630 (Washington, DC: US Bureau of Mines, 1965), 673.

[14]Matt Blake, "Bosses Toast to 'Harmless Fracking': Haliburton Executive Drinks Fluid as Part of a PR Stunt to Prove It Is Safe," DailyMail.com, November 1, 2013, http://www.dailymail.co.uk/news/article-2483690/Bosses-toast-harmless-fracking-Haliburton-executive-drinks-fluid-PR-stunt-prove-safe.html.

[15]For a discussion on the importance of directional drilling, see "The Unsung Masters of the Oil Industry: Oil Firms You Have Never Heard of Are Booming," *The Economist*, July 21, 2012, http://www.economist.com/node/21559358.

[16]"Implications of the Gas Price Increase in India," Enerdata.net, October 30, 2014, http://www.enerdata.net/enerdatauk/press-and-publication/energy-news-001/gas-prices-increase-india-implications_30493.html.

[17]For a discussion on proppant technology, see Don Lyle, "Proppants Open Production Pathways: From Sand to Ceramics and Beyond, Specially Designed Proppants Provide Economic Advantages," http://www.slb.com/~/media/Files/stimulation/industry_articles/201101_ep_proppant_design.pdf.

[18]Michael Fitzsimmons, "Apache: Fracking without Fresh Water to Cut Costs," November 22, 2013, http://seekingalpha.com/article/1858201-apache-fracking-without-fresh-water-to-cut-costs. See also Emily Guerin, "Permian Basin: America's Newest Fracking Boom Where There's Not Much Water," March 19, 2014, http://www.hcn.org/blogs/goat/permian-basin-in-new-mexico-and-west-texas-americas-newest-fracking-boom.

[19]J. Paktinat, B. O'Neil, and M. Tulissi, "Case Studies: Improved Performance of High Brine Friction Reducers in Fracturing Shale Reservoirs," paper presented at the SPE Eastern Regional Meeting held in Columbus, Ohio, August 17–19, 2011 (Society of Petroleum Engineers, 2011), SPE 148794, http://trican.ca/pdf/services_technology/tech_papers/SPE_148794.pdf.

[20]"USEPA Report Reveals ODNR Repeatedly AWOL from Field Command Meetings during Critical Early Days of Massive Fracking Fire Incident," Ohio Environmental Council, Newsroom, Press Releases, July 23, 2014, http://www.theoec.org/press-releases/usepa-report-reveals-odnr-repeatedly-awol-field-command-meetings-during-critical.

[21]Karen Sullivan Glaser et al., "Seeking the Sweet Spot: Reservoir and Completion Quality in Organic Shales," http://www.slb.com/~/media/Files/resources/oilfield_review/ors13/win13/02_sweet_spot.pdf.

[22]Matt DiLallo, "3 Reasons Why Chesapeake Energy Corporation's Stock Could Rise Again," The Motley Fool.com, Investing Commentary, November 28, 2014, http://www.fool.com/investing/general/2014/11/28/3-reasons-why-chesapeake-energy-corporations-stock.aspx.

[23]Ernest J. Moniz et al., "The Future of Natural Gas: An Interdisciplinary MIT Study," MIT Energy Initiative, June 6, 2011, http://mitei.mit.edu/publications/reports-studies/future-natural-gas.

[24]Michael Bickle et al., "Shale Gas Extraction in the UK: A Review of Hydraulic Fracturing," The Royal Society and the Royal Academy of Engineering, June 2012, DES2597, http://www.raeng.org.uk/publications/reports/shale-gas-extraction-in-the-uk.

[25]S. L. Brantley, D. Yoxtheimer, S. Arjmand, P. Grieve, R. Vidic, J. Pollak, G. T. Llewellyn, J. Abad, C. Simon, "Water Resource Impacts during Unconventional Shale Gas Development: The Pennsylvania Experience," *International Journal of Coal Geology* 126 (2014): 140–56.

[26]T. H. Darraha, A. Vengosh, R. B. Jackson, N. R. Warner, R. J. Poreda, "Noble Gases Identify the Mechanisms of Fugitive Gas Contamination in Drinking-Water Wells Overlying the Marcellus and Barnett Shales," *Proceedings of the National Academy of Sciences* 111, no. 39 (2014): 14076–81.

[27]S. G. Osborn, A. Vengosh, N. R. Warner, R. B. Jackson, "Methane Contamination of Drinking Water Accompanying Gas-Well Drilling and Hydraulic Fracturing," *Proceedings of the National Academy of Sciences* 108, no. 20 (2011): 8172–76.

[28]L. J. Molofsky, J. A. Connor, A. S. Wylie, T. Wagner, and S. K. Farhat, "Evaluation of Methane Sources in Groundwater in Northeastern Pennsylvania," *Groundwater* 51, no. 3 (2013): 333–49.

[29]Ronald A. Sloto, "Baseline Groundwater Quality from 20 Domestic Wells in Sullivan County, Pennsylvania, 2012," U.S. Geological Survey, Scientific Investigations Report 2013-5085, http://pubs.usgs.gov/sir/2013/5085/.

[30]L. M. Cathles III, L. Brown, M. Taam and A. Hunter, "A Commentary on 'The Greenhouse-Gas Footprint of Natural Gas in Shale Formations' by R. W. Howarth, R. Santoro, and Anthony Ingraffea," *Climatic Change* 113, no. 2 (2012): 525–35. See also J. K. Shoemaker and D. P. Schrag, "The Danger of Overvaluing Methane's Influence on Future Climate Change," *Climatic Change* 120, no. 4 (2013): 903–14.

[31]L. M. Cathles, "Future Rx: Optimism, Preparation, Acceptance of Risk," Geological Society, London, Special Publications, first published on October 24, 2013, http://dx.doi.org/10.1144/SP393.6.

[32]M. R. Allen, D. J. Frame, C. Huntingford, C. D. Jones, J. A. Lowe, M. Meinshausen, and N. Meinshausen, "Warming Caused by Cumulative Carbon Emissions towards the Trillionth Tonne," *Nature* 458 (2009): 1163–66.

[33]Jacobson and Delucchi, "Providing All Global Energy with Wind, Water, and Solar Power, Part 1."

[34]The decline in the rate of German CO_2 emissions reductions has occurred because its nuclear energy program is being shut down and replaced by coal-fired power plants. In 2012, Germany had 1000 MW more coal-fired power capacity than in 2011. When this process is complete in ~2025, coal-fired power capacity will have increased by 10,700 MW from the 2011 German coal-fired capacity. See details in Jos G. J. Olivier et al., "Trends in Global CO_2 Emissions: 2013 Report" (The Hague: PBL Netherlands Environmental Assessment Agency, 2013), http://edgar.jrc.ec.europa.eu/news_docs/pbl-2013-trends-in-global-co2-emissions-2013-report-1148.pdf.

[35]See the 2014 EPA methane emissions report, "Overview of Greenhouse Gases: Methane Emissions," US Environmental Protection Agency, http://www.epa.gov/climatechange/ghgemissions/gases/ch4.html.

[36]E. G. Hertwich and G. P. Peters, "Carbon Footprint of Nations: A Global, Trade-Linked Analysis," *Environmental Science and Technology* 43 (2009): 6414–20.

[37]Ana Swanson, "Here's One Thing the U.S. Does Export to China: Carbon Dioxide," Forbes.com, November 12, 2014, http://www.forbes.com/sites/anaswanson/2014/11/12/heres-one-thing-the-us-does-export-to-china-carbon-dioxide/.

[38]Jan Christensen, *Encyclopaedia Britannica*, s.v. "Norway: Economy," http://www.britannica.com/EBchecked/topic/420178/Norway/37915/Economy.

[39]W. Grassl, "Integral Human Development in Analytical Perspective: A Trinitarian Model," *Journal of Markets and Morality* (March 2013), http://www.highbeam.com/doc/1G1-363191408.html.

[40]William Oddie, "Environmnetalism That Harms the Poor," *Crisis Magazine* (June 26, 2015), http://www.crisismagazine.com/2015/environmentalism-that-harms-the-poor, quotes Charles Moore, "The Holy Father Is Wrong to Say That Our Way of Life Is Doomed," *The Telegraph*, June 20, 2015, http://www.telegraph.co.uk/news/worldnews/the-pope/11686814/The-Holy-Father-is-wrong-to-say-that-our-way-of-life-is-doomed.html.

ASA Members: Submit comments and questions on this article at www.asa3.org→FORUMS→PSCF DISCUSSION.

Theodicy through a Lens of Science

Wilton H. Bunch

Wilton H. Bunch

A theodicy is an attempt to explain the old question, "Why do bad things happen to good people?" within the assumptions of the existence of God and certain concepts of his nature. There are many explanations: some old, some by current authors. All of them resemble the "saving the appearance" approach of science, and accomplish this aim quite well, but all suffer when presented in situations of pastoral care.

I will argue that evil, from natural disasters to personal tragedies, is not caused voluntarily by God but is a product of the randomness of this world where randomness is our understanding of the unpredictability of a process (epistemic randomness). This is consistent with the classical understandings of God and is better accepted in the pastoral situation.

In less than 24 hours, Floria Tosca's world was turned upside down. Her lover, Mario Cavaradossi, was arrested and tortured into unconsciousness for allegedly hiding an escaped political prisoner. To save Mario from further torture, Tosca confessed the location of the escapee, which confession only brought her wrath from Cavaradossi. His angry denunciations for giving this information were his last words to her as he was being dragged to the gallows. As if this were not enough, Scarpia, the chief of police and a fearsome psychopath, is eagerly preparing to rape her. She cries out to God. (Since this is opera, her lament is set to gorgeous music, but the lyrics must suffice here.)

> I lived for art, I lived for love:
> Never did I harm a living creature!
>
> Whatever misfortunes I encountered
> I sought with secret hand to succour.
>
> Ever in pure faith, my prayers rose in the holy chapels.
>
> Ever in pure faith, I brought flowers to the altars.
>
> In this hour of pain, why, why, O Lord, why dost Thou repay me thus?[1]

Why do such things happen to God's people? Why does God appear to repay good deeds with pain such as hers? Floria was not the first to ask this question, and she will not be the last. I suspect the existence of suffering has produced more atheists than any other issue of God and humans. Trying to answer this question has led to a field of theology known as theodicy.

This article will deal with three ideas. First, it will show that thinking about theology can use the same methods as thinking within science, and when contradictions arise, theology can use similar methods to deal with these. Nowhere is this truer than when the issue is human suffering. Second, it will review some of the common theodicies and their weakness in pastoral situations. Finally, it will suggest an alternative which absolves God from evil and is pastorally sensitive.

Wilton Bunch *holds an MD from Loma Linda University, a PhD in physiology from the University of Minnesota, and an MDiv from the Church Divinity School of the Pacific. He formerly served as chair of the Department of Orthopaedics at Loyola University of Chicago and dean of the College of Medicine, University of South Florida. Currently, he is a professor in the Department of Philosophy at Samford University, a founding fellow of the Center for Science and Religion there, and an Episcopal priest.*

Theodicy

Theodicy is derived from two words, "*Theos*" and "*dike*," literally meaning the trial or judgment of God. In common usage, theodicy is a philosophical and/or theological exercise involving a justification of the righteousness of God.[2] Somewhat more colloquially, it is a defense of God's goodness and omnipotence in view of the existence of evil. Theodicy is a way to rationalize the presumed actions of God which are harmful to his people. Theodicy is an attempt to answer the old question, "Why do bad things happen to good people?"

All theists hold notions of God and God's characteristics that would in science be called assumptions. The first assumption is that a powerful being, worthy of worship, given the name God, actually exists.[3] Having made this assumption, we can move on to our assumptions about God's character. Implicit in the assumption that God is worthy of our worship is that this is a good God. We will focus on two parts to this assumption: God never does what is morally wrong, and God is a loving God. Initially we base this assumption on accounts of God's actions for his people as described in the Old Testament. We then move through scripture to the many statements of Jesus concerning the character of his Father, to 1 John which insists not that God loves, or is loving, but that God *is* love.

Much of the evangelical world places much more emphasis on the assumption that "will" is a most essential aspect of God. God is free to will whatever God chooses, and humans must not question the actions that result from the expressions of his will. The expansion of this term expresses that whatever happens in the universe is planned, ordained, and governed—without exception—by God. Even if God works through secondary causes, he is still in total control.

Advocates of this position go to great lengths to show that there can be no exceptions to this control. As R. C. Sproul explains,

> The mere existence of chance is enough to rip God from his cosmic throne. Chance does not need to rule; it does not need to be sovereign. If it exists as a mere, impotent humble servant, it leaves God not only out of date but out of a job. If chance exists in its frailest possible form, God is finished.[4]

If a single molecule is out of its intended position, this would show that God is not in control; but we need not worry, all molecules and other small particles are exactly where God intended. Obviously, this is not a position held by quantum physicists!

Even believers who do not go to these lengths still speak and sing of God's power and his sovereignty over all creation, that is, his ability to express and fulfill his will. Does this language of power and sovereignty make God responsible for disease and death? Many Christians would answer this question with a resounding "yes," but despite this, they also accept love as a characteristic of God. This conclusion becomes their cornerstone in dealing with the tragedies of daily living. Alasdair MacIntyre describes this belief complex as pre-modern, but it is a common assumption of many people in my world of ministry.[5]

These assumptions come together to establish a paradigm which specifies the existence of God and describes certain characteristics of God. A paradigm is a collection of observations, hypotheses, and assumptions that provide the context for describing and explaining further observations and ideas.[6] We have developed a simplified, two-factor paradigm for thinking about God's character: God is loving, and God is sovereign over all events and occurrences. This is certainly not a complete description of God;[7] it does not include omnipotence, omniscience, omnipresence, and other aspects, but it will allow us to focus on God's role in human suffering.

Because there are events and observations that do not match this paradigm, theologians go to great lengths to reconcile these whenever they think or talk about God. For example, we assume that God is love. The correctness of this assumption is challenged every day. Good people are subject to natural evils such as hurricanes, tornados, floods, and droughts. They are betrayed, mugged, stabbed, and shot by other humans. They are in accidents. They suffer diseases such as heart disease, strokes, and cancer. They are abandoned by those they love, and finally they die. How could a loving God allow such to befall any human created in his image?

Instead of focusing on love, we may assume the importance of God's will and that God has the power to impose this will on humans. If God has this

power, we wonder why he does not use it for good instead of appearing to be arbitrary and sometimes even appearing to be a tyrant.

Explaining these apparent inconsistencies is the work of theologians and is called "theodicy." In medieval natural philosophy and early science, a similar process was called "preserving the phenomena." The term asserts that a scientific theory is worth holding if it (1) accounts for or predicts new data and (2) is simple.[8]

Not all use the term "preserving the phenomena" in exactly the same way.[9] Here it will refer to "phenomena" as a common understanding, a hypothesis, a scientific law, or a well-held belief usually based on some data. This larger understanding is then threatened by other, new data, usually observational. To a scientist, data is true, unchangeable, nonnegotiable, not to be "fiddled with." It is the explanations placed on data that are changeable, questionable, and sometimes false.[10] In "preserving the appearance," the data that conflict with the phenomena are interpreted, augmented, expanded, or explained in such a way that the phenomena remain essentially intact.

One of the ancient examples of this was Aristotle's model of the universe, which was the early normative paradigm. It described the universe as a sphere with the sun, moon, each planet, and the fixed stars on perfect spheres which rotated around the earth. There was no empty space, and the further regions were more perfect than the regions below the moon.

There were observations made by the early Babylonians and subsequent astronomers which showed that the movements in the heavens did not match the model. Most obvious was the path of the planets which appeared to be moving counterclockwise with the fixed stars, then suddenly reversing direction, only to make another turn to the original course. Soon this strange motion would be repeated as the planet made its circular trip across the sky.

Many people tried to find a way to explain these observations, most successfully Ptolemy, a first-century astronomer. He devised a system of epicycles to explain the wandering nature of the planets. In this description, each planet made a second counterclockwise circle upon the main path around the earth. In half of this second rotation, the planet would be moving in the same direction as the main rotation and would appear to be headed "correctly." In the other half, it would be moving counter to the main motion and would appear to be moving in a retrograde manner. This series of small circles on the larger motion accurately described the observed motion and was later termed "preserving the phenomena"; that is, it preserved the Aristotelian model despite the data.

Aristotle's authority was maintained by Ptolemy's modification, so it was accepted everywhere, even by the church, which claimed to read the Bible literally on this point. (The biblical model was vastly different, but was subsumed by Aristotle's.)

In general, we try to "preserve the phenomena" when we form hypotheses and/or give explanations which seem to explain what is otherwise a contradiction between our closely held beliefs and our observations. This process works well until too many inconsistencies surface and, to use the language of Kuhn, a crisis develops and the old paradigm is replaced by a new one.[11]

Theodicy is the example we wish to explore; it is the process of developing the explanations offered for the observation that bad things frequently happen to good people. In doing this, we are determined to "preserve the phenomena" we ascribe to God, his character and his nature. In doing this, we are acting the way that natural philosophers and scientists have always behaved.

We must do this cautiously. Karl Barth, perhaps the preeminent theologian of the twentieth century, was very concerned about human confidence in speaking about God and the message of God for us. When we speak, we may do so with "words of our own coining or scripture quotations," but we must not "confuse our words with the fullness of the Word of God."[12] We should do our best to understand God, but we should always be humble about our efforts and conclusions.

Barfield uses the term "idols of the study" for hypotheses and "factitious extrapolations" that are considered to be ultimate instead of recognizing them as human constructions.[13] These idols are formed by people who do not take Barth's cautions seriously. Although Barfield is harsh, he is no

more so than Jesus "teaching human precepts as doctrines" (Mark 7:7).[14] I believe all of these to be particularly appropriate for hypotheses about God.

Theodicy is a division of theology: *theos* and *logos*, words about God. The words of any theodicy are words about the relation of God and human suffering. These are human words, as precise and accurate as the best thinkers of the ages have been able to devise. But they are human words, attempting to preserve the phenomena. We must never confuse ourselves into believing that the conclusions we reach about God and human suffering are absolutely congruent with reality.

This view can be compared with "critical realism" as described by John Polkinghorne.[15] There is a reality, and this may be exactly the way things appear. However, there are a number of obstacles. Therefore we may not see clearly or understand correctly. As a result, we need to apply our ideas of reality cautiously and gently.

Theodicies deal with apparent contradictions concerning God and the world. Many philosophers have presented ways to think about it, but a very common approach is to think about this as an incomplete triangle. You cannot have a triangle with one point asserting that God is all powerful, a second point claiming that God is good and loving, and the third point asserting that evil exists. Any connection of two points is possible, but not all three. Consider these possibilities: (1) God can be all-powerful and evil can exist, but then it is hard to say that God is loving. If God were loving, he could destroy the evil and there would be no problem of suffering of his followers; (2) God can be loving and evil exists, but then God seems to lack power to do anything about evil; (3) God can be both powerful and loving, but this requires denial of the existence of evil. This conception provides us with ways to begin a theodicy.

Evil Does Not Exist

The last of these possibilities seems to be the most popular: God is powerful and loving and, implicitly, the existence of evil is denied. A proof text for this might be, "All things work together for good to those who love God" (Romans 8:28). This verse is frequently taken to mean that what we see and discern to be evil really is good; we just do not understand, but the events are working toward a plan. What we need is faith and confidence, together with the patience, for it all to unfold.

However, plainly speaking, this approach is simply a denial of evil. God is in control, whatever is happening is God's will, and therefore it cannot be truly evil. Our duty is to accept what comes to us cheerfully. Many Christians hold this view and find that it gives them great comfort. There are at least two ways this denial of evil is expressed: (1) what appears to be evil is really punishment; and (2) evil produces character.

1. What Appears to Be Evil Is Really Punishment

A precise way to deny the existence of evil is to say that what we perceive as evil is punishment designed to correct our deviant behavior. This explanation has biblical roots; the prophets of ancient Israel used this language frequently. Nathan told David that his son would be king, but that if he committed iniquity, he would be disciplined by God, using men to administer the pain (2 Samuel 7:14). Jeremiah (chapters 1–25) frequently used the concept of discipline to express what God would do to Judah for their widespread sinfulness. The idea of these passages is that pain and suffering can show us that our lives are not what they should be and awaken us from our worldly happiness.

The 1892 *Book of Common Prayer*, in its service for the sick, says, "Wherefore, whatsoever your sickness be, know you certainly that it is God's visitation," and that "we should patiently and with thanksgiving, bear our heavenly Father's correction."[16] This theology of 120 years ago is not dead; it is alive and well within and without the walls of churches today. The word "father" links this apparent evil to the punishment of an earthly parent that is designed to get the misbehaving child back on the right track. But if we make this connection, and indulge in anthropomorphism, we must also remember the idea of proportionality. Good parents discipline, but they do not abuse; good parents are not tyrants.

This theology can be seen regularly in literature. In *The Plague* by Albert Camus, Fr. Paneloux, the Jesuit pastor, preached the message of God's punishment, saying that the plague and the resultant huge numbers of deaths were God's chastisement for the

population's sins.[17] (After Fr. Panaloux watched a small boy die, he became much less certain of this explanation.)

Although this response denies the existence of evil, it does acknowledge that the event is the result of a deliberate decision and action by God. There is no question of the role of God, but it leaves the question of love unanswered.

2. Evil Produces Character

Somewhat similar is the idea that what we perceive as evil is actually material for building character. This hypothesis assumes that God is the actor, and therefore the action is not evil. It includes God's love, in that the intended result is a better human being.

C.S. Lewis explained that God's love for people is of the type that is committed to making them into the best people they can be. Frequently, this is painful.[18] Because good eventually comes of it, God is justified in allowing or ordaining this type of suffering so that people will grow and mature. God is acting out of love, and the apparent evil is only that—apparent, not real.

This explanation has been developed in great detail by John Hick who puts present suffering into the larger context of our eventual eternal bliss. "Humankind is brought into being … as a spiritually and morally immature creature, and then growing and developing though the exercise of freedom."[19] The virtues we develop as the result of suffering are of great value in building our character.

This leads to invoking God indirectly in a number of statements made to people with disabilities. These statements imply not only a doctrine of what it means to be disabled, but also the idea that evil assists a person in developing character.

"You are special in God's eyes."
(If this is "special," what does God do to those he hates?)

"God gave you this to develop your character."
(I've developed enough character to last a lifetime, maybe it's your turn.)

"You are such an inspiration to us in the way you overcome your difficulties."
(I'm just glad that you don't complain the way you know I would.)[20]

One way or the other, suffering is considered to be good for us. However, the idea that God is deliberately causing suffering for one reason or another is counterintuitive to the practice of medicine, nursing, and the allied medical specialties. The goal of medicine is always to relieve suffering even when it cannot cure; does this mean that medicine is sometimes working against God's will? How can a doctor know when to intervene and when to stay away? Have the practitioners of modern medicine become God's antagonists? I think not!

There is only one theory of a place where suffering is redemptive: Purgatory. All stays in Purgatory are temporary; the souls placed there will eventually attain Paradise. The doctrine of purgatory developed as theologians considered that sinners who repented prior to death did not deserve the immediate transformation to Paradise with saints and martyrs, but were still somehow within God's grace. Thus, a doctrine of a time of purification and eventual elevation seemed reasonable. One author calculated the years in Purgatory to be twenty-five years for each venial sin and fifty for each mortal sin. The reprobate who repented late in life would not have a rapid trip to glory, but will make it in the end.[24] This doctrine answers the objections that incommensurate degrees of suffering are experienced by different victims.

People who support this doctrine must hold a robust version of free will. For Purgatory to be effective, humans must have the freedom to imagine themselves as better and to remake their lives. Those consigned to Purgatory have the power and the will to change their lives into one characterized by purity. This doctrine is not widely held by Christians outside segments of the Roman Catholic Church. For those who do not believe in Purgatory, this example merely illustrates the inadequacy of the "character building" defense.

I believe that the idea that God actually intends for people to undergo extreme physical or mental anguish is cruel and incompatible with the scriptural account of a God who loves his creatures. It is inconsistent with Jesus as the revelation of God. It is inconsistent with 1 John that declares, not that God loves, but that God *is* love. Directly linking divine actions and human suffering is too high a price to pay to preserve the phenomena, and it seems to create

more inconsistencies, rather than resolve them. This means that we must look for another explanation, another way to preserve our paradigm that includes God's power and love.

"Evil" Is Not Caused by a Loving God; It Is The Result of Human Errors and Sins.

There is truth to the explanation that some evil comes from human causes. Some suffering we bring upon ourselves; we get what we deserve. As we sow, so shall we also reap (Galatians 6:7). Imagine a three-pack-a-day smoker who after twenty years develops lung cancer. Physicians will treat that person with respect and the best medical care, but the question of causation is clear. God did not cause that suffering.

Aquinas expressed this very clearly by saying that all human tragedy is the result of human flaws. The entire world, including humans, was created good; suffering entered by the exercise of the human will. Except for the interventions of God's love, this theodicy completely eliminated God from the world of human pain. The world is full of darkness, wickedness, unbelief, and selfishness. It is these forces, not God, that are responsible for human pain.

This is also an answer to the gross atrocities of humanity that result in the death and suffering for millions of God's believers. The overwhelming capacity for evil possessed by some persons and regimes produces plagues as horrible as any bacteria.

This answer of human etiology may work well for lung cancer or mass murderers, but what about the sweet, lovely young girl whose life is terminated by a careless driver? If God can foresee this tragedy, why did he allow it to happen?

To return to the concept of a triangle, this answer asserts that God loves and that evil exists, but leaves us with the conclusion that God cannot be all-powerful. If God were powerful, God would use this power to prevent evil rather than allowing it to occur. So we attempt to preserve the phenomenon of a loving God, but at the expense of a weak and even impotent one. Is such a god worthy of worship? I think not.

Some try to restore strength and power to such a god by assuming the power of knowledge of the future. Thus we have a god who is not responsible for the presence of evil, and cannot seem to do anything about it, but can accurately foresee it.

This was the explanation of the actions of Oedipus in Sophocles's play of the same name.[22] The gods foretold that Oedipus would kill his father and marry his mother; this came to be, but these events were the results of his free actions. His suffering was due to his own free will. This explanation has not lost its popularity in 2,500 years, but I do not find it helpful.

A personal note of cynicism: These attempts to "save the phenomena" may work in theory, but I have observed that those who most loudly proclaim God's personal involvement in pain and suffering tend to be young and personally free from tragedy. They should listen to those who have suffered, and they should read Dante more carefully.

> You will come to learn how bitter as salt and stone
> is the bread of others,
> how hard the way that goes up and down stairs
> that are never your own.[23]

Many young pastors today lack the experience to comment appropriately on human suffering. They are like Fr. Paneloux, who was separated from human anguish by his vestments and had not experienced suffering first hand. Dr. Rieux described him thus:

> Paneloux is a man of learning, a scholar. He hasn't come in contact with death; that's why he can speak with such assurance of the truth—with a capital T. But … any country priest would try to relieve human suffering before trying to point out its excellence.[24]

Pastors like Paneloux are good at creating explanations while at their desks, but incapable of ministering to those in pain.

Other Theodicies

The theodicies that are developed from thinking about an incomplete triangle account for most of the explanations of Christians in the pews. Theologians have developed other, more sophisticated explanations such as the human story, which is part of the universe and is unfinished and therefore unpredictable.[25] Others suggest that human freedom depends on freedom for nature. Our world is good, but it is

not perfect. It is not by the direct action of God that humans suffer, but suffering is intrinsic to the structure of our world.

John Polkinghorne, a physicist who became an Anglican priest, generalizes this idea by suggesting that we must "acknowledge that by bringing the world into existence God has self-limited divine power by allowing the other truly to be itself."[26] After listing a number of natural disasters over which God had no control, he goes on to say, "That these things are so is not gratuitous or due to divine oversight or indifference. They are the necessary cost of a creation given by its Creator the freedom to be itself."[27]

Without the freedom demonstrated by creation, it would be difficult, if not impossible, to imagine a universe in which we were free to love or reject God. If our love is truly our own, it must be self-initiated, and we must be free either to do acts of love or to do unloving acts which may cause great harm. To say that a creature is free must mean that the creature has the freedom to choose.[28] If God wants to create loving beings, God must create free beings.[29]

Some will read these ideas to mean that since God designed the universe he must somehow be responsible. John Silber has made a distinction between status and voluntary responsibility,[30] and Ronald Hall has suggested that this is of assistance in thinking about God.[31] To hold a person responsible in the "status" understanding is to hold him responsible for his essence, his being, who he is. In contrast, to hold a person responsible in the "voluntary" sense is to hold her responsible for specific, intended, voluntary acts that she has performed. This is a distinction between who one is and what one does.

We can illustrate this by thinking about the usual academic hierarchy. When I was a medical school dean, I was held responsible by the president, by the board of regents, and, most importantly, by the press for the education of the students and residents, the research and publications of the faculty, and the welfare of the animals in the laboratories. This was status responsibility. I certainly was not a direct actor in any of these, or in the myriad of other activities that take place in a medical complex; I had status responsibility.

In contrast, the faculty members, who had direct contact with students, residents, and patients, had voluntary responsibility since their conduct was consciously and deliberately chosen, and they acted freely. Similarly, the faculty, doing research deliberately and freely, designed their experiments and reported their results with voluntary responsibility. The same could be said for every other person in the medical complex.

This was sharply illustrated one Sunday when an orthopaedist on the faculty refused to treat a 19-year-old woman with a fractured femur because she was indigent, ordering her to be sent to the county hospital. By 10 am the next day, we had calls from both Medicaid and Medicare officials saying that if the story as told by her mother was correct, we would be shut off from all federal reimbursements. By 11 am, an investigative reporter announced that he would be there at 1 pm for an interview. Suddenly, the Medical Center vice-president was "traveling"; the hospital president was "unavailable." By virtue of who I was, this was my problem. That was status responsibility.

The troublesome orthopaedist had voluntary responsibility for this fiasco. He had intentionally and deliberately acted to send this woman away. He could have chosen to ask someone else to care for her; he could have called me—I would rather have fixed her femur than try to fix the fallout. But, he thought, intended, and acted, and therefore had voluntary responsibility. I had only status responsibility.

By virtue of being the creator, God has status responsibility for the evil that occurs in the world. However, this does not mean that God is directly and actively involved in decisions to allow evil to occur. We do not experience a recapitulation of the Job story.

Of all the ways of thinking of God and human suffering, the explanations involving freedom of creation and humans are the best my head can accept, but my heart is unsatisfied because I have experienced great evils. Within a short period of time, my younger brother died of a brain tumor, our two-month-old son was killed in a car accident, and my wife became psychotic. Later my sister was killed in a car accident, my career in medicine was terminated over a situation in which I had neither responsibility nor authority, and our daughter was murdered. I understand Floria Tosca's cry, "Why, why, O Lord."

These events are evil by any definition. To be human is to experience pain. Is there not an explanation to help me, one that I could give to someone else who is suffering from crime, oppression, or disease?

Perhaps I wish for too much. Both Alvin Plantinga and John Hick are explicit in that they do not expect a theodicy to help sufferers find peace or practical help.[32] Freud made the same observation from a different perspective.

> No matter how much we may shrink with horror from certain situations—of a galley-slave in antiquity, of a peasant during the Thirty Years' War, of a victim of the Holy Inquisition, of a Jew awaiting a pogrom—it is nevertheless impossible for us to feel our way into such people; to gauge their pain.[33]

It may be that only those who are suffering understand the power of evil, but this conclusion puts an insurmountable burden on caregivers.

Randomness as the Explanation of Many Evils

Another way to think about the problem of God and human suffering is to inquire if accidents ever occur. An answer of many Christians is "no," what we perceive as an accident is really an intended action of God. They often claim that God is either punishing us or building our character. An existentialist would answer "yes," the world is a chaotic place; there are accidents. Many unexpected things happen; they are random events—unintended, unexpected, and named "accidents." When these accidents produce suffering, they are hard to bear—exactly because they appear so random.

The word "random" is used in many different contexts and with different meanings. Most generally, random events refer to events that proceed, are made, or occur without some definite aim, reason, or pattern. James Bradley has listed nine examples of events to which the word random is attached.[34] However, there are so many variations in the use of the word that some have despaired of a unique, organizing idea of its meanings.[35] In this article, randomness refers to our understanding of the unpredictability of a process or an outcome.[36]

There are at least two concepts of randomness that concern us: epistemic and ontological randomness. The first is concerned with the appearance of randomness: what we know or believe we know. The second is the absolute truth about randomness and the natural world. This article takes the position that, for the purpose of thinking about theodicy, we do not need to delineate which is occurring.

From the human viewpoint, unpredictability is inherent in the nature of our world.[37] This is true at all levels, from quantum physics to a macro process such as the weather. In some, the process is partially understood by scientists; in others, it is not. The process of plate pressures and shifts that produce the earthquakes that plague the west coast of North America are understood, but the next slippage cannot be predicted. There is a confluence of deterministic causal streams that lead to an unpredictable outcome. From the viewpoint of the observer, their occurrence is random.

The volcanos in the same region are not as well understood, but they are not the mystery to scientists that they are to the person in the street. However, even with all the measuring devices available, some scientists monitoring Mount St. Helens were surprised and killed by the 1980 eruption. This too is a deterministic process with an unpredictable outcome. Not only is the eruption unpredictable in the short term, the next mountain to erupt is unknown. The periodicity also demonstrates epistemological randomness. There were 65 years between the eruptions of Mount Lassen and Mount St. Helens, but many more years since the previous eruption of Mount Lassen.

To speak of God and randomness in the same sentence produces a spectrum of responses. Christians who hold to some type of divine determinism, such as R.C. Sproul, quoted above, find this idea completely unacceptable. In contrast, David Bartholomew explains that chance is within the providence of God and that chance and randomness are used to accomplish his purposes. Chance provides a space for God to operate without disturbing the general lawfulness of the world.[38] Bradley takes an intermediate position: it is not inconsistent with historical Christianity to adopt the instrumentalist interpretation,[39] which is another term for "saving

the phenomena."[40] I believe that just as there is a spectrum of responses to the idea of God and randomness, there is also a plethora of possibilities for God to use or to ignore randomness.

If randomness is part of many of the terrible things that happen to good people, we may wonder why God found it necessary to create randomness. We must understand how we are using the word here. Stephen Barr says,

> When people speak of randomness, whether in science, in other professions, or in everyday life, they are not speaking of how things in this world relate to God, but how they are related to each other.[41]

For those for whom the subtleties of theological reasoning are not enough (see Barth's concerns of speaking about God, above), Alexander Pope reminds us that "fools rush in where angels fear to tread."[42] We will attempt not to rush in, but we will briefly consider a few possible answers to our question of why randomness exists.

Thinking from science, randomness does not seem to be an afterthought of the Creator, but part of the divine design; creation, as we understand it, would be impossible without randomness.[43] It is the random genetic mutations and combinations that provide the variety of organisms which will become subject to natural selection, eventually producing the creatures we know.[44] On a macro level, the extinctions, such as the asteroid that wiped out the dinosaurs and allowed the growth and spread of mammals, were random events, but they were crucial for the progress of evolution. These are examples of how we might imagine that God uses randomness to accomplish his purposes.

Thinking from theology, humans are intrinsically random by virtue of their membership in nature. Furthermore, they have free will, which is analogous to the freedom of creation and is considered to be a good by philosophers and common people alike. Generally speaking, an action is free in the sense that it cannot be caused by anything outside of the agent. To push this point, it is claimed that not even God can cause a person to freely do what is wrong.[45]

Every human being has the opportunity (choice) to make a difference in something or someone, but not all choose to do so. One has only to look at a college faculty to see those who devote themselves to assisting students to mature and grow and those who only appear on campus for their lectures. But, for each, the choice is theirs.

Another Suggestion

Thus far, we have used pure thinking to attempt to resolve the problem that human suffering causes for our concepts of God. We have behaved like Plato in the *Timaeus* who thought about the world and said, "Let me tell you a most likely story to explain what we see and experience."[46] We have tried to think like Einstein who had no experimental data for his theories of motion and gravitation, but made a similar claim; this is the way the world must be. We should have no reason to feel inadequate for having used our minds in this problem; this is an aspect of science, but it is not the only approach to truth. There are other roads to truth, and one of the most powerful of these is experimentation. Despite Einstein's confidence in his thought experiments, he was pleased by the empirical verification of the observed bending of starlight.

Computer simulation has been used to understand a wide variety of natural conditions such as cancer, to make meteorological predictions, to test the molecular modeling of new drugs, to design traffic flows, and to build models of human cognition. Computer simulation is not the same as observing an event in nature or manipulating nature in an experiment, but it can be very helpful in understanding concepts and possibilities. The Center for Science and Religion at Samford University is engaged in a project of computer simulation named "Randomness and Divine Providence" that is studying the effect of random stimuli on a model of neural circuits required for locomotion. Preliminary results indicate that the number of generations required to reach a target of fitness follows a log-normal distribution, as do many biological processes. When duplication of primitive components is allowed, the speed of evolution of multiple appendage entities is increased and subpopulations developed, which result also parallels biological observations.

To date, none of this relates directly to theodicy, but it does demonstrate that, in appropriate models, randomness can have pronounced effects

in developing reproducible outcomes. To the extent that these results can be generalized to real life, randomness is not just noise, an irritant, or a distraction, but events that are random can produce change. The results of these stimulations do not prove, but rather are consistent with, the idea that random events can change our lives and our world.

Returning to the role of theodicy, I agree with Bradley, that introducing the concepts of randomness is very helpful in "preserving the appearance" of historical theology, including doctrines of good and yet affirming the presence of evil.[47] Further, thinking of randomness in the occurrence of evil and suffering has the advantage of explaining many, if not all, situations of human suffering. It has the pastoral advantage of "explaining" a wide variety of specific evils ranging from the death of a child to natural disasters, to evil actions of persons that are not explained by the theodicies of punishment or personal improvement, with or without claims that God is loving.

God's Direct Actions in Human Suffering

Does the hypothesis that evil results from random events mean that God is totally separate, distant, and disinterested in our grief and sorrows? Is this a theodicy only because it totally protects God from any responsibility? Not at all. The suffering Christ, who took on our humanity, is ever present and near, ready to provide comfort to suffering humans.

Barbara Brown Taylor described the care she received after a concussion and the people who took care of her. She believed that she experienced God's direct intervention in two ways. God was near and caring for her through humans who did not know her, but who were concerned about her every need. She considered this care to be so extraordinary that it deserved the term "miracle." A second miracle she experienced was how safe she felt despite her head injury. This safety, she recognized, came from far beyond her pain; a safety net she knew would catch her no matter how far she fell. "Although my injuries were human, my safety felt divine."[48]

I have experienced such a safety net. I once had an operation that was technically perfect, but I received an infected injection in the recovery room and developed a condition with a sixty-percent mortality rate. I knew of the high likelihood of death, but remained calm while in the intensive care unit despite having tubes placed in every natural orifice and in some created for the occasion. This tranquility was the result of the conviction that "whether I live or whether I die, I am in the hand of God." The thought was constant, repetitive, blocked out most fears and, I am willing to believe, was a gift of the presence of God. "Lo, I am with you always, even to the end of the world" (Matthew 28:20) applies to more than missionary activities.

These two examples illustrate that God's grace is frequently best recognized when a person is totally out of control and unable to predict what will happen next. Since Christian belief begins with the reception of grace, our attempts at elimination of uncertainty may make it harder to receive and experience grace. Thus, there may be one desirable side effect of pain and suffering, despite my denials above.

It is this confidence of grace—although not proven or even fully explained, but attested to by many—that God is not responsible for our suffering but is with us in our suffering, that allows us to worship God despite our sorrows. We can become like Bruce in *Bang the Drum Slowly* who is dying of a cancer for which there was no treatment, and yet claimed, "I am doomed, but the world is all rosy—it never looked better. The bad things never looked so little, and the good never looked so big."[49] For theists, this is not simple denial, but confidence in God.

Summary

The popular theodicies do not serve their function of preserving the paradigm of a loving and powerful God. Following the path of these common theodicies is not pastorally sensitive and only leads to contradictions. Thinking about random events as the cause of evil and suffering performs this function better, and is pastorally sensitive.

Acknowledgments

I wish to thank Steve Donaldson and Tom Woolley for conversations and insightful suggestions. I also thank three anonymous referees for their helpful comments. ✦

Notes

[1]G. Giacosa and L. Illica, *Tosca,* libretto trans. John Gutman (New York: G. Schirmer, 1951), 31.
[2]Kenneth Surin, *Theology and the Problem of Evil* (Eugene, OR: Wipf & Stock, 1986), 1.
[3]Theodicy, as I will discuss it, will not question this assumption.
[4]R.C. Sproul, *Not a Chance: The Myth of Chance in Modern Science and Cosmology* (Grand Rapids, MI: Baker Books, 1994), 3.
[5]Alasdair MacIntyre, "Is Understanding Religion Compatible with Believing?," in *Rationality*, ed. Bryan R. Wilson (Oxford: Blackwell, 1974), 73.
[6]Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago, IL: The University of Chicago Press, 2012), 23–34.
[7]Thomas Oden, *Classic Christianity: A Systematic Theology* (New York: HarperOne, 1992), 35ff.
[8]Michael J. Crowe, *Theories of the World from Antiquity to the Copernican Revolution*, 2nd rev. ed. (Mineola, NY: Dover Publications, 2001), 66.
[9]G.E.R. Lloyd, "Saving the Appearance," *The Classical Quarterly,* New Series 28, no. 1 (1978): 202–22.
[10]James Bogen and James Woodward, "Saving the Phenomena," *The Philosophical Review* 97, no. 3 (July 1988): 303–52.
[11]Kuhn, *The Structure of Scientific Revolutions*, 77–91.
[12]Karl Barth, *The Doctrine of the Word of God,* vol. 1, pt. 1, trans. G. T. Thomson (Edinburgh: T&T Clark, 1936), 159–62.
[13]Owen Barfield, *Saving the Appearances: A Study in Idolatry* (Oxford: Barfield Press, 2011), 63.
[14]All scriptural references are from *The New Oxford Annotated Bible*, ed. Bruce M. Metzger and Roland E. Murphy (New York: Oxford University Press, 1991).
[15]John Polkinghorne, "The Metaphysics of Divine Action," in *Chaos and Complexity: Scientific Perspectives on Divine Action*, ed. Robert John Russell, Nancey Murphy, and Arthur R. Peacocke (Berkeley, CA: The Center for Theology and the Natural Sciences, 1996).
[16]*The Book of Common Prayer* (New York: Oxford University Press, 1892), 292–93.
[17]Albert Camus, *The Plague* (New York: Vintage Books, 1991), 94–99.
[18]C. S. Lewis, *The Problem of Pain* (New York: HarperOne, 2001), 19–29.
[19]John Hick, "An Irenaean Theodicy," in *Encountering Evil*, ed. Stephen T. Davis (Louisville, KY: Westminster John Knox Press, 2001), 43.
[20]Deborah Beth Creamer, *Disability and Christian Theology: Embodied Limits and Constructive Possibilities* (Oxford: Oxford University Press, 2009), 35.
[21]Raymond Angelo Belliotti, *Dante's Deadly Sins: Moral Philosophy in Hell* (Malden, MA: John Wiley and Sons, 2011), 71.
[22]Sophocles, *Oedipus the King*, trans. Robert Fagles (New York: Viking Press, 1982).
[23]Dante Alighieri, *The Divine Comedy: Paradiso*, trans. John Ciardi (New York: New American Library, 1970), 744.
[24]Camus, *The Plague*, 126.
[25]John F. Haught, *Science and Faith: A New Introduction* (New York: Paulist Press, 2012), 71–73.
[26]John Polkinghorne, *Belief in God in an Age of Science* (New Haven, CT: Yale University Press, 1998), 13.
[27]Ibid.
[28]Lewis, *The Problem of Pain*, 14.
[29]Robert J. Spitzer, *New Proofs for the Existence of God* (Grand Rapids, MI: William B. Eerdmans, 2010), 232–35.
[30]John Silber, "Being and Doing: A Study of Status Responsibility and Voluntary Responsibility," in *The Anatomy of Knowledge*, ed. Marjorie Grene (Amherst MA: The University of Massachusetts Press, 1969), 165–216.
[31]Ronald L. Hall, "Responsibility and Intention: Reflections on the Problem of God's Will and Human Suffering," *Perspectives in Religious Studies* 6, no. 2 (1979): 142–51.
[32]Alvin Plantinga, *God, Freedom and Evil* (London: Allen and Unwin, 1974), 29; and Hick, "An Irenaean Theodicy," 86.
[33]Sigmund Freud, *Civilization and Its Discontents*, trans. James Storachey (New York: W.W. Norton, 1989), 27.
[34]James Bradley, "Randomness and God's Nature," *Perspectives on Science and Christian Faith* 64, no. 2 (2012): 76–78.
[35]Colin Howson and Peter Urbach, *Scientific Reasoning: The Bayesian Approach*, 2nd ed. (Chicago, IL: Open Court, 1993), 324.
[36]Antony Eagle, "Randomness Is Unpredictability," *British Journal for the Philosophy of Science* 56, no. 4 (2005): 749.
[37]Paul Ewart, "The Necessity of Chance: Randomness, Purpose and the Sovereignty of God," *Science and Christian Belief* 21, no. 2 (2009): 111.
[38]David Bartholomew, *God, Chance, and Purpose: Can God Have It Both Ways?* (Cambridge: Cambridge University Press, 2008), 173–95.
[39]Bradley, "Randomness and God's Nature," 75–79.
[40]Crowe, *Theories of the World from Antiquity to the Copernican Revolution,* 66.
[41]Stephen M. Barr, "Chance, by Design: The Scientific Concept of Randomness Is Consistent with Divine Providence," *First Things,* December 2012, http://www.firstthings.com/article/2012/12/chance-by-design.
[42]Alexander Pope, "An Essay on Criticism" (1711), Project Gutenberg, February 2015, http://www.gutenberg.org/files/7409/7409-h/7409-h.htm.
[43]Bartholomew, *God, Chance and Purpose: Can God Have It Both Ways?*, 14.
[44]Ewart, "The Necessity of Chance: Randomness, Purpose and the Sovereignty of God," 119.
[45]Michael Tooley, "The Problem of Evil," *Stanford Encyclopedia of Philosophy*, ed. Edward N. Zalta (Spring 2015), http://plato.stanford.edu/archives/spr2015/entries/evil/.
[46]Plato, *Timaeus*, trans. Peter Kalkavage (Newburyport, MA: Focus Publishing, 2001), 59–60.
[47]Bradley, "Randomness and God's Nature," 79.
[48]Barbara Brown Taylor, *An Altar in the World* (New York: HarperCollins, 2009), 80.
[49]Mark Harris, *Bang the Drum Slowly* (Lincoln, NE: University of Nebraska Press, 1956), 45.

Michael Tenneson

Article

A New Survey Instrument and Its Findings for Relating Science and Theology

Michael Tenneson, David Bundrick, and Matthew Stanford

David Bundrick

Matthew Stanford

We report on the development and application of a survey instrument that measures the patterns of thought used by individuals attempting to relate theology and science. Survey responses of 1,491 people from five populations of science professors, theologians, other educators, students, and church laypersons were evaluated. We suggest a standardized conceptual framework and terminology; summarize science and theology relational approaches used by a broad spectrum of scientists, educators, pastors, and students; and discuss ways that the survey can be used to promote integrative practices. Based on theoretical constructs and empirical analyses, we propose the terms Compartmentalism, Conflict: Science over Theology, Conflict: Theology over Science, Complementarism, and Concordism to describe ways people relate theology and science. Overall, the favored approach of all groups we studied was Complementarism. Three groups with strong religious commitment also used Concordism to a great extent. In some populations, a large number of people did not use any science-theology paradigms to evaluate theology and science propositions. Young earth creationists predominantly used Conflict: Theology over Science and Complementarism. Old earth creationists and evolutionary creationists relied mostly on Complementarism. We end the article with some recommendations to advance the integration of science and theology.

Can theology and science be integrated in meaningful ways? Scholars have written much about biblical interpretation and methods of science, but less attention has been given to the practical integration of the two. This is a challenging undertaking because the interpretation of God's world (scientific methods) and God's Word (biblical interpretation) often requires different tools and approaches. Consequently, coherent and consistent science-theology paradigms are difficult to achieve, and their practical applications may be even more problematic.

We agree with Alister McGrath when he wrote, "It is increasingly clear that relating Christian faith to the natural sciences is one of the most pressing academic tasks of our day."[1] Not all who are involved in the study of relating theology and science share McGrath's expertise as both a scientist and a theologian. Can the practicing pastor or lay person productively explore faith and science in ways that do not do damage to valid scientific and theological methods and procedures? Or, is the venture hopelessly complicated and frustrating because of differing theological and scientific presuppositions? Is meaningful integration and application of science and theology practical? We think yes, but it requires theologians to become knowledgeable of basic scientific principles and scientists to develop their skills in theology; and both groups need to pay more attention to the excellent contributions of philosophers to this discussion.

In this article, we present evidence that many scientists, educators, theologians, students, and church attendees make significant effort at such integration.

We describe the theoretical foundations and development of a survey to identify the patterns of thought ("science-theology paradigms") typically used by individuals attempting to relate theology and science. We have analyzed survey responses of 1,491 people from five populations: (1) a diverse group of science professors in the United States (n=312); (2) a group of educators, pastors, and students in the Assemblies of God (AG) (n=117); (3) a group of college undergraduates at a large Christian university in the South (n=551); (4) Protestant pastors, educators, and students who attended a faith and science conference (n=109); and (5) faculty and students from AG higher education institutions in the US (n=402).

The purposes of this article are (a) to provide a conceptual framework and common terminology for theology/science integration that will advance the science-theology dialogue; (b) to report on science and theology relational approaches used by a broad spectrum of scientists, educators, pastors, and students; and (c) to illustrate how the STPS (Science-Theology Paradigm Scale) can be used to promote integrative practices.

Theoretical Foundations

Most people embrace—consciously or subconsciously—one of several science-theology paradigms. These are mental frameworks (or constructs) for relating scientific understanding and Christian theology. Increased understanding of these science-theology paradigms will lead to more effective and credible communication among an increasingly scientifically literate public.

The relationship between *science* (in the narrow sense of the natural sciences: biology, chemistry, physics, and their subdisciplines)[2] and *religion* (in the narrow sense of biblical theology)[3] in America—and particularly in higher education—changed significantly over the past two centuries as empiricism and naturalism became the characteristic philosophical underpinnings of the university.[4] The new organizing principle in the life sciences, Darwinian evolution, replaced the framework of natural theology in the latter half of the nineteenth century.[5] While some speculate that the gulf is so great between the two that there can be no interplay,[6] recent research into attitudes and beliefs of both practicing scientists[7] and Christian youth[8] tells us that there is great interest in integrating science and theology. For example, Christian philosophers of science during the last half-century proposed several theoretical patterns for relating science and religion. Following are eight contemporary typologies that provide a broad picture of attempts to develop conceptual frameworks to describe theology and science interactions.

Ian G. Barbour, physicist and late professor emeritus of religion at Carleton College, did much to inaugurate the formal study of the relationship between science and religion and, over a longer period of time than anyone to date, worked to classify the various patterns for relating the two.[9] Consequently, we describe three of his typologies below.

Barbour's First Typology

Noting neo-orthodox theologian H. Richard Niebuhr's classification of five strategies which Christians historically had adopted in attempting to relate Christ and culture,[10] Barbour adapted them in 1960 to apply to the relationship between religion and science: (a) religion against science; (b) religion under science; (c) religion above science; (d) religion separate from science; and (e) religion transforming science. The fifth category, Barbour argued, refers to science and religion in dialogue, in a dynamic interaction in which both are subject to reevaluation. Barbour also noted that science and religion provide complementary modes of description since they ask differing types of questions, refer to differing aspects of experience, and serve differing functions in life.[11]

Barbour's Second Typology

By describing how science and religion could be variously in conflict, isolated from one another (compartmentalized), or in dialogue with one another, Barbour in 1968 outlined a threefold classification scheme for relating science and theology: Conflict, Compartmentalization, and Dialogue. Barbour described "Conflict" as including two opposite extremes. On the one hand, there is a scriptural literalism (in which every word of the Bible is accepted as divinely revealed) that places theology in a superior position to science. On the other hand, there is an evolutionary naturalism (in which the Bible is virtually ignored) that places science in a superior position to theology.[12]

Barbour's Third Typology

In consecutive publications (1990, 1997), Barbour gave final form to his fourfold typology of the relationship between science and religion: Conflict, Independence, Dialogue, and Integration.[13] In perhaps his most mature treatment of the subject, Barbour in 2000 applied the typology to particular scientific disciplines such as astronomy, quantum physics, evolution, genetics, and neuroscience.[14] Summary descriptions of Barbour's four theoretical types of relationships between science and religion are given here.

1. *Conflict*. Science and religion are enemies. Those operating within the Conflict paradigm must choose between science and religion. Two subcategories ("Scientific Materialism" and "Biblical Literalism") represent the opposite extremes of conflict between science and religion. Both posit that science and religion make rival claims about the same domain (the realm of nature) and both engage in warfare rhetoric.[15]

2. *Independence*. Science and religion are viewed as separate domains, mutually exclusive. "They can be distinguished according to the questions they ask, the domains to which they refer, and the methods they employ."[16] Science asks objective "how" questions, while religion asks personal "why" questions about meaning, purpose, and destiny. The Independence model asserts that the primary sphere of religion is God's activity in history, not nature; theology is based on divine revelation, whereas science is based on human observation and reason. Because science and religion are independent aspects of life, the possibilities of both conflict and constructive dialogue between the two are avoided.

3. *Dialogue*. A more constructive relationship between science and religion, the Dialogue pattern emphasizes the similarities (rather than the differences) between science and religion, while preserving the integrity of each field. "Dialogue may arise from considering the *presuppositions* of the scientific enterprise, or from exploring similarities between the *methods* of science and those of religion, or from analyzing *concepts* in one field that are analogous to those in the other."[17] Barbour notes, "Science is not as objective nor religion as subjective as had been assumed."[18]

4. *Integration*. Advocates of the Integration model argue for a greater degree of conceptual unity between science and religion than do the adherents of the Dialogue model. Barbour suggested three distinct versions of integration, which he called Natural Theology, Theology of Nature, and Systematic Synthesis.

Other scientist-theologians addressing integration include the late Arthur R. Peacocke (physical biochemist, Anglican priest, and dean of Clare College, Cambridge) and John C. Polkinghorne (theoretical physicist, Anglican priest, and president of Queens' College, Cambridge).[19]

Peacocke's Typology

Peacocke identified eight "possible loci of proposed interactions on this two-dimensional grid" of modern science and Christian theology.[20] The eight models are as follows:

1. *Science and theology are concerned with two distinct realities*. In this model, "reality is conceived of as existing in dual orders, a duality, both existing in our world" (p. xiii). This duality encompasses separately (a) the temporal, the natural, the order of nature, and the physical-biological; and (b) the eternal, the supernatural, the realm of faith, and the mind-spirit. In effect there are two realities, and, because science and theology are concerned with two separate and distinct realms, no interaction is possible.

2. *Science and theology are interacting approaches to the same reality*. There is only one reality, so interaction between science and theology is possible. In this model, science and theology theoretically would have equal opportunity to influence change in the other, but Peacocke noted that this model requires change in one direction: "modifications … in theological affirmations and … attitudes to science" (p. xiv).

3. *Science and theology are two distinct noninteracting approaches to the same reality*. Unlike Model #1, in this model there is only one reality, not two, so interaction between science and theology is possible, as it is in Model #2. However, unlike Model #2, in this Model #3, science and theology do not interact because they examine different aspects of their shared reality. In this scenario, for example, science deals with observable qualities such as prediction and control (the question "how"), and theology deals with ultimate goals and meaning (the question "why").

4. *Science and theology constitute two distinct language systems*. Though science and theology may or may not deal with the same reality, they experience little or no intracommunication and, therefore, one can have no bearing on the other.

5. *Science and theology are generated by quite different attitudes by their practitioners*. In this model, scientists are characterized by attitudes of logical neutrality and objectivity; theologians, by subjective involvement and commitment.

6. *Science and theology are both subservient to their distinctive objects and can only be defined in relation to them*. Both include confessional and rational factors: science has "faith" in the intelligibility of nature and in the orderliness of the universe; theology has faith in God. "Both are intellectual disciplines shaped by their object (nature or God) to which they direct their attention" (p. xiv).

7. *Science and theology may be integrated by using scientific concepts in theology*. Many advances in the natural sciences are consonant with theological perspectives. Scientific notions may be utilized to illuminate theological insights.

8. *Science generates a metaphysic in terms of which theology is then formulated*. This metaphysic develops from either the content of science or the philosophy of science.

While Peacocke's eightfold model certainly identifies issues to consider in the interaction of natural science and Christian theology, it lacks some of the simplicity, logical consistency, and structural symmetry of later science-theology integrative schema.[21]

Polkinghorne's Typology

Polkinghorne suggested four possible "points of interaction" between science and theology.

1. *Total Absorption*. There is nothing but scientifically discerned reality. All nonscientific levels of meaning, such as theological beliefs, are ultimately subverted by a thoroughgoing scientific reductionism (the philosophy that the whole is nothing more than the sum of the parts). All is physics.[22]

2. *Conflicts*. Conflicts arise when knowledge appears to have discredited the plain meaning of scripture (e.g., origins, miracles, future life). In this sense, science plays a "surgical" or "antiseptic" role with interpretation of the Bible.[23] Polkinghorne notes that biology academicians often display hostility toward religion in writings that target the general educated public; he, however, rejected the conflict model and the easy, "ill-judged reductionist triumphalism" of some biologists.[24] "Only in the media, and in the popular and polemical scientific writing, does there persist the myth of the light of pure scientific truth confronting the darkness of obscurantist religious error."[25]

3. *Natural Theology*. Such a position maintains that there must be harmony or consonance between the assertions made by science and theology about the world. The physical world demonstrates certain theological truths, such as the arguments from design that provide support for the doctrine of Divine Origins.[26]

4. *Mutual Influence of Modes of Thought*. Both science and theology seek understanding of the one reality of the world and are capable of mutually influencing each other by analogies of thought. One might learn lessons that might be relevant to the other, such as scientists' discovery of the wave-particle duality of light in the development of quantum field theory and theologians' understanding of the God-man duality of Jesus Christ in the development of Christology.[27]

Wright's Typology

Biologist Richard Wright named four patterns for relating theology and science.[28]

1. *Concordism*: The Bible contains vital information about the natural world that can supplement the information gathered by the direct study of nature, and these two sources of information will harmonize when properly understood. There are gaps in both the biblical and scientific record, and a thorough understanding comes only from study of both sources of data.

2. *Substitutionism*: The Bible contains scientific truth and, because the Bible is understood to be God's literal and authoritative Word, Bible science is more trustworthy than conventional science. Therefore the science of the Bible ("creation science") is to be substituted for the naturalistic interpretations of scientists.

3. *Compartmentalism*: Science and theology deal with entirely separate realms, and they must be kept apart. The Bible is not a handbook of science, and there is no common ground on which the Bible and science can meet. The creation account in Genesis is considered mythological, and evolution presents no problem to Christian compartmentalists unless it is extended into a worldview that excludes the possibility of Christian faith.

4. *Complementarism*: Both biblical truth and scientific knowledge are needed for a balanced view of origins and the natural world. They are not competing views, nor completely separate; they complement each other. They offer different kinds of explanations because they ask different kinds of questions, employ different methodologies, and have different purposes. Complementarists recognize the limitations of both fields (theology and science) and so feel free to generate complementary explanations of the natural world.

Bube's Typology

In a book published as the culmination of his career-long study of the relationship between science and Christian theology, Richard Bube, a physicist and professor of materials science and electrical engineering, proposed seven theoretical patterns.[29]

1. *Science Has Destroyed Christian Theology*: Science and theology tell us the same kind of things about the same realm. When scientific and theological descriptions conflict, one must be right and the other wrong; in this encounter, scientific descriptions always prove to be the winner (similar to Barbour's "Conflict–Scientific Materialism" category).

2. *Christian Theology in Spite of Science*: Science and theology tell us the same kind of things about the same realm. When scientific and theological descriptions conflict, one must be right and the other wrong; in this encounter, theological descriptions always prove to be correct (similar to Wright's "Substitutionism" and Barbour's "Conflict–Biblical Literalism" category).

3. *Science and Christian Theology Are Unrelated*: Science and theology tell us different kinds of things about different realms. There is no common ground. Science has absolutely nothing to say about theology; theology has absolutely nothing to say about science. Conflict is impossible by definition (similar to Wright's "Compartmentalism" and Barbour's "Independence" category).

4. *Science Demands Christian Theology*: Science and theology tell us the same kind of things about the same realm. An understanding of the scientific descriptions of the world provides such overwhelming evidence of the truths of the Bible and Christian theology that one has no defensible choice but to believe them (similar to Wright's "Concordism" and Barbour's "Integration–Natural Theology" category).

5. *Science Redefines Christian Theology*: Science and theology tell us the same kind of things about the same realm. Traditional biblical theology must be completely redefined to be consistent with the developments of modern science. Since religious beliefs are a product of evolutionary development, theology will continue to be transformed by increasing scientific knowledge (similar to Barbour's "Integration–Theology of Nature" category).

6. *A New Synthesis of Science and Christian Theology*: Science and theology should tell us the same kind of things about the same realm, but the present status of science and theology makes this impossible. Both science and theology need to be transformed radically into new approaches compatible with one another and a new understanding of reality (similar to Barbour's "Integration-Systematic Synthesis" category).

7. *Christian Theology and Science: Complementary Insights*: Science and theology tell us different things about the same realm. Each, when true to its own authentic capabilities, provides us with valid insights into the nature of reality from different perspectives. These two types of insights must be integrated to obtain a coherent and adequate view of reality (similar to Wright's "Complementarism" and Barbour's "Dialogue" categories).

Carlson's Typology

With the assistance of six contributors to the volume he edited, physicist Richard F. Carlson identified five patterns for relating science and theology, arguing that "there is no single distinctly Christian viewpoint on matters of the relationship of natural science and Christian faith."[30] Quickly dismissing the first pattern, Scientism, since it makes no room at

all for theology, he presented four principal, distinct viewpoints held by Christians, especially in the US. Carlson's fivefold schema follows:

1. *Scientism (or Scientific Materialism)*: Science is the only avenue to truth. When science and religion are in conflict, science is always preeminent. This is the position of "scientific imperialism" (similar to Bube's "Science Has Destroyed Christian Theology" and Barbour's "Conflict–Scientific Materialism" categories).

2. *Creationism*: When Christian belief and science are in conflict, Christianity is preeminent. In any conflict between scientific and theological conclusions, the science is considered to be defective, incomplete, or inadequate (similar to Bube's "Christian Theology in Spite of Science," Barbour's "Conflict–Biblical Literalism," and Wright's "Substitutionism").

3. *Independence*: Both science and theology are valued in themselves, but each is seen as parallel to the other and thus not interacting. Since there is no common ground shared by science and Christianity, there is no possibility for conflict (similar to Bube's "Science and Christian Theology Are Unrelated," Barbour's "Independence," and Wright's "Compartmentalism").

4. *Qualified Agreement*: Science and theology overlap, and many of the findings of science are acceptable (except for contemporary Darwinism and theories of chemical evolution) to Christian theology. When science and theology are in conflict, the best way to explain the scientific data is to extend science beyond a purely naturalistic methodology and posit an intelligent designer (similar to Bube's "Science Demands Christian Theology" and Barbour's "Integration–Natural Theology" and somewhat similar to Wright's "Concordism").

5. *Partnership*: A full integration of science and theology in which they work together as partners in theorizing about important matters. The two enterprises dialogue and influence each other, and the contributions of both are valued. Science and theology are not seen as threats to each other, but science can enhance theology and theology can inform science (similar to Bube's "Christian Theology and Science: Complementary Insights," and Wright's "Complementarism," and somewhat similar to Barbour's "Dialogue" category).

Synthesis of the Theoretical Science-Theology Paradigms

Employing the criteria of *parsimony* (economy of explanation), *symmetry* (balance of opposing paradigms), and *salience* (inclusion of only the most important and relevant paradigms), we synthesized the above-mentioned schemes into a fivefold model. This model is theoretically grounded and has been empirically tested. Content validity was established by a panel of experts, construct validity was confirmed via principal components analysis, and reliability testing showed that it is internally consistent. These five paradigms are not mutually exclusive. People often utilize more than one of them simultaneously.

1. *Conflict: Theology over Science* or "Theologians Know Best" is that pattern of relating theology and science in which theology and science fundamentally conflict with each other. When such conflicts arise, theological explanations should be accepted as correct. Kurt Wise (paleontologist and student of Stephen Jay Gould)[31] and Ken Ham (director of the young earth creationist ministry, "Answers in Genesis")[32] embrace this model.

2. *Conflict: Science over Theology* or "Scientists Know Best" is the paradigm in which theology and science fundamentally conflict with each other in describing reality, and scientific explanations naturally should be accepted as correct. This model is utilized by many atheists such as Richard Dawkins, Daniel Dennett, Sam Harris, and Christopher Hitchens.

3. In *Compartmentalism*, theology and science describe completely separate realities, and because of this separation neither conflict nor agreement between scientific and theological descriptions of reality can exist. In other words, "they share no common ground." Agnostics Stephen Jay Gould, who coined the terminology "non-overlapping magisteria" (or NOMA),[33] and Neil deGrasse Tyson[34] exemplify the use of this paradigm.

4. *Complementarism* posits that both theology and science are incomplete. Theology and science describe different aspects of reality but, taken together, an accurate scientific description and an accurate theological description should provide a more complete understanding of reality. This paradigm is utilized by Denis Lamoureux[35] and

Francis Collins[36] and was the overarching framework for a five-year "Science and Religion" series conducted by philosophers and scientists speaking at various Chinese universities.[37]

5. The moniker "*Concordism*" that we have chosen to use for our fifth category carries with it much historical and philological baggage. We summarize its varied use in the following paragraphs. For our research purposes, we define Concordism in the following way. Concordists assume, with respect to the relationship between theology and science, agreement or harmony. Concordism is not the expectation of a one-to-one relationship between biblical and scientific propositions. Rather, as Hugh Ross says, "the scientific record and the biblical message of creation extensively overlap."[38] For our purposes, we do not need to agree on exactly what is meant by "extensively," and it is evident that agreement can occur only when the two disciplines are probing the same phenomenon or idea. Further, Concordism does not require scientists and theologians to use the same tools and processes, but their conclusions should be compatible. If they disagree, one or the other or both are wrong—or they just seem to disagree due to reference frame or phenomenological differences. Plantinga sees science and religion in superficial conflict and in deep harmony.[39] We do, too.

Writers have defined Concordism in myriad ways, some of which conflict. We offer a brief overview. Randy Isaac describes a Concordism continuum from "strong" to "weak."[40] A position at one end of this continuum could be called "nonconcordist." Strong concordists anticipate complete agreement between science and the scriptures, whereas weak concordists (a.k.a. accommodationists) expect to see less agreement. The latter view derives from the idea that the biblical record was adapted to the worldview and cultural milieu of the first hearers/readers. Nonconcordists, at the opposite end of the continuum, would not anticipate any agreement. Some examples of Concordists follow. Carol Hill promotes a moderate concordist position that she calls "The Worldview Approach."[41] Hugh Ross, a strong concordist, says "Concordists see complete harmony … between the biblical account and nature's record."[42] John Walton, who might, in Isaac's schema, be termed a weak concordist, posits that Genesis 1 was "an account of functional … rather than an account of material origins …"[43] Amos Yong continues along this vein by suggesting that a Pentecostal hermeneutic should yield more of a complementary melding of readings of nature and scripture rather than a strong concordist interpretation.[44]

In a similar but slightly different manner, Lamoureux defines "strict" and "general" Concordism. Strict Concordism accepts young earth creation. General Concordism accepts old earth creation. For both, any direct correlation between science and the Bible is proof of divine inspiration because scripture was written before modern science.[45] Ted Davis[46] and Bernard Ramm[47] equate (hard) Concordism with old earth creationism (a.k.a. progressive creationism).

Lamoureux, a critic of Ross's strong Concordism, differentiates between scientific, theological, and historical Concordism. For example, theological concordists believe that "the Holy Spirit revealed scientific facts to the biblical writers thousands of years before their discovery by science."[48]

Although not specifically evaluated by the survey instrument described in this article, some people expect scientists and theologians to actively seek integration whenever possible. They should embrace each other's methods and contributions whenever appropriate. This differs from the complementarist approach of simply "adding" science and theology together to get a more complete picture. We call people with this perspective integrational Concordists. They promote a dynamic interaction between the two: a deep interdependence. They believe that science, when taking into account ethical and theological considerations, does not look the same as science that leaves "those subjective concerns" to the theologians. In the same vein, theology benefits from the findings of science when the various origins positions held by Christians are examined. Integrational Concordism is similar to "Theistic Science" as advocated by Moreland and Craig,[49] and the "Creative Mutual Interaction" of Russell.[50] By definition, these approaches are antithetical to the methodological naturalism advocated by many scientists. Like Moreland, Craig, and Russell, integrational Concordists believe that there are truths that can only be adequately explored through the deep collaborations of theology and science.

Development of a Valid and Reliable Science-Theology Paradigm Scale

One of us (Bundrick) created a survey instrument to measure science-theology paradigms used by scientists as part of his doctoral research in 2003.[51] We reduced the instrument's length and confirmed its reliability and validity in 2011 using responses of participants in the inaugural Faith and Science Conference sponsored by the Assemblies of God.[52]

Prior to Bundrick's Science-Theology Paradigm Scale (STPS; originally the Science-Faith Paradigm Scale 2003), no survey instrument existed to measure theoretical patterns for relating science and theology. To ensure that the STPS would have good validity and initial reliability, standard procedures for developing psychometric instruments (surveys) in the affective domain were followed,[53] including standard protocols for producing and implementing the online survey.[54] Subjects responded anonymously and confidentially to survey items. The longer 2003 version initially incorporated 79 questionnaire items that had been judged by a panel of expert raters to correspond to the conceptual definitions of the five theoretical paradigms.[55] The survey was later pared down to 50 items via exploratory factor analysis. Also included in the survey were demographic items and three existing scales to assist in evaluating construct validity: the Scientific Attitude Inventory II,[56] the Francis Scale of Attitudes toward Christianity—Adult Form, Short Version,[57] and the Marlowe-Crowne Social Desirability Scale—Short Form C.[58] The shorter 2011 STPS version (see Appendix) has 25 items, selected from the larger survey by factor analysis.

The Sample: Science Professors

The investigator employed a stratified random sample methodology to collect data within each specific strata of college and university science professors in the US: (a) gender; (b) ethnicity; (c) science discipline (e.g., chemistry, biology, geology, astronomy); (d) academic rank (instructor, assistant professor, associate professor, professor); (e) type of institution (public, private-not religious, private-Catholic, private-Protestant, and private-other religion) where the science professors served; (f) categories of institutions (e.g., Research I university or community college) as formerly classified by the Carnegie Foundation for the Advancement of Teaching; (g) personal religious affiliation (None, Evangelical Protestant, Mainline Protestant, Catholic, Other) of the professors; and (h) self-reported religious commitment (minimum, below average, average, above average, maximum) of the scientists surveyed. A sample of 1,500 college and university science professors teaching in the "hard sciences," both life and nonlife, was thus delineated.[59] Data from 312 acceptable survey responses were analyzed.[60] Initial analysis verified that there was a fairly even distribution of survey responders in terms of their demographic variables (itemized in this case as a–h).

Survey Validity and Reliability

Principal components analysis can tell researchers how many latent variables or components underlie survey responses. That is, it can help researchers identify the mental constructs or ways of thinking that survey takers use to respond to survey statements.[61] Principal components analysis of these data provided strong empirical evidence for the existence of the five anticipated components or "science-theology paradigms": Factor 1 *Conflict: Science over Theology*;[62] Factor 2 *Conflict: Theology over Science*; Factor 3 *Compartmentalism*; Factor 4 *Complementarism*; and Factor 5 *Concordism*.[63] Factor loading analysis[64] yielded a 50-item Science-Theology Paradigm Scale (STPS) consisting of five subscales, each possessing strong content validity,[65] construct validity,[66] and initial reliability.[67] Later iterations of the instrument have confirmed its reliability and validity.

Reliability refers to the internal consistency of each STPS subscale (component or factor). Each factor corresponds to one of the five science-theology paradigms. Cronbach's alpha (coefficient of reliability) is the most common measure of internal consistency, that is, how closely related a set of items are as a group.[68] A Cronbach's alpha of 0.70 or greater (1.0 is maximum internal consistency) is generally accepted as adequate evidence of reliability. The Cronbach's alphas of the five STPS subscales ranged from 0.87 to 0.95. This means that if we repeated the survey with the same sample population, we would probably get the same results.

Identification of Science-Theology Paradigms of Scientists

Producing a valid STPS with initial reliability was successful. However, is such a survey instrument

able to identify the theology-science relational paradigms actually employed in practice by various people? In an attempt to answer that question, we assessed the potential usefulness and adequacy of the STPS to differentiate groups of respondents based on their affinities with one or more of the five science-theology paradigms.

A comparison of differences in mean standardized scores on the five STPS subscales (science-theology paradigms) demonstrated that the STPS successfully differentiated among groups of respondents on the basis of various demographic variables. While, in general, it did not appear that respondents' *gender*, *race*, *ethnicity*, or *science discipline* influenced their scores on the five STPS subscales, the variables of personal *religious affiliation* and self-reported levels of *religious commitment* correlated highly significantly with all five factors (Table 1). Initial apparent correlations with other demographic variables disappeared when they were controlled for religious commitment and religious affiliation.

Table 1. Pearson Correlations between Scores on the Science-Theology Paradigm Scale Factors and Demographic Variables

Demographic Variable	Factors				
	1	2	3	4	5
Gender	−.019	.046	.091	−.086	.034
Race	−.024	.009	.011	.022	−.002
Hispanic	−.056	.081	−.033	.032	.076
Academic Discipline	−.027	.005	.001	−.015	.021
Religious Affiliation	−.280**	.204**	−.250**	.243**	.268**
Religious Commitment	−.713**	.525**	−.592**	.609**	.577**
Institution Type	−.309**	.118	−.238**	.336**	.205**
Academic Rank	.001	−.142*	.057	−.043	.034
Carnegie Classification	−.042	.177**	−.137*	.031	.097

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

Science Faculty, 2003

Survey respondents were deemed to embrace a paradigm if they agreed or strongly agreed with 80% of the survey statements aligned with that position. While many (46%) science faculty did not use any science-theology paradigm, a majority (54%) incorporated at least one (Table 2).

Table 2. Science Faculty Who Used No, One, or Two Simultaneous Science-Theology Paradigms (n = 312; 2003)

Science-Theology Paradigm Used	% (n)
None	46.5% (145)
One Only	42.6% (133)
Two Simultaneous	10.9% (34)
Total	100.0% (312)

Our research did not support the popular notion that most scientists use either the Conflict: Science over Theology or the Compartmentalism (science and theology share no common ground) paradigms. Rather, for scientists using only one paradigm, Complementarism (science and theology are incomplete without the other) was the plurality paradigm (70%), followed by Conflict: Science over Theology (14%), Concordism (8%), Compartmentalism (5%) and Conflict: Theology over Science (2%) (Table 3).

Table 3. Science-Theology Paradigms of Science Faculty Employing Only One Science-Theology Paradigm (n = 133)

Science-Theology Paradigm	% (n)
Complementarism	69.9% (93)
Conflict: Science over Theology	14.3% (19)
Concordism	8.3% (11)
Compartmentalism	5.3% (7)
Conflict: Theology over Science	2.2% (3)
Total	100.0% (133)

Similar results were found for scientists using two simultaneous paradigms; Complementarism with Concordism (41%), Conflict: Science over Theology with Compartmenalism (38%), Conflict: Theology over Science with Concordism (15%), Compartmentalism with Complementarism (3%), and Conflict Science over Theology with Complementarism (3%) (Table 4).

Table 4. Science Faculty Using Two Science-Theology Paradigms Simultaneously (n = 34)

Combined Science-Theology Paradigm	% (n)
Complementarism with Concordism	41.2% (14)
Conflict: Science over Theology with Compartmentalism	38.2% (13)
Conflict: Theology over Science with Concordism	14.7% (5)
Compartmentalism with Complementarism	2.9% (1)
Conflict: Science over Theology with Complementarism	2.9% (1)
Total	99.9% (34)

Similar findings were reported by sociologist Elaine Ecklund.[69] She described in-depth interviews with 275 natural and social scientists at the top twenty-one US research universities. The great majority (70%) seek to "develop overlapping and context-specific narratives for negotiating religion-science relationships." Only 15% saw religion and science in conflict, and another 15% believed that religion and science are never in conflict because they have nothing to say to each other (Compartmentalism). Ecklund also reported that scientists are only slightly less religious than the general US population and that about 50% of evangelicals believe that science and religion can inform each other (compared to 38% of Americans).[70]

The science-theology paradigm embraced by any particular science professor has very much to do with personal religious affiliation (Evangelical Protestant, Mainline Protestant, Catholic, Other, or None) and degree of commitment to that religion.

As a group, only science professors reporting their religious affiliation to be "None" employed either the Conflict: Science over Theology paradigm or the Compartmentalism paradigm.

Those respondents identifying with more conservative religious affiliation (Evangelical Protestant), compared to those identifying with more liberal religious affiliation (Mainline Protestant) and "Other," were far more likely to shun the Conflict: Science over Theology or the Compartmentalism paradigms—with Catholics on average being more comparable to mainline Protestants.

Nonreligious-affiliated science professors scored extremely negatively on the Conflict: Theology over Science subscale. Evangelical Protestant science professors did not embrace the Conflict: Theology over Science paradigm, but they were far less likely than others to shun its use.

Generally, all categories of science professors, except that of "None" (no religious affiliation), scored positively on the Complementarism paradigm—but with distinctly different average scores: Evangelical Protestants the highest, Catholics next, Mainline Protestants low, and "Other" lowest.

Finally, with respect to religious affiliation, only Evangelical Protestant science professors as a group identified positively with the Concordism paradigm. Those not religiously affiliated were dramatically distant from the Concordism paradigm.

Similar patterns of differences in average scores among groups of respondents are observable on the demographic variable of religious commitment (self-reported on a scale from "minimum" to "maximum"). Average scores on the Complementarism, Concordism, and Conflict: Theology over Science paradigm subscales increased in direct proportion to increases in reported levels of religious commitment. That is, the more committed a science professor is to her religion, the more likely she is to employ one of these three patterns for relating science and theology.

Conversely, average scores on the Compartmentalism and Conflict: Science over Theology paradigm subscales decreased in direct proportion to increases in reported levels of religious commitment. That is, the more committed a science professor is to his religion, the less likely he will be to employ one of these two patterns for relating science and theology.

These findings illustrate the value of the STPS in the examination of how scientists relate theology and science. When the respondents' personal religious

affiliation was taken into account, scores varied greatly on the Compartmentalism subscale on the basis of gender. Female respondents (regardless of religious affiliation) scored much lower than males on the Compartmentalism subscale. In other words, female college and university science professors were significantly less likely than males to compartmentalize their scientific and theological perspectives about the natural world.

We formed three major conclusions from the development of the STPS and its application to science faculty. First, the data demonstrate the existence of at least five broadly synthesized patterns of relating science and theology in the tradition of Western Christianity among college and university science professors in the United States. Second, the STPS can measure the degree to which individuals identify with the respective science-theology paradigms. Third, through preliminary exploratory analysis of differences in mean STPS scores based on demographic variables, evidence indicates that the STPS is capable of differentiating among groups.

AG Educators, Pastors, and Students, 2011

We also used the STPS to examine science and theology relational approaches of Assemblies of God (AG) constituents. Survey respondents were 117 AG pastors, educators, and students who attended a faith and science conference sponsored by the AG in June 2011 (240 total conference attendees).

Most respondents were male (80%), older than 30 (60%), affiliated with the AG (78%), and very religiously committed (99%). Their areas of expertise were evenly divided among science, theology, and "other." Most were educators (30%), pastors (27%) and students (9%).

Principal components analysis suggested that the respondents used four science-theology constructs: "Conflict: Theology over Science," "Complementarism with Concordism," "Anti-Compartmentalism," and "Anti-Conflict-Science over Theology." These findings correspond well with the empirical constructs described earlier in this article. Reliabilities (Cronbach's alpha) were acceptable, ranging from 0.80 to 0.68 for the four factors.

Respondents were determined to be affiliated with a particular science-theology paradigm if they agreed or strongly agreed with 80% of the survey statements allied with that position. A few (21%) respondents did not align with any science-theology paradigm. A plurality aligned with one (50%), and some (29%) conflated two or three science-theology paradigms (Table 5).

Table 5. AG Constituents Who Used No, One, Two, or Three Simultaneous Science-Theology Paradigms (n = 117; 2011).

Science-Theology Paradigm Used	% (n)
None	20.5% (24)
One Only	50.4% (59)
Two Simultaneous	23.1% (27)
Three Simultaneous	6.0% (7)
Total	100.0% (117)

Most respondents who used only one science-theology paradigm utilized Complementarism (76%), followed by Concordism (12%) and Conflict: Theology over Science (12%) (Table 6).

Table 6. Science-Theology Paradigms of AG Constituents Employing Only One Science-Theology Paradigm (n = 59).

Science-Theology Paradigm	% (n)
Complementarism	76.3% (45)
Concordism	11.9% (7)
Conflict: Theology over Science	11.9% (7)
Total	100.0% (59)

Respondents using two or three simultaneous science-theology paradigms favored Complementarism with Concordism (78%), followed by Conflict: Theology over Science with Complementarism (15%), and Conflict: Theology over Science with Concordism (7%) (Table 7). Seven (6%) combined three: Conflict: Theology over Science with Concordism and with Complementarism (Table 5).

Table 7. AG Constituents Using Two Science-Theology Paradigms Simultaneously (n = 27).

Combined Science-Theology Paradigm	% (n)
Complementarism with Concordism	77.8% (21)
Conflict: Theology over Science with Complementarism	14.8% (4)
Conflict: Theology over Science with Concordism	7.4% (2)
Total	100.0% (27)

We found that this group related theology and science to a high degree. Nearly 80% of respondents used some combination of Concordism, Complementarism, and Conflict: Theology over Science. Of these, the two integrative approaches (Concordism and Complementarism) were often conflated. One of the conflict paradigms (Conflict: Theology over Science) was solidly represented also. The scientists in this group (n = 23) favored Complementarism.

Students at a Christian University in the South, 2014

Five hundred fifty-one students at a large Christian university in the South completed the STPS during the Spring 2014 semester. They identified themselves as Protestant Christian (62.6%), Catholic Christian (20.3%), nonreligious (8.3%), and religious non-Christian (3.8%). Most (52.6%) were freshmen, followed by sophomores (28.1%), juniors (10.9%), and seniors (8.2%). They majored in a wide array of disciplines: Life Sciences (39.0%), Social Sciences (23.6%), Physical Sciences (5.6%), and other (20.3%). Nearly all respondents (99.1%) were younger than 24 years of age.

Most of the respondents used only one paradigm (51.0%; Table 8), and the most common single approach was Complementarism (Table 9). The other paradigms were used by relatively few people (Table 9). Many fewer people used two paradigms at the same time (12.7%), three simultaneously (1.6%), and four at the same time (0.2%). A significant percentage (34.2%) did not use any identifiable science-theology paradigm (Table 8).

Table 8. Christian University in the South Respondents Who Used No, One, Two, Three, or Four Simultaneous Science-Theology Paradigms (n = 551; 2014).

Science-Theology Paradigm Used	% (n)
None	34.1% (188)
One Only	51.0% (283)
Two Simultaneous	12.7% (70)
Three Simultaneous	1.6% (9)
Four Simultaneous	0.2% (1)
Total	100.0% (551)

Table 9. Science-Theology Paradigms of Christian University in the South Respondents Employing Only One Science-Theology Paradigm (n = 283).

Science-Theology Paradigm	% (n)
Complementarism	70.7% (200)
Conflict: Theology over Science	10.2% (29)
Conflict: Science over Theology	7.4% (21)
Concordism	6.4% (18)
Compartmentalism	5.3% (15)
Total	100.0% (283)

A large majority (41.4%) of respondents using two simultaneous science-theology paradigms favored Complementarism with Concordism (Table 10). Eight other combinations were used, with Conflict: Theology over Science with Complementarism as the next most frequently utilized paradigms (28.6%).

Table 10. Christian University in the South Respondents Using Two Science-Theology Paradigms Simultaneously (n = 70).

Combined Science-Theology Paradigm	% (n)
Complementarism with Concordism	41.4% (29)
Conflict: Theology over Science with Complementarism	28.6% (20)
Conflict: Science over Theology with Compartmentalism	11.4% (8)
Conflict: Theology over Science with Concordism	10.0% (7)
Conflict: Science over Theology with Complementarism	2.9% (2)
Conflict: Science over Theology with Concordism	1.4% (1)
Conflict: Theology over Science with Compartmentalism	1.4% (1)
Compartmentalism with Complementarism	1.4% (1)
Compartmentalism with Concordism	1.4% (1)
Total	100.0% (70)

Ten respondents (1.8% of the total) used three and four paradigms simultaneously (Table 11).

Table 11. Christian University in the South Respondents Using Three and Four Science-Theology Paradigms Simultaneously (n = 10).

Combined Science-Theology Paradigms	% (n)
Conflict: Science over Theology with Complementarism with Concordism	40% (4)
Conflict: Theology over Science with Complementarism with Concordism	30% (3)
Conflict: Science over Theology with Compartmentalism with Concordism	10% (1)
Conflict: Theology over Science with Compartmentalism with Complementarism	10% (1)
Conflict: Science over Theology with Conflict: Theology over Science with Complementarism with Concordism	10% (1)
Total	100% (10)

This population is more similar to the science faculty surveyed in 2003 than to any of the other studied populations (AG educators, pastors, and students [2011], Protestant educators, pastors, and students [2014], faith and science conference attendees [2014] or the faculty and students at AG colleges and universities [2014–2015]). Nevertheless, as with each of the other populations, Complementarism is the dominant relational approach used.

Starting with this sample, and continuing with subsequent groups, we also asked them to indicate their preferred origins model (Young Earth Creation (YEC), Old Earth Creation (OEC), Evolutionary Creation (EC; a.k.a. Theistic Evolution), Deistic Evolution (DE), and Atheistic Evolution (AE)). We examined these perspectives for those who used only one or no science-theology paradigm (n = 471; Table 8).

As expected, most atheistic evolutionists favored Conflict: Science over Theology and no science-theology paradigm. Deistic evolutionists, evolutionary creationists, old earth creationists, young earth creationists favored Complementarism or no science-theology paradigm (Table 12).

Table 12. Origins Perspective and Dominant Science-Theology Paradigm Used by Students at a Christian University in the South (n = 471)

	Science-Theology Paradigm Used						
Origins Perspective	**Concordism % (n)**	**Complementarism % (n)**	**Compartmentalism % (n)**	**Conflict: Theology over Science % (n)**	**Conflict: Science over Theology % (n)**	**None Used % (n)**	**Total % (n)**
YEC	3.6% (3)	37.3% (31)	4.8% (4)	18.1% (15)	1.2% (1)	34.9% (29)	17.6% (83)
OEC	4.3% (5)	44.3% (51)	2.6% (3)	6.1% (7)	4.3% (5)	38.3% (44)	24.4% (115)
EC	5.2% (8)	52.9% (81)	2.0% (3)	1.3% (2)	0.0% (0)	38.6% (59)	32.5% (153)
DE	2.2% (1)	46.7% (21)	4.4% (2)	4.4% (2)	4.4% (2)	37.8% (17)	9.6% (45)
AE	0.0% (0)	12.5% (3)	8.3% (2)	0.0% (0)	45.8% (11)	33.3% (8)	5.1% (24)
Other	2.0% (1)	25.5% (13)	2.0% (1)	5.9% (3)	3.9% (2)	60.8% (31)	10.8% (51)
Total	3.8% (18)	42.5% (200)	3.2% (15)	6.2% (29)	4.5% (21)	39.9% (188)	100.0% (471)

Protestant Pastors, Educators, and Students, 2014

In June 2014, 109 attendees at a faith and science conference sponsored by the General Secretary of the AG, Evangel University, and the Pensmore Foundation, completed the STPS survey. Respondents were church leaders (30.8%), college educators (26.5%), college students (2.6%), and "other" (40.1% including business owners, high school teachers, medical professionals, etc.) (350 total attendees).

Most respondents were Protestant Christian (90.6%), Pentecostal (76.1%), and above-average to maximally religiously committed (92.4%). Their areas of expertise were evenly divided among science, theology, and "other."

Compared to the previous populations studied, this group exhibited a very high degree of integration. Only 11% did not utilize any integrative approach (Table 13), and the Conflict: Science over Theology and Compartmentalism approaches were not utilized at all (Table 14).

Forty-four percent utilized only one science-theology paradigm, while 45% used more than one paradigm at the same time. (Table 13).

Table 13. 2014 Faith and Science Conference Respondents Who Used No, One, Two, or Three Simultaneous Science-Theology Paradigms (n=109).

Science-Theology Paradigm Used	% (n)
None	11.0% (12)
One Only	44.0% (48)
Two Simultaneous	34.9% (38)
Three Simultaneous	10.1% (11)
Total	100.0% (109)

For single paradigm users, Complementarism dominated (68.8%), followed by Conflict: Theology over Science and Concordism (Table 14).

Table 14. 2014 Faith and Science Conference Respondents Employing Only One Science-Theology Paradigm (n=48).

Science-Theology Paradigm	% (n)
Complementarism	68.8% (33)
Conflict: Theology over Science	18.8% (9)
Concordism	12.5% (6)
Conflict: Science over Theology	0.0% (0)
Compartmentalism	0.0% (0)
Total	100.0% (48)

The preferred two-paradigm approach was Complementarism with Concordism (57.9%). Conflict: Theology over Science with Complementarism (29.0%) and Conflict: Theology over Science with Concordism (13.2%) were combined less frequently (Table 15).

Table 15. 2014 Faith and Science Conference Respondents Using Two Science-Theology Paradigms Simultaneously (n=38).

Combined Science-Theology Paradigm	% (n)
Complementarism with Concordism	57.9% (22)
Conflict: Theology over Science with Complementarism	29.0% (11)
Conflict: Theology over Science with Concordism	13.2% (5)
Total	100.0% (38)

Eleven respondents (10.1% of the total) used three paradigms simultaneously (Conflict: Theology over Science with Compartmentalism and with Concordism).

The relationships between origins views and science-theology paradigms are summarized in Table 16. Young earth creationists favored Conflict: Theology over Science while old earth creationists and evolutionary creationists relied on Complementarism.

Table 16. Origins Perspective and Dominant Science-Theology Paradigm of 2014 Faith and Science Conference Respondents (n = 59)

	Science-Theology Paradigm						
Origins Perspective	**Concordism % (n)**	**Comple-mentarism % (n)**	**Compart-mentalism % (n)**	**Conflict: Theology over Science % (n)**	**Conflict: Science over Theology % (n)**	**None Used % (n)**	**Total % (n)**
YEC	9.1% (1)	18.2% (2)	0.0% (0)	54.5% (6)	0.0% (0)	18.2% (2)	18.6% (11)
OEC	12.5% (4)	68.8% (22)	0.0% (0)	6.3% (2)	0.0% (0)	12.5% (4)	54.2% (32)
EC	0.0% (0)	66.7% (4)	0.0% (0)	0.0% (0)	0.0% (0)	33.3% (2)	10.2% (6)
DE	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)
AE	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)
Other	10% (1)	50% (5)	0.0% (0)	10% (1)	0.0% (0)	30% (3)	16.9% (10)
Total	10.2% (6)	55.9% (33)	0.0% (0)	15.2% (9)	0.0% (0)	18.6% (11)	100% (59)

Faculty and Students at AG Colleges and Universities, 2014–2015

During November 2014 and January 2015, faculty and students at AG institutions of higher learning were invited to take the STPS. Four hundred and two valid responses were collected and evaluated. Respondents were students (62%), educators (21.3%), church leaders (6.5%), and "other" or no response (10.2%).

Most respondents were Protestant Christian (91.5%), Pentecostal (79.3%), and regularly attended an AG church (66.8%). The vast majority were above-average to maximally religiously committed (93.0%). Most were working in religious studies (27.3%), the social sciences (27.0%), and the humanities (13.3%). Only 17.6% of the respondents were in the sciences. Students were fairly evenly divided between Freshmen (12.3%), Sophomores (12.0%), Juniors (19.5%), Seniors (16.5%), and graduate students (12.3%). The ages of this population were bimodal. A little over half of the respondents were under 24 years of age (undergraduate students). The rest were fairly evenly distributed among the decades between 24 and 60 or older.

While 20% used no science-theology paradigm, 42.5% used one (mostly Complementarism—see Table 18), 29% utilized two, and 8.5% used three or four simultaneous science-theology paradigms (Table 17).

Table 17. Faculty and Students at AG Colleges and Universities (2014–2015) Who Used No, One, Two, Three, or Four Simultaneous Science-Theology Paradigms (n = 402).

Science-Theology Paradigm Used	% (n)
None	19.9% (80)
One Only	42.5% (171)
Two Simultaneous	29.1% (117)
Three Simultaneous	8.0% (32)
Four Simultaneous	0.5% (2)
Total	100.0% (402)

The three favored approaches used by those with one science-theology paradigm were Complementarism (67.3%), Conflict: Theology over Science (18.7%), and Concordism (12.9%) (Table 18).

Table 18. Faculty and Students at AG Colleges and Universities (2014–2015) Who Used One Science-Theology Paradigm (n = 171).

Science-Theology Paradigm	% (n)
Complementarism	67.3% (115)
Conflict: Theology over Science	18.7% (32)
Concordism	12.9% (22)
Conflict: Science over Theology	1.2% (2)
Compartmentalism	0.0% (0)
Total	100.0% (171)

Respondents using two simultaneous paradigms preferred Complementarism with Concordism (45.3%), followed by Conflict: Theology over Science with Complementarism (28.2%), and Conflict: Theology over Science with Concordism (22.2%) (Table 19).

Table 19. Faculty and Students at AG Colleges and Universities (2014–2015) Who Used Two Simultaneous Science-Theology Paradigms (n = 117).

Combined Science-Theology Paradigm	% (n)
Complementarism with Concordism	45.3% (53)
Conflict: Theology over Science with Complementarism	28.2% (33)
Conflict: Theology over Science with Concordism	22.2% (26)
Conflict: Theology over Science with Compartmentalism	3.4% (4)
Conflict: Science over Theology with Compartmentalism	0.9% (1)
Total	100.0% (117)

A few respondents used three or four simultaneous combined paradigms (8.5%) (Table 17 and Table 20).

Table 20. Faculty and Students at AG Colleges and Universities (2014–2015) Who Used Three Simultaneous Science-Theology Paradigms (n = 32).

Combined Science-Theology Paradigm	% (n)
Conflict: Theology over Science with Complementarism with Concordism	96.9% (31)
Conflict: Science over Theology with Complementarism with Concordism	3.1% (1)
Total	100.0% (32)

Two respondents used four paradigms simultaneously: (1) Conflict: Science over Theology with Conflict: Theology over Science with Compartmentalism and with Complementarism; and (2) Conflict: Science over Theology with Conflict: Theology over Science with Compartmentalism and with Concordism.

Relationships between origins perspectives and science-theology paradigms are summarized in Table 21 below. For this sample, young earth creationists used Conflict: Theology over Science and Complementarism equally frequently. Concordism was used half as often. As with previous samples, old earth creationists and evolutionary creationists primarily utilized Complementarism.

Table 21. Origins Perspective and Dominant Science-Theology Paradigm of Students and Faculty at AG Colleges and Universities (2014–2015) (n = 232)

	Science-Theology Paradigm						
Origins Perspective	**Concordism % (n)**	**Comple-mentarism % (n)**	**Compart-mentalism % (n)**	**Conflict: Theology over Science % (n)**	**Conflict: Science over Theology % (n)**	**None Used % (n)**	**Total % (n)**
YEC	12.0% (9)	26.7% (20)	0.0% (0)	26.7% (20)	0.0% (0)	34.7% (26)	32.3% (75)
OEC	9.5% (7)	47.3% (35)	2.7% (2)	13.5% (10)	0.0% (0)	27.0% (20)	31.9% (74)
EC	7.6% (5)	66.7% (44)	0.0% (0)	0.0% (0)	0.0% (0)	25.8% (17)	28.4% (66)
DE	0.0% (0)	80.0% (4)	0.0% (0)	0.0% (0)	0.0% (0)	20.0% (1)	2.2% (5)
AE	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)
Other	0.0% (0)	50.0% (6)	0.0% (0)	8.3% (1)	0.0% (0)	41.7% (5)	5.2% (12)
Total	8.8% (21)	45.8% (109)	0.8% (2)	12.7% (31)	0.0% (0)	31.9% (69)	100.0% (232)

Conclusions

Many scientists, theologians, philosophers of science, pastors, and laypersons have attempted to engage in science-theology dialogue but have been limited by an unfamiliarity of the jargon and an absence of established schemata. In order to move ahead with a common vocabulary and hermeneutical framework, we propose the terms Compartmentalism, Conflict: Science over Theology, Conflict: Theology over Science, Complementarism, and Concordism to describe ways to relate theology and science. Our research has empirically verified the existence of these science-theology paradigms.

The STPS makes it possible to identify the science-theology paradigms employed by individuals and groups, and enables researchers to examine associations with other affective variables. We report on some of these interactions for science professors of various religious affiliations along with a group of people affiliated with the Assemblies of God (AG), and a group of college students from a large Christian university.

American scientists (2003) favored Complementarism. Fewer used Conflict: Science over Theology, Concordism, Compartmentalism, and Conflict: Theology over Science. Students at a large Christian university (2014) similarly favored Complementarism. AG educators, pastors, and students (2011) favored Complementarism and Concordism, as did Protestant faith and science conference attendees (2014) and faculty and students at AG institutions of higher learning (2014–2015). The science-theology paradigms Complementarism and Concordism were combined more frequently in the latter three groups.

Notable differences between the studied populations have to do with the proportions of respondents using no science-theology paradigms. The greatest percentages in this category were the science faculty (2003) (46.5%) and students at a Christian university in the South (2014) (34.1%). The lowest rates of no science-theology paradigm use were found in the attendees at the 2014 faith and science conference (11.0%), faculty and students at AG institutions of higher learning (2014–2015) (19.9%), and attendees at a 2011 faith and science conference (20.5%). These differences probably have more to do with levels of religious commitment than any other measured demographic. These relationships warrant further study.

Our comparisons of respondent perspectives on origins, along with the science-theology paradigms they use, merit deeper investigation. At this stage, we can say that for the populations we studied, Complementarism and Conflict: Theology over Science are the predominant approaches for YEC adherents. For OEC and EC adherents, Complementarism dominates, followed by Concordism. These findings suggest to us that the Concordism paradigm should not be equated with any particular origins viewpoint such as YEC or OEC. Rather, like an affinity for intelligent design theory, it cuts across camp boundaries. We intend to follow up these tentative findings with deeper investigations of more heterogeneous populations.

The STPS instrument, in its current iteration, does not probe the important aspect of mutual interdependence of theology and science. We believe that many people agree with Carlson's science and theology "Partnership" model which posits that science must embrace relevant aspects of theology (such as ethics and morality) and that theology must embrace relevant contributions from science.[71] Future iterations of the STPS will include such items.

To develop theology and science integrative proficiency, we should consider the science-theology relational patterns we use in practice, and compare them to the models we favor in principle. Not only will our theory and practice become more consistent, but this process may lead to more respectful and insightful interactions with people who use different science-theology paradigms. This, in turn, may lead to better understandings by the layperson of particular science-theology paradigm strengths and weaknesses.

Finally, fine-tuning our science-theology paradigms will help the church engage with culture and the scientific establishment, and may mitigate the mass defection of Christian young people to atheism.[72]

Acknowledgments

We wish to thank our respective institutions (Evangel University for Tenneson and Bundrick, Baylor University for Stanford) for logistical support. We also wish to thank our colleagues for helping us with terminology. We are especially indebted to Steve Badger (Professor Emeritus, Evangel University) for the many years of research collaboration and theological and scientific insights he shared with Tenneson and Bundrick. ✦

Appendix

Science-Theology Paradigm Scale

Short Form

Please use the following scale to indicate your best response to each item:

a. Disagree Strongly b. Disagree c. Neutral d. Agree e. Agree Strongly

1. __ Science and theology deal with entirely different realms of knowledge, and so they must be kept separate.
2. __ The Bible is literally and completely true even when it appears to contradict a scientific matter.
3. __ Reliable information comes only as the result of investigation by the scientific method.
4. __ Accurate scientific investigations of the natural world affirm the valid conclusions of theology.
5. __ Science can contribute nothing of significance to our understanding of theology, and theology can contribute nothing of significance to our understanding of science.
6. __ Differing insights derived from both theology and science should be taken into account equally in the attempt to develop a more adequate and coherent view of the natural world.
7. __ All phenomena find their only true and complete description in the physical and chemical description of the behavior of matter.
8. __ Science has little or nothing to say about theology, and theology has little or nothing to say about science.
9. __ A scientifically constructed mathematical model for the existence of the universe would be logically consistent with a theologically derived explanation for why the universe exists.
10. __ When using languages and methods appropriate to their own realms of discourse, both science and theology may provide different but meaningful descriptions of the same natural phenomena.
11. __ Because the Genesis account of creation is true, evolution is necessarily false.
12. __ True knowledge about anything can come only from the scientific method, not from theology.
13. __ Descriptions of the natural world provided by science should be consistent with descriptions of the natural world provided by theology.
14. __ Every part of biblical revelation that seems to present a scientific mechanism must surely do so with absolute authority and finality.
15. __ Science and theology have little significance for each other.
16. __ Science and theology, when true to their respective principles and methodologies, provide differing, yet valid and relevant, insights that must be taken into account when describing the nature of reality.
17. __ Complete consistency between scripture and science regarding the ending of the universe should be attainable.
18. __ We must reject any input from science that conflicts with theological interpretation of the Bible.
19. __ A scientific description is the only meaningful description of reality that can be given.
20. __ In order to obtain the fullest insight into the nature of reality, the different (but complementary) insights of science and theology should be integrated.
21. __ It is highly unlikely for science and theology to have any valid interaction.

22. __ Valid scientific descriptions and valid theological descriptions of the world will not contradict each other.

23. __ Science is the only valid source of insights into the nature of reality.

24. __ Both science and theology may generate explanations of the natural world that, taken together, give us a more complete understanding of reality.

25. __ When theology and science conflict, theological conclusions must always take precedence over the claims of science.

Scoring

	Survey Item #
Paradigm I	3, 7, 12, 19, 23
Paradigm II	2, 11, 14, 18, 25
Paradigm III	1, 5, 8, 15, 21
Paradigm IV	6, 10, 16, 20, 24
Paradigm V	4, 9, 13, 17, 22

Your primary pattern for relating science to Christian theology ("science-theology paradigm") is indicated by the largest percentage score calculated on the basis of weighted responses on each paradigm scale. For the scoring mechanism, contact the author.

Key

Paradigm I = Conflict: Science over Theology

Conflict: Science over Theology is that pattern of relating science and theology that is based on the understanding that science and theology describe the same kind of things about the same realm of reality. In this pattern, when scientific and theological descriptions conflict, scientific descriptions are believed to be correct.

Paradigm II = Conflict: Theology over Science

Conflict: Theology over Science is that pattern of relating science and theology that is based on the understanding that science and theology describe the same kind of things about the same realm of reality. In this pattern, when scientific and theological descriptions conflict, theological descriptions are believed to be correct.

Paradigm III = Compartmentalism

Compartmentalism is that pattern of relating science and theology that is based on the understanding that science and theology describe different kinds of things about different realms of reality. In this pattern, since there is no common ground between science and theology, conflict between the two is impossible by definition.

Paradigm IV = Complementarism

Complementarism is that pattern of relating science and theology that is based on the understanding that science and theology describe different kinds of things about the same realm of reality. Each, when utilized authentically (i.e. in accordance with its own genuine capabilities and methodology), provides valid insights into the nature of reality from its unique perspective. Through dialogue between authentic science and authentic theology, a more coherent and adequate view of reality may be obtained by integrating both scientifically derived insights and theologically derived insights.

Paradigm V = Concordism

Concordism is that pattern of relating science and theology that is based on the understanding that science and theology describe the same kind of things about the same realm of reality. A perfect scientific description of the world and a perfect theological description of the world would be completely harmonious.

About the Authors

Michael Tenneson *(PhD in science education, University of Missouri; MS in biology/statistics, University of North Dakota; MA in missiology/biblical literature, Assemblies of God Theological Seminary; and BA in biology, UCLA) is a professor of biology and Chair of the Department of Science and Technology at Evangel University. He has taught there for nearly 30 years. He has studied the ecology and behavior of a variety of animals, and has most recently been involved in research related to the science/theology interface.*

David Bundrick *(PhD in adult and higher education at the University of Missouri; ThM, Princeton Theological Seminary; and MDiv, Assemblies of God Theological Seminary) served in Christian higher education for 31 years as a professor and administrator. In his doctoral research, he analyzed the historical tension between science and theology in American higher education and identified the paradigms employed by university science professors for relating theology and science.*

Matthew S. Stanford *(PhD in neuroscience, MA in experimental psychology, BS in psychology, Baylor University) is CEO of the Hope and Healing Center & Institute (HHCI) in Houston, TX, and adjunct professor in the Department of Psychiatry and Behavioral Sciences at Baylor College of Medicine and the Department of Psychology at the University of Houston. Stanford is a fellow of the Association for Psychological Science. He is the author of two books,* Grace for the Afflicted: A Clinical and Biblical Perspective on Mental Illness *and* The Biology of Sin: Grace, Hope and Healing for Those Who Feel Trapped.

Notes

[1]Alister E. McGrath, "Faith and the Natural Sciences," *CCCU Advance*, Fall 2002. A professor of historical theology holding a DPhil in molecular biophysics, McGrath took seriously his own assertion of the importance of relating Christian theology to the natural sciences and has written prolifically on the subject, as illustrated here: *The Foundations of Dialogue in Science and Religion* (West Sussex, UK: Blackwell, 1999); *Science and Religion: A New Introduction* (Oxford: Blackwell, 1999); *A Scientific Theology*, 3 vols. (London: T&T Clark, 2002–2003); *The Science of God: An Introduction to Scientific Theology* (Grand Rapids, MI: Eerdmans, 2004); *Dawkins' God: Genes, Memes, and the Meaning of Life* (Malden, MA: Blackwell, 2005); *A Fine-Tuned Universe: The Quest for God in Science and Theology*, Gifford Lectures (Louisville, KY: Westminster John Knox, 2009); *Darwinism and the Divine: Evolutionary Thought and Natural Theology* (Malden, MA: Wiley-Blackwell, 2011); and *Surprised by Meaning: Science, Faith, and How We Make Sense of Things* (Louisville, KY: Westminster John Knox, 2011).

[2]In this article, the authors employ "science" in the sense of "mainstream science" or "normal science," which includes the methods, processes, and conclusions of studies of the natural world.

[3]Generally, in this article, the authors employ the terms "religion," "theology" (or "biblical theology"), and "faith" (or "Christian faith") somewhat interchangeably, in the sense of a set of reasoned beliefs concerning God, humanity and the cosmos derived from interpretation of the Bible and Christian tradition. In regard to the surveys administered as part of the studies reported herein, the researcher designed the questions with the intention that the respondents, who represent a diversity of religious beliefs (including "None" and "Other"), would bring their own meanings to the terms.

[4]See S. M. Guralnick, *Science and the Ante-Bellum American College* (Philadelphia, PA: The American Philosophical Society, 1975).

[5]Charles Darwin, *On the Origin of Species by Means of Natural Selection, or, the Preservation of Favoured Races in the Struggle for Life* (London: J. Murray, 1859).

[6]Stephen Jay Gould, "Nonoverlapping Magisteria," *Natural History* 106 (March 1997): 16–22.

[7]Elaine Howard Ecklund, "Scientists Negotiate Boundaries between Religion and Science," *Journal for the Scientific Study of Religion* 50, no. 3 (2011): 552–69.

[8]The Barna Group, "Six Reasons Young Christians Leave Church," accessed December 4, 2011, https://www.barna.org/barna-update/millennials/528-six-reasons-young-christians-leave-church#.VZLCKE2SLL8.

[9]Robert John Russell, ed., *Fifty Years in Science and Religion: Ian G. Barbour and His Legacy*, Ashgate Science and Religion Series (Burlington, VT: Ashgate Publishers, 2004). Major works by Ian G. Barbour on the topic are listed here in chronological order: *Christianity and the Scientist*, The Haddam House Series on The Christian in His Vocation (New York: Association Press, 1960); *Issues in Science and Religion* (Englewood Cliffs, NJ: Prentice-Hal1, 1966); "Science and Religion Today," in *Science and Religion: New Perspectives on the Dialogue*, ed. Ian G. Barbour (New York: Harper & Row, 1968), 3–29; *Myths, Models, and Paradigms: A Comparative Study in Science and Religion* (New York: Harper & Row, 1974); *Religion in an Age of Science*, vol. 1, *The Gifford Lectures 1989–1991* (San Francisco, CA: Harper, 1990); *Religion and Science: Historical and Contemporary Issues*, revised and expanded edition of *Religion in an Age of Science* (San Francisco, CA: Harper, 1997); *When Science Meets Religion: Enemies, Strangers, or Partners?* (San Francisco, CA: HarperSanFrancisco, 2000); and *Nature, Human Nature, and God*, Theology and the Sciences Series (Minneapolis, MN: Fortress Press, 2009).

[10]H. Richard Niebuhr, *Christ and Culture* (New York: Harper, 1951).

[11]Barbour, *Christianity and the Scientist*, 86, 89, 106–18. A quarter century later, Nancey Murphy, like Barbour, explicated a typology for the relation of theology to science based on Richard Niebuhr's five-fold typology of Christian attitudes toward culture. See N. Murphy, "Theology the Transformer of Science? A Niebuhrian Typology for the Relationship of Theology to Science," *Pacific Theological Review* 18 (1985): 16–23. While the category descriptions below come from Murphy, the labels employed to summarize the descriptors are the authors':

a. *Theology requires the rejection of science where the two conflict.* This fits Niebuhr's "Christ against culture category," the view that loyalty to Christ requires the rejection of the culture. When applied to theology and science, the perspective that evolutionary science and the biblical account of creation are competing truth claims exemplifies this view.

b. *Science requires the rejection of theology where they conflict.* This is based on Niebuhr's category, "Christ of

culture," the position represented by the Protestant cultural hegemony of the late nineteenth and early twentieth centuries in which theology is accommodated to culture. In this view, aspects of theology that cannot be accommodated to culture are excised.

c. *Theology subsumes science.* "Christ above culture" is the position that science and theology, sharing a common method of reasoning, may be synthesized into one coherent system. In this view "theology and science are related to one another as encompassing whole to part," with theology and science organized as concentric spheres, and with theology at the outermost edge representing the ultimate context of explanation.

d. *Science and theology are separate.* The Niebuhrian category, "Christ and culture in paradox," leads to the dualist or "two-world" view of faith and science. According to this view, science and theology have separate spheres, involve different kinds of knowledge, and employ distinct languages; therefore, they cannot interact or compete.

e. *Theology affects science.* Niebuhr's final category, "Christ as the transformer of culture," is the viewpoint that says theology can and ought to affect science. Scientific theories are not derived purely from collected data; instead, "control beliefs"—some philosophical and some theological—influence the invention and acceptance of scientific theories.

[12]Barbour, "Science and Religion Today," in *Science and Religion: New Perspectives on the Dialogue*.

[13]Barbour, *Religion in an Age of Science*; Barbour, *Religion and Science: Historical and Contemporary Issues*.

[14]Barbour, *When Science Meets Religion*.

[15]Ibid., 10–17.

[16]Ibid., 17.

[17]Ibid., 23.

[18]Ibid., 25.

[19]Arthur R. Peacocke, *Theology for a Scientific Age: Being and Becoming—Natural and Divine* (Oxford: Basil Blackwell, 1990); and John C. Polkinghorne, *Science and Christian Belief: Theological Reflections of a Bottom-up Thinker* (London: SPCK, 1994), published simultaneously as *The Faith of a Physicist* (Princeton, NJ: Princeton University Press, 1994).

[20]Arthur R. Peacocke, *The Sciences and Theology in the Twentieth Century*, The Oxford International Symposium (Notre Dame, IN: University of Notre Dame Press, 1981), xiii–xv.

[21]In response to Peacocke, R. J. Russell ("A Critical Reappraisal of Peacocke's Thought on Religion and Science," *Religion and Intellectual Life* 2 [1985]: 48–58) refined Peacocke's schema geometrically by pointing out that Peacocke's positions may be differentiated with respect to four dimensions of the science-theology relationship: approaches, languages, attitudes, and objects (corresponding to Peacocke's categories 3, 4, 5, and 6). In each of these four dimensions, the relationship between science and theology can be described on a continuum ranging from (a) similar and interacting or (b) different and noninteracting. Thus, in four-dimensional space, the axis in each dimension represents one of the four categories describing the relationship between science and theology: approaches, languages, attitudes, and objects. For example, the axis representing "attitude" would have "subjective" at one extreme end and "objective" at the opposite. Some would put science and theology at opposite ends, while others would see some overlap, indicating that theology and science both include overlapping measures, objectivity and subjectivity. Russell's schema presents advantages and disadvantages. Each of the arguments about the relationship (interacting and similar or noninteracting and different) between science and theology can be framed independently of the other. At the same time, these arguments can be incorporated into a unified structure, making explicit "the inherently complex and rich multidimensional nature of the theology and science terrain" (Russell, p. 50). However, in reality, Russell's four-dimensional grid provides for an infinite number of theoretical positions, making it virtually impossible to identify and categorize specific science-theology paradigms.

[22]John C. Polkinghorne, *One World: The Interaction of Science and Theology* (London: SPCK, 1986), 64.

[23]Ibid., 65–77.

[24]Ibid., 79–80.

[25]Ibid., 77.

[26]Ibid., 77–83.

[27]Ibid., 83–85.

[28]Richard T. Wright, *Biology through the Eyes of Faith* (San Francisco, CA: Harper & Row, 1989).

[29]Richard H. Bube, *Putting It All Together: Seven Patterns for Relating Science and the Christian Faith* (Lanham, MD: University Press of America, 1995).

[30]Richard F. Carlson, ed., *Science and Christianity: Four Views* (Downers Grove, IL: InterVarsity Press, 2000).

[31]Kurt P. Wise, *Faith, Form, and Time: What the Bible Teaches and Science Confirms about Creation and the Age of the Universe* (Nashville, TN: B&H Publishing Group, 2002).

[32]Ken Ham and Greg Hall, *Already Compromised* (Green Forest, AR: Master Books, 2011).

[33]This view was formalized by Stephen Jay Gould, "Nonoverlapping Magisteria," *Natural History* 106 (March 1997): 16–22.

[34]Bigthink.com, "Neil deGrasse Tyson: Atheist or Agnostic?" blog entry by Mark Cheney, YouTube video, April 25, 2012, http://bigthink.com/think-tank/neil-degrasse-tyson-atheist-or-agnostic.

[35]Denis O. Lamoureux, *Evolutionary Creation: A Christian Approach to Evolution* (Eugene, OR: Wipf & Stock, 2008).

[36]Francis Collins, *The Language of God* (New York: Free Press, 2006).

[37]Melville Y. Stewart, ed., *Science and Religion in Dialogue*, 2 vols. (West Sussex, UK: Wiley-Blackwell, 2010).

[38]Hugh Ross, *More Than a Theory: Revealing a Testable Model for Creation* (Grand Rapids, MI: Baker Books, 2009), 30.

[39]Alvin Plantinga, *Where the Conflict Really Lies: Science, Religion, and Naturalism* (Oxford: Oxford University Press, 2011).

[40]The website of the American Scientific Affiliation, "Concordism," blog entry by Randy Isaac, February 27, 2008, http://www2.asa3.org/users/randyisaac/weblog/ce81e/Concordism.html.

[41]Carol A. Hill, "A Third Alternative to Concordism and Divine Accommodation: The Worldview Approach," *Perspectives on Science and Christian Faith* 59, no. 2 (2007): 129–34.

[42]Ross, *More Than a Theory*, 30.

[43]John H. Walton, *The Lost World of Genesis One: Ancient Cosmology and the Origins Debate* (Downers Grove, IL: InterVarsity Press, 2009), 163.

[44]Amos Yong, "Reading Scripture and Nature: Pentecostal Hermeneutics and Their Implications for the Contempo-

rary Evangelical Theology and Science Conversation," *Perspectives on Science and Christian Faith* 63, no. 1 (2011): 3–15.

[45]Lamoureux, *Evolutionary Creation*, 17.

[46]*The BioLogos Forum*, "Science and the Bible: Concordism, Part 1," blog entry by Ted Davis, June 19, 2012, http://biologos.org/blog/science-and-the-bible-concordism-part-one.

[47]Bernard Ramm, *The Christian View of Science and Scripture* (Grand Rapids, MI: William B. Eerdmans, 1954), 145.

[48]Lamoureux, *Evolutionary Creation*, 475.

[49]J. P. Moreland and William Lane Craig, *Philosophical Foundations for a Christian Worldview* (Downer's Grove, IL: InterVarsity Press, 2009).

[50]Robert J. Russell, *Cosmology, Evolution, and Resurrection Hope: Theology and Science in Creative Mutual Interaction* (Kitchener, ON: Pandora Press, 2006).

[51]David Ray Bundrick, "The Development of a Scale to Identify College and University Science Professors' Science-Faith Paradigms" (PhD diss., University of Missouri-Columbia, 2003), ProQuest (AAI3091906).

[52]*Proceedings of the Inaugural Faith and Science Conference: Springfield, Missouri, June 27–28, 2011*, ed. David R. Bundrick and Steve Badger (Springfield, MO: Gospel Publishing House, 2011), 38–42.

[53]Robert K. Gable and Marian B. Wolf, *Instrument Development in the Affective Domain: Measuring Attitudes and Values in Corporate and School Settings*, 2nd ed. (Norwell, MA: Kluwer Academic Publishers, 1993).

[54]Don A. Dillman, *Mail and Internet Surveys: The Tailored Design Method*, 2nd ed. (Hoboken, NJ: John Wiley, 2007).

[55]The panel consisted of eleven professionals (scientists and science professors) with expertise in the content areas of both science and theology and familiarity with the interface between them. The panel of experts included a professor of chemistry at a Christian liberal arts college; a state college science instructor who serves as adjunct professor of pathology at a medical college; a professor of biochemistry at a Christian liberal arts college; a professor of science education who serves as an associate dean in the college of education at a state research university; a professor of science history at a Christian liberal arts college; a retired instructor in mathematics at a Canadian university; an author and member of the Interdisciplinary Biblical Research Institute; a professor of geology at a state research university; an instructor in physics at a historically church-related college who serves as an adjunct professor in a Lutheran seminary; an associate professor of biology at a Christian liberal arts college; a professor of physics and astronomy at a Christian liberal arts college and founding member of the International Society for Science and Religion. These judges used a content validity rating form developed by the researcher according to the sample provided by Gable and Wolf (*Instrument Development in the Affective Domain*, 99–100), to assign each of the original 132 items to the most appropriately corresponding science-faith paradigm conceptual definition. The judges also indicated how certain they felt about their assignment of each item to its respective category, using the following scale: 1. I am *not* very certain that this placement is correct; 2. I am *rather* certain that this placement is correct; 3. I am *very* certain that this placement is correct.

[56]R. W. Moore and R. L. Hill Foy, "The Scientific Attitude Inventory: A Revision (SAI II)," *Journal of Research in Science Teaching* 34 (1997): 327–36.

[57]Leslie J. Francis, "Reliability and Validity of the Francis Scale of Attitude towards Christianity," *Panorama: Journal of Comparative Religious Education and Values* 4 (1992): 17–19; Leslie J. Francis, "Reliability and Validity of a Short Scale of Attitude towards Christianity among Adults," *Psychological Reports* 72 (1993): 615–18; and Leslie J. Francis, J. M. Lewis, D. Lester, and R. Philipchalk, "Reliability and Validity of a Short Scale of Attitude towards Christianity among Students in the UK, USA, Australia, and Canada," *Psychological Reports* 77 (1995): 431–34.

[58]D. P. Crowne and D. Marlowe, "A New Scale of Social Desirability Independent of Psychopathology," *Journal of Counseling Psychology* 24 (1960): 349–54; W. M. Reynolds, "Development of Reliable and Valid Short Forms of the Marlowe-Crowne Social Desirability Scale," *Journal of Clinical Psychology* 38 (1982): 119–25; and A. B. Silverstein, "Validity of Random Short Forms: II. The Marlowe-Crowne Social Desirability Scale," *Journal of Clinical Psychology* 39 (1983): 582–84.

[59]Anthony Biglan, "Relationships between Subject Matter Characteristics and the Structure and Output of University Departments," *Journal of Applied Psychology* 57 (1973): 204–13. Professors were selected from the subject matter areas represented by two octants in Biglan's classification scheme: the Hard-Pure-Life system (botany, entomology, microbiology, physiology, zoology) and the Hard-Pure-Nonlife system (astronomy, chemistry, geology, math, physics). This classification scheme corresponds roughly to the two categories of "biological sciences" and "physical sciences" used in replications of Leuba's benchmark study: cf. James H. Leuba, *The Belief in God and Immortality: A Psychological, Anthropological, and Statistical Study* (Boston, MA: Sherman, French & Co., 1916); E. J. Larson and L. Witham, "Scientists Are Still Keeping the Faith," *Nature* 386 (1997): 435–36; and E. J. Larson and L. Witham, "Leading Scientists Still Reject God," *Nature* 394 (1998): 313.

[60]Adequacy of the number of valid survey responses (n = 312) was supported by (a) utilization of a stratified random sample paired with (b) demonstrated good variance among the respondents relative to the following demographic categories: gender, personal religious affiliation, levels of religious commitment, academic rank, academic discipline (life sciences and the nonlife sciences), institutional public/private-religious affiliation types, and Carnegie Classification of the professors' respective schools. Additionally, 312 completed surveys fall within the range deemed acceptable by (a) Gable and Wolf (see note 54), who recommend a sample size of 6–10 times the number of items on this type of survey instrument, and (b) Dillman (see note 55), who recommends 246 completed surveys for a population between 100,000 and 1,000,000 to achieve a 95% confidence level with a +/– 5% sampling error, assuming an 80/20 split.

[61]Robert F. DeVellis, *Scale Development: Theory and Applications*, 3rd ed. (Los Angeles, CA: Sage Publications, 2011).

[62]The "Conflict" model for the relationship between science and theology in American higher education gained prominence in the latter half of the nineteenth century; was chronicled in Andrew Dickson White, *A History of the Warfare of Science with Theology in Christendom* (London: Macmillan, 1896); and was epitomized by the 1925 Scopes Monkey Trial in Dayton, Tennessee (Doug Linder, "Speech on the Occasion of the 75th Anniversary of the Opening of the Scopes Trial," July 10, 2000, University of Missouri Kansas City School of Law, *Famous Trials in*

American History, http://www.law.umkc.edu/faculty/projects/ftrials/scopes/confspeech.html). However, much of the late twentieth-century literature discussing the theoretical patterns for relating science and theology tends to minimize the contemporary influence of the conflict paradigm in favor of more compartmental, integrative, or complementary paradigms. Nevertheless, in this current research, the STPS factors having the highest number of items loading were the two conflict models. The Conflict: Science over Theology paradigm was represented by 13 strong factor loadings, and the Conflict: Theology over Science paradigm was represented by 12 strong factor loadings. Therefore, the conflict model is still strongly identifiable in the academy.

[63]Although at least ten survey items loaded >0.50 on each of the first four factors (science-theology paradigms) in the STPS, only five items loaded on factor five, Concordism. This produced a weaker factor that was revealed clearly only by orthogonal rotation during Principal Components Analysis. There are several reasons why this factor may have appeared with less strength than the other four factors. First, the fifth paradigm (Concordism) could have appeared to be weak in the principal components analysis because of the inability of the researcher to adequately construct statements to operationalize the concept of Concordism. Second, results of the first content-validity rating exercise indicated that there were not sufficient distinctions between many items constructed variously for either Complementarism or Concordism. As a result, the second content-validity rating exercise was conducted in an attempt to articulate this distinction more clearly and gain additional validated items for these two categories. This process itself may have indicated that these two science-theology paradigms are closely related, and are perhaps merely subcategories of a larger paradigm in which scientific and religious beliefs are seen to be compatible or convergent, rather than in conflict or compartmentalized. Third, the fifth paradigm may have appeared weak in the principal components analysis because of the very low number of respondents that would have been likely to score consistently on the items representing the Concordism paradigm. Because there are significant religious qualifications for science faculty in Bible colleges, and an essential characteristic of Bible colleges is the harmonization of all academic disciplines with the Bible, it is speculated that Concordism would be a paradigm more characteristically operationalized by science instructors at colleges affiliated with the Association for Biblical Higher Education (formerly the Accrediting Association of Bible Colleges). Therefore, the Concordism factor may have appeared only weakly in the principal components analysis due to the fact that Bible college science professors, who were expected to provide a substantial source of variance in the survey data, were significantly underrepresented among the respondents. Despite the relatively weak appearance of factor five, there was adequate evidence for the five-factor solution.

[64]Only factor loadings greater than 0.40 were used in the analysis, see B. Freeman and K. Coll, "Factor Structure and the Role of Questionnaire (RQ): A Study of High School Counselors," *Measurement and Evaluation in Counseling and Development* 30 (1997): 32–40.

[65]The evidence for the content validity for the STPS was determined well before the survey was administered to the sample. This was accomplished by means of the development of conceptual definitions and operational statements for the five theoretical science-theology paradigms on the basis of the literature review. Contributing further evidence to the content validity were the judgmental rating exercises conducted by the researcher with the assistance of a panel of content experts utilizing content-validity rating forms specially prepared for that purpose (see note 56). Further evidence for the content validity of the STPS is provided by the fact that all 50 items appearing on the final version of the STPS loaded on the science-faith paradigms to which they had been assigned by the expert panel during the content validity rating process.

[66]Evidence for the construct validity of the STPS came primarily from the principal components analysis of the data from the 312 cases. Employing Principal Components Analysis with orthogonal (Varimax) rotation, a five-factor solution was found, explaining 56.1% of the variance. This researcher utilized the criterion of 0.50 for factor loading, though factor loadings higher than just 0.40 are considered moderate to high, see Freeman and Coll, "Factor Structure and the Role of Questionnaire (RQ)."

Analysis of the Pearson Correlations between the respondents' standardized scores on the STPS subscales and their scores on the Francis Scale of Attitudes toward Christianity (FSAC) provided additional evidence for the construct validity of the STPS. These correlations were highly significant ($p < 0.01$), were in expected directions (positive or negative), provided positive evidence to support the construct validity of the instrument, and added to the interpretability of the STPS. Analysis of the Pearson Correlations between the respondents' standardized scores on the STPS subscales and their scores on the Scientific Attitude Inventory-II (SAI-II) provided some additional but limited evidence for the construct validity of the STPS.

[67]Statistical analysis performed on the five subscales was successful in gaining evidence for initial reliability of the STPS. Test-retest reliability was beyond the scope of this initial scale development.

[68]Lee J. Cronbach, "Coefficient Alpha and the Internal Structure of Tests," *Psychometrika* 16 (1951): 297–334.

[69]Elaine Howard Ecklund, "Scientists Negotiate Boundaries between Religion and Science," *Journal for the Scientific Study of Religion* 50, no. 3 (2011): 552–69.

[70]Elaine Howard Ecklund, "Surveying Religious People about Science and Scientists," Lecture, AAAS 2014 Annual Meeting, Chicago, Illinois, February 16, 2014.

[71]Carlson, ed., *Science and Christianity: Four Views*.

[72]The Barna Group, "Six Reasons Young Christians Leave Church," https://www.barna.org/barna-update/millennials/528-six-reasons-young-christians-leave-church#.VZLCKE2SLL8; and Dan Guenther, "Reconciling the Faith: Christian Students Who Move from Fear to Engagement with the Sciences," in *Proceedings of the Inaugural Faith and Science Conference*, ed. David Bundrick and Steve Badger (Springfield, MO: Gospel Publishing House, 2011).

Jean Claude Parlebas

Science and Christian Faith in the France of Pascal and Today

Jean Claude Parlebas

During my former career as a full-time researcher at the Centre National de la Recherche Scientifique (CNRS, France), I was very much interested in the work and life of Blaise Pascal in addition to my own field of research. Two aspects of his life especially attracted my attention: Pascal was both a magnificent scientist and a Christian thinker with a personal faith. In this communication, I would like to develop two aims. The first aim is to recount a short biography describing Pascal as a foremost mathematician and physicist as well as a Christ-centered dedicated believer. The second one is to explain the influence that Pascal still has in France today.

Short Account of Pascal's Life

Born in Clermont-Ferrand, France, on June 19, 1623, Blaise Pascal lost his mother at the age of three. His grandfather, Martin Pascal, like many other French-educated people of the Renaissance time—he was a tax supervisor—had been attracted by Reformation ideas and faith.[1] That attraction lasted until St. Barthelmew's Day massacre of August 24, 1572, the beginning of a wave of violence. Then Martin became frightened and returned to the Roman Catholic religion.

Martin's son, Etienne, was Blaise Pascal's father. Very much interested in mathematics and sciences, Etienne served as a king's civil counselor. Blaise's father did not like the way school was taught at that time. Thus, he taught Blaise and his two sisters at home by himself. He placed special emphasis on studying Latin and Greek. Moreover, he had some pioneer educational ideas, such as privileging observation over scholastic learning.

In 1631, the family moved from Clermont to Paris. Etienne was even more determined to educate his son on his own, since Blaise showed extraordinary intellectual abilities. Blaise Pascal's early aptitudes were probably challenged by his father's frequent conversations with leading scientists of the time.

Pascal's scientific work began when he was no more than eleven years old. By then he had already composed a short treatise on the sounds of vibrating bodies. Moreover, he managed to demonstrate one of Euclid's propositions, on the sum of the angles of a triangle. However, Etienne responded to those early abilities by forbidding his son to study mathematics during the next three years, and by expecting him to focus on the study of Latin and Greek. This ban on mathematics merely served to make Blaise even more interested in that forbidden subject. At twelve years old, he began to work on geometry. At the age of sixteen, Pascal wrote a book, *Essay on Conics*. In addition, he is among the first to develop what is now called "projective geometry."

J. C. Parlebas *is now Directeur de Recherche Honoraire (Centre National de la Recherche Scientifique) and was formerly at the Institut de Physique et Chimie des Matériaux de Strasbourg. He has also served as one of the vice presidents of the French InterVarsity groups (Association des Groupes Bibliques Universitaires de France).*

In 1638, it happened that Etienne was opposed to the tax laws promulgated by the French prime minister. Thus he left Paris with his family to escape prison. Fortunately, two years later, this conflict was resolved. The family moved to Rouen, where Etienne became responsible for raising taxes. Blaise worked very hard to help his father. Meanwhile, he also managed to progress with his own scientific research. He developed a new theorem at the edge of his favorite field of geometry. This theorem was the foundation for an important and almost entirely undeveloped branch of mathematics, that of probabilities.

At the age of nineteen, Pascal created the concept and development of the Pascaline. It was a machine capable of performing addition and subtraction, especially designed to assist his father. Although the Pascaline was a commercial failure due to its high cost, it was, however, a starting point for further research on mechanical calculating machines. Pascal himself improved the design of his machine for another ten years and built about twenty Pascaline copies. This shows that Pascal was both an excellent theoretical thinker and a smart experimental engineer, building both theoretically and experimentally. Actually, his Pascaline concept remained up-to-date, in its field, until about the year 1920!

From 1650 on, Pascal became interested in various forms of infinitesimal calculations. Indeed, at that time and in the upper-class society, gambling games were very popular, sometimes associated with bets. Also, people involved in hazardous commercial transactions wished to know more about the risks they were about to take. All these situations prompted Pascal to use mathematics in a new way. Basically, he understood that among a large number of disordered and chaotic situations, it is possible to discover laws of statistical and repetitive order. His *Treatise of Arithmetic Triangle* was an important preparation to Gottfried Leibniz's own work. Furthermore, using Pascal's results, Christiaan Huygens was able to publish a *Handbook of Probabilities* as early as 1657. Pascal's method was a radically new one and led him to expand the differential and integral calculus a few years later. Finally, let me just mention that what would be called the "Gaussian curve" was actually another way of applying the famous Pascal triangle. Indeed, Pascal can be considered the father of the mathematical theory of probability and combinatorial analysis.

Around Pascal's time, much of the intellectual knowledge of Western Europe was not original but was derived from classical antiquity. In that context, Pascal's contribution to modern science was to adopt a new scientific method as compared to using a past scholastic point of view.

> From Aristotle to Descartes, the field was held by an abstract, deductive approach. Instead, Pascal concentrated exclusively on fact, experimental observation and then rigorous analysis as the sole tests of truth. His new approach to science was then dominated by the idea of objective, as opposed to philosophical interpretations of nature.[2]

One example of Pascal's new approach to science is given by his experiments to study the phenomenon of a vacuum. Furthermore, Pascal provided the essential link between the mechanics of fluids and rigid bodies. With his knowledge of hydrostatics, he successfully participated in draining marshes in the French Poitiers area at the request of his friend, the Duke of Roannez. Pascal also invented the syringe and the hydraulic press, both based on "Pascal's principle." These are all examples of theories resulting in applied and concrete actions. Pascal was definitively a pioneer of rigorous modern scientific research when he claimed the following basic principle:

> In order to show that a given hypothesis is evident, it is not sufficient that a lot of phenomena are in accord with the considered hypothesis. Instead, if only one phenomenon disagrees with it, it must be regarded as wrong.[3]

With Pascal, a new science was confirmed, namely experimental physics, in agreement with only a very small number of scientists of that time.

In 1646, Pascal's father had an accident and was confined to his house. Some neighbors who were Jansenists came to visit and help him. The Jansenists were a spiritual Catholic group, following Cornelius Jansen. In some aspects, they were moved by a kind of "evangelical way of thinking," especially pointing out Augustine's doctrine of grace and stressing "inner life" within the Roman Catholic religion. Their beliefs were very different from the teachings of the Jesuits, who were the most influential group at that time and had a relativist point of view as far as faith and life were concerned. The whole Pascal family began adopting a Jansenist-inspired faith.

Even though Pascal kept going throughout what he called a "worldly period" for a few more years, the above-mentioned experience had been crucial for him as a spiritual first step. Furthermore, due to his family inheritance, he could enjoy a relatively high standard of living. However, since his father's death, Pascal faced a kind of inner and spiritual vacuum which he was unable to fill. Within that dramatic personal situation with feelings of emptiness, neither his scientific works nor any kind of entertainment could help him. Pascal sought further spiritual guidance to try to find truth and peace. Finally he cried out to God:

> My God, I turn to you to ask you a special gift that all creatures, altogether, fail to provide to me ... Since the conversion of my own heart, which I expect from you, is a too difficult task for natural efforts, I can only turn to the Author and almighty Master of my natural heart. To whom shall I cry, to whom shall I have recourse, except to you? Anything which is not God is unable to bring me fulfilment. God himself, I ask and look for. To you only, my God, I address myself in order to win you to my case. Open my heart, Lord.[4]

God responded to the above prayer on November 23, 1654, after Pascal had experienced a serious coach accident. Pascal managed to escape, but he remained terrified of having been so close to death. Several days later, after recovering, Pascal had an intense spiritual vision around midnight. He immediately wrote his vision on a small piece of paper. This paper, called "The Memorial," was discovered a few days after his death sewn within his own coat. In summary, it contains the following words:

> 1654, Monday November 23, Fire, God of Abraham, God of Isaac, God of Jacob. Not the God of philosophers or scholars. Certainty. Certainty. Feeling. Joy. Peace. God of Jesus Christ. My God and your God. Your God shall be mine. Forgetfulness of this world and of everything, except of God. He can only be found through the ways taught in the Gospel … Highness of a human being. Righteous Father, the world did not discover you, but I did. Joy, joy, joy, tears of joy … My God, shall you go away from me? May I not be eternally separated from you! Eternal life is to know you as the only true God and the One you sent, Jesus Christ. Jesus Christ. Jesus Christ. I turned away from him. I ran away from him. I renounced him. I crucified him. May I never be separated from him! He can only be kept through the ways taught in the Gospel. Total and kind renunciation. Submission to Jesus Christ and to my supervisor. Eternally in joy after a crucial day on earth. Amen.[5]

From that moment on, Pascal held without any reserve to the truth of the Gospel, both intellectually and in experience. Pascal's theology was centered on the person of Jesus Christ as Savior and based on a personal meeting with a living Christ. It is within this framework that his *Pensées*, a defense of Christianity, must be understood.

> The penetrating intelligence Pascal applied to spiritual thoughts was tied to his personal discovery of God, the God of the Bible, incarnate in Jesus Christ. Faith, which expresses a personal decision to say yes to God through Jesus Christ, leads to reconciliation and peace. But of faith are also born a transformed life and a total consecration to God. This is why Pascal was so opposed to the relativism of the Jesuits. His beliefs were rigorous and his morality uncompromising.[6]

The writer Antoine Arnauld had been condemned for heretical teaching inspired by Jansen and Augustine, and for opposing the standard beliefs of the Roman Catholic Church. Using a pseudonym for security reasons, Pascal wrote a series of pamphlets that were published underground. At that point, Pascal also became a pioneer of modern times since his pamphlets were a kind of early newspaper. These pamphlets were supposed to look like letters between two friends, one in the city and one in the countryside. They came to be known as "The Provincial Letters." They were very popular and afforded Pascal a good opportunity to criticize Jesuit dialectics. Let us recall that King Louis XIV himself had banned the Port Royal Jansenist movement as early as 1661. In a similar way, he banned the Reformed faith from France several years later in 1685. Furthermore, in 1712, this same king expelled all the Anabaptists belonging either to Mennonite or Amish movements.

After his Christian conversion at the age of thirty-one, Pascal did not stop working scientifically until the time when serious illness prevented any kind of intellectual work. Also, his scientific research did not hinder him from loving and serving his God. With Roannez, Pascal imagined and developed the last of his achievements that perfectly reflected his desire

for concrete social actions. He set up and promoted the first "buslines" of shuttle coaches, ferrying passengers within Paris on a fixed schedule and given routes. The coaches were equipped with several seats, and five *sols* (comparable to five dollars) were asked for one carriage. This last example illustrates the significant contribution that Pascal made to the emergence of a modern spirit of applied science and engineering with important social implications. However, more should be said about that first pioneer coach company: the profits of the company were intended to help poor people living in the French city of Blois. This last detail envisaged by Pascal was, of course, a way of applying his Christian faith to concrete charity actions.

Unfortunately, Pascal suffered increasingly from headaches that began when he was a young man. Especially after 1658, he fell seriously ill. In 1662, Pascal's illness became more virulent. Aware that he was unlikely to survive, he sought to find a hospital for incurable diseases, but his doctors declared him not transportable. On August 3, Pascal communicated his last will and testament to a solicitor. In this testament, Blaise is expecting and praying that "God will forgive his sins through the merit of the precious blood of our Savior and Redeemer." On August 17, Pascal experienced serious convulsions that warned him that death was near. Pascal died on the morning of August 19, 1662, at the age of only thirty-nine. His last words were, "May God never surrender me!"[7] In spite of his deficient health, Pascal left an example of a magnificent persevering Christian and scientist.

Influence of Pascal in France Today

As a former full-time CNRS researcher in theoretical material physics, I can give the following testimony. What was expected from our quantum mechanical model and related computing calculations was either to explain already-existing experimental data concerning a given material property, or, alternatively, to predict systematic results which would require experimental verification in the future. This way of practicing research was directly inspired by Pascal's pioneering concept of modern science. In the foreword of my doctoral thesis (in the field of solid state physics), I wrote the following: "As a tribute of respect to the great example of Blaise Pascal, a man of faith and genius."[8] Several decades later, I briefly recall here why Pascal was both a scientific genius who significantly contributed to modern science, and a dedicated Christian thinker who still urges every seeker of God, especially in France but also around the world, to experience a personal faith in the Lord Jesus. I accepted the biblical Gospel through the testimony of an InterVarsity group in Strasbourg. However, the example of Pascal, whom I knew as early as high-school level, prepared me to do so.

Let me briefly explain references to Pascal still found in France today. First, before France adopted euro currency, one of the highest bank notes (around one hundred dollars) exhibited Pascal's picture. Jacques Attali, representative of the present French intelligentsia, is fascinated by the great figure of Pascal.[9] Jean Brun, a foremost evangelical Christian thinker, wrote a small but pertinent book on Pascal's philosophy.[10] Moreover, as far as a link can be analyzed between Pascal's science and Christian faith, Dutch professor Reijer Hooykaas (history of sciences) offered a view still recognized in France today.[11] Several years ago, the theologian Henri Blocher taught a training course about how to introduce the Gospel, particularly in the French cultural context. Blocher concluded his course as follows:

> Blaise Pascal is a topmost scientist and believer, as well as a highly elegant writer, centered upon his relation to Jesus Christ. If Descartes is representative of France in general, Pascal is the very evangelist within the French context.[12]

More recently and before an audience of engineering students, Frédéric Baudin treated the important question of philosophy and truth according to Pascal.[13] For a critical and very interesting commentary of each word in "The Memorial," we refer to a recent book that is also representative of Pascal's attraction for a certain French intelligentsia with a Roman Catholic background.[14] We should also mention the Blaise Pascal Association, a Roman Catholic association concerned with *science versus belief* questions.

Quite recently, David Brown, who was a longtime general secretary and is now chairman of the French InterVarsity groups, imagined a dialogue with Pascal in order to ask him how he sees life and faith.[15] Brown's book is aimed at helping French

students discover basic questions and try to find solutions following the great example of Pascal. Furthermore, after having recalled the strong influence of both Catholicism and philosophy in today's specific French cultural background, Brown, in a recent paper about French culture, concludes by asking: "When shall we ever see an 'evangelical Voltaire' in France?"[16] The question is still valid for today, but we must also remember that about one century before the famous French eighteenth-century philosopher, there had already been a kind of "evangelical Voltaire" named Pascal. Within the framework of French InterVarsity groups and with the help of a US foundation, Brown brought Veritas Forum meetings to the French universities.

A few years ago, I was asked to speak at such a Forum at the University of Strasbourg on the following subject: "What is a successful professional life?" In my conclusion, I was led to call attention to the example of Pascal who had been both a successful scientist and a leading Christian. Also, Brown in conjunction with Lydia Jaeger, director of the Nogent Bible Institute, France, started a yearly meeting of French-speaking evangelical scientists. I had the privilege of addressing the first of those meetings, with a talk entitled "Can science be neutral?" In my talk, I could not prevent myself from citing Pascal's famous words:

> The last step of our own reason process is to admit that there are a lot of things still above our present understanding.[17]

Pascal has definitively been, for me, a great source of inspiration! In January 2013, the title of the abovementioned annual meeting was "Christian Scientists from Yesterday to Nowadays." Of course, Pascal was among the past scientists whose work, life, and faith were recalled during the conference.[18]

Conclusion

In this communication, I have tried to explain how Pascal has made and can make a difference. Pascal was the father of many new and basic developments in both physics and mathematics. Pascal's novel approach to science was dominated by the idea of careful observation of the studied object or phenomenon as opposed to a philosophical interpretation of the considered study in a subjective way. Furthermore, Pascal's spirit of innovation and risk was also an important contribution to the emergence of modern applied science and engineering.

When it came to Christian thinking, Pascal applied the same principle. The concrete (experiment) must complete the abstract (theory). In the question of knowing God, experience is a determining contribution, as Pascal experienced for himself after having been confronted by the written word of God, that is, the Gospel of the Bible. Pascal's Christ-centered faith is summarized in his following statement: "Jesus is a God whom we can approach without pride and before whom we can humble ourselves without despair."[19] Faith flows from the heart, which, for Pascal, stands as a necessary complement to human reason. God is not to be proved; he is to be experienced.[20] Up to now, the *Pensées* has been a powerful defense for Christ-centered faith and apologetics, especially among scientific and educated people.

Concerning a Christian testimony, Pascal's contribution is undeniable in the following sense. Christian faith is known (for example, among French InterVarsity groups) to be based on (1) a historical and objective event, namely the life, death, and resurrection of Jesus Christ, accomplished once for all time, and (2) a subjective personal experience which can still be reproduced, once in a life, namely a personal meeting with God through Jesus Christ. I am sure that Pascal would agree with that statement. His influence among general readers, either those scientifically oriented or those searching for the truth, is still going on today in France and around the world, and is of significant importance.

I specifically mentioned a few recent challenges and opportunities among French graduate students and colleagues. Everyone is challenged to experiment with Pascal's wager, which is to personally meet God through the Gospel of Jesus Christ. The gist of the wager is that one cannot come to the knowledge of God's existence through reason alone, so the wise thing to do is to live as if God does exist because such a life has everything to gain and nothing to lose. If we live as though God exists, and he does indeed exist, we have gained heaven. If he does not exist, we have lost nothing. If, on the other hand, we live as though God does not exist and he really does exist, we have gained hell and have lost heaven and bliss.

If one weighs the options, clearly the rational choice is to live as if God exists, the better of the possible choices.[21]

Acknowledgments

I would like to thank Denis R. Alexander who encouraged me to begin to write on this subject, as well as Christopher Sinclair for his critical reading of a first draft of this essay. Also I am grateful to James C. Peterson who drew my attention to several important points and suggested the title of this communication. ✦

Notes

[1]J. Attali, *Blaise Pascal, ou le génie français* (Paris: Fayard, 2000).
[2]M. Baude, "Blaise Pascal," in *The Lion Handbook of Christian Belief,* ed. A. E. McGrath and J. I. Packer (Herts, England: Lion, 1982), 445.
[3]Ibid.
[4]A. Kuen, *Ils sont nés deux fois* (St-Légier, Switzerland: Emmaüs, 2008), 31.
[5]Ibid.
[6]Baude, "Blaise Pascal," 445.
[7]Attali, *Blaise Pascal, ou le Génie Français,* 355.
[8]J. C. Parlebas, *Interaction Effects between Impurities on the Electronic Structure of Transition Metals*, PhD diss., Université Louis Pasteur, Strasbourg, 1976.
[9]Attali, *Blaise Pascal, ou le génie français.*
[10]J. Brun, *La philosophie de Pascal* in the collection *Que sais-je?* (Paris: Presses Universitaires de France, 1992).
[11]R. Hooykaas, "Pascal: His Science and His Religion," *Dutch Classics Tractrix* 1 (1989): 115–39.
[12]H. Blocher, "Proclamer l'évangile en tenant compte du contexte français," (paper, Formation à l'évangélisation, séminaire de formation, Mission Mondiale, Billy Graham, Béziers, France, 1995).
[13]F. Baudin, "Philosophie et vérité chez Blaise Pascal" (paper presented at the Culture-Environnement-Médias [CEM] Conférence, 2008).
[14]X. Patier, *Blaise Pascal: La nuit de l'extase* (Paris: Cerf, 2014).
[15]D. Brown, "*On parie combien?,*" de la série Question suivante GBU (Marne-la-Vallée, France: Editions Farel, 2011).
[16]D. Brown, "Culture et communication de l'évangile: La culture française," *Les cahiers de l'école pastorale* 82 (2011): 63.
[17]J. C. Parlebas, "La science peut-elle être neutre?," in *Quelles conditions pour une science en bonne santé?*, ed. L. Jaeger (Marne-la-Vallée, France: Editions Farel, 2010), 43.
[18]D. Brown and A. Lombet, "Des scientifiques chrétiens à travers les siècles" (paper, Le chrétien dans la science: Journée du Réseau des Scientifiques Evangéliques, Paris, 2013).
[19]B. Pascal, *Pensées et opuscules,* ed. L. Brunschvicg (Paris: Hachette, 1909), 144
[20]Baude, "Blaise Pascal."
[21]Brown, *On parie combien?*

ASA Members: Submit comments and questions on this article at www.asa3.org→FORUMS→PSCF DISCUSSION.

Ethics

IS EVIDENCE-BASED PSYCHIATRY ETHICAL? by Mona Gupta. New York: Oxford University Press, 2014. 224 pages, appendix, references, index. Paperback; $52.95. ISBN: 9780199641116.

What would make anyone question the ubiquitous authority of evidence-based practice in healthcare today? Evidence-based practice is the *sine qua non* of practice in all areas of healthcare. It is the guiding light by which the expert clinician steps through the maze of clinical, legal, ethical, moral, and political issues that affect contemporary practice. It is the holy grail of clinical science. But not for Mona Gupta, who, in her book *Is Evidence-Based Psychiatry Ethical?*, reminds readers that clinical practice involves a rational appreciation for the needs and goals of individual persons who have come for treatment and that determination of those practice goals needs to take place with an understanding of personal values in the context of human relationships, not only in the utilitarian context of statistical analyses and significant findings. In less technical language, I would summarize Gupta's message as the idea that clinical practice in psychiatry should be administered with a large dose of humility and rational, self-reflexive critique, so that psychiatrists do not repeat psychiatry's past abuses of power or utilitarian motivations that have nothing to do with the treatment goals of a particular individual.

Gupta lays out her argument in nine chapters that act as a primer to understanding the field of evidence-based psychiatry (EBP) in the context of the larger field of evidence-based medicine (EBM). In her first chapter, she provides an overview and justification of the book. Gupta unreservedly points out some of the problems faced by contemporary psychiatry—that it has a history of association with harmful treatments and poor public opinion, that it is not viewed as a real science, that distinctions between normalcy and abnormality seem based on beliefs and values, and that psychiatry's ethical value is, therefore, questionable. Gupta engages a discussion of how psychiatrists have migrated EBM to psychiatry without considering whether the assumptions inherent in EBM can even be applied ethically and morally to the practice of psychiatry.

In chapter 2, Gupta defines concepts and terms associated with EBM, as well as the basic steps inherent to ethical decision making in medicine. Her writing is informed by analysis of two foundational texts, as well as interviews of people whom she considers experts in EBM. Chapter 2 amounts to a close reading of ideas in the field of EBM and stands as an informed critique of its basic premises and promises, including gaps, which she identifies as "areas of uncertainty" (p. 6). She extends her critique of EBM in chapter 3 through a discussion of the broader literature concerning not only the role of ethics in EBM, but also the conflicting views on the benefits and difficulties of its use and promotion.

Chapters 4–6 have a similar structure and intent as chapters 1–3, but they are more specifically applied to EBP. An interesting aspect of this discussion focuses on the epistemology of psychiatry and its ties to philosophical concepts of mind. Another is an analysis of basic assumptions and biases within the discipline of psychiatry and EBM as well as how the ethics of EBM apply to psychiatry. What becomes very apparent in this discussion is the increasing gap between clinicians who see psychiatric conditions as having a fundamentally biological etiology and those who take a more biopsychosocial and spiritual approach to the understanding of health. In addition, Gupta points to disagreements in terms of how health resources are allocated in our society, and whether a utilitarian approach to psychiatry constitutes ethical practice.

Chapter 7 is a report on Gupta's group interviews of mental health experts, philosophers, and EBM developers about their views of ethics in the context of EBM. Main points that emerge from the interviews include (1) how EBM arises out of political and social trends; (2) whether EBM "is value-free or value-laden" (p. 149); (3) discussion and contrasting of the main goals of EBM, these being to improve health outcomes and satisfy patient preferences; and (4) whether EBM should be used to allocate resources. Gupta elaborates on each of these main points, but at one point overgeneralizes the discussion, stating that "mental health experts and philosophers disagree. Evidence is not value-free …" (p. 164). It would be more prudent, in the context of her discussion, to claim that "EBM developers and philosophers disagree," as many mental health experts are eager to point out that social science and, indeed, all of science is anything but a values-free endeavor.

In chapters 8 and 9, Gupta provides a summative discussion and offers conclusions about the ethics of EBM, contrasting it with several other approaches to practice, including the biopsychosocial model. Essentially, Gupta argues that EBM cannot form the totality of ethical practice, which must always be situated within the values-informed reality, what I would call the "phenomenology" of the person seeking treatment. However, she acknowledges the virtue of EBM's "call to cultivate intellectual virtues, both intellectual (e.g., judiciousness and explicitness) and moral (e.g., conscientiousness, honesty, courage; p. 177).

Throughout this text, Gupta methodically works through complicated and detailed information about ethics, psychiatry, medicine, and evidence-based practice. The book is a goldmine of information about these issues as they pertain to psychiatry and ethics. For people working in psychiatry who have not been exposed to these arguments, the book is a comprehensive introduction to the assumptions, biases, ideological influences, and moral divides within the discipline.

For those who have considered these matters before, the book provides more-limited insight into the differences in thought and approach to the topic of ethics between philosophers, clinicians, and clinical researchers invested in EBP. However, some readers might find the discussion familiar, as many of the arguments in the book parallel discourse in the philosophy of science that critiques positivism and scientism. In fact, at many points in the book, the reader might replace EBM and EBP with the word "science," and the discussion would be very reminiscent of arguments about scientism, objectivity and neutrality, researcher bias, and concept reification that have been debated widely over the years.

Nevertheless, the author situates these arguments within the particularities of psychiatry, which makes the book use-

ful to those in that field. For example, the book addresses topics such as the social context and politics of mental health funding; service structure and administration; who sets the mental health agenda; and the influence of insurance, governments, and research-focused organizations. Moral issues related to prioritization of the needs of the individual versus the needs of government, funding bodies, personal bankrolls, and corporations are discussed at several points in a fashion that provides for rich perspective with a tone of *parrhesia*, candidly laying bare some of the most difficult moral concerns of the discipline.

The book is not without other challenges. As I read, I wondered who the audience for the book really was and, at times, found the structure and content somewhat tedious. I found myself thinking that it reads like a doctoral dissertation, only to realize later that the text is based largely on the author's (2009) dissertation. The text is thick on detail but not fast on delivery. A clinician having limited time for continuing education would well be advised that the text is not a page-turner. Transforming a dissertation into a published monograph is not easy, in part because the audiences can be quite different. As a result, the book is useful for those who have, or are required to have, the time to devote to this text. Unfortunately, Gupta's text does not actually succeed in bridging that gap between academia and clinical practice that she identifies as a basic problem within the discipline.

Throughout the text, I was also distracted by vacillation between EBM and EBP. While Gupta defined the differences between these terms well, at times I found her discussing EBM, when I really was wondering more specifically about the implications for EBP.

Finally, I have some concerns about the scope of the text itself. Focusing specifically on psychiatry is reasonable, as this is the author's area of training and practice. However, Gupta has addressed a topic important to mental health, not just to psychiatry. As a result, the text contributes to the fragmentation of discourse in mental health that detracts from ethical and moral delivery of services to those in need. A considerable amount of thought and research comes from psychology, nursing, and other allied health disciplines. Psychiatrists would do best not to reinforce the intellectual silos within mental health, as this perpetuates the very problems Gupta discusses as being central to her field.

Reviewed by Theresa Zolner, Associate Professor of Psychology, The King's University, Edmonton, AB T6B 2H3.

Philosophy & Theology

BEING AS COMMUNION: A Metaphysics of Information by William Dembski. Surrey, UK: Ashgate, 2014. xvii + 218 pages. Paperback; $34.95. ISBN: 9780754638582.

William Dembski, author of *Being as Communion: A Metaphysics of Information*, holds a PhD in philosophy and another in mathematics. A Christian theist of broadly evangelical leanings, he is probably best known for his role in the emergence of the controversial intelligent design movement. His previous two books, *The Design Inference* (1998) and *No Free Lunch* (2002), develop and deploy an information-theoretic apparatus for identifying and analyzing patterns in nature whose origin and development, Dembski argues, materialism is constitutionally incapable of explaining. In these two books, he argues that materialist science only appears to account for the informational complexity of nature because it surreptitiously helps itself (as in a "free lunch") to an unconfessed teleology disguised as chance and necessity, thereby appearing to keep the world free of nonnatural sources of telic agency such as God or immanent teleology (which might require a "design inference"). His most recent book, the subject of this review, completes Dembski's trilogy on intelligent design by further expanding on and articulating the philosophical underpinnings of the two earlier books' themes. While he wrote *Being as Communion* to give us "a metaphysical picture of what the world must be like for intelligent design to be credible" (xiii), much of its content holds interest and value beyond the vicissitudes of the intelligent design research program itself, and therefore (despite its place in the trilogy) functions well as a "stand-alone" book for those new to Dembski's work.

The numerous philosophical, scientific, and theological ideas that find their way into these 200 or more pages of sophisticated critique, argumentation, and speculation cannot be adequately represented in a review of this size. My goal, therefore, will be merely to give the reader a sense of some of what this book offers in the way of topics and issues, and then conclude with a few brief comments on its accomplishment.

Dembski opens his book, setting the stage for what he will call his metaphysics of "informational realism," by drawing attention to a deep, yet largely ignored, tension between our present age of information and the West's underlying materialistic worldview: if we embrace materialism, which renders reality into nothing but massy particles agglomerated by nontelic material forces, then most of the things (information included) that we have valued throughout history (values included) "become dim reflections of their former selves," a disenchantment of reality which, when squarely faced, cannot but lead to "the ultimate dissolution of all human aspiration" (pp. 4–5). Dembski believes that his informational realism lays the basis for preserving the transcendent realities of human aspiration which materialism must render as mere appearances. In the final sentence of his book, Dembski concludes that "the information approach to reality takes the world as it is" (p. 203). And "the world as it is" gives itself to us already rife with minds, meanings, values, and purposes, none of which can be taken seriously for long by either materialism or a civilization beholden to materialism's atomistic and reductionistic strictures. Thus, what we find between the first and the last chapters of this book is an attempt not only to preserve the West's humanistic heritage but also to resituate it in the context of a metaphysics of information that establishes a fundamentally relational ontology capable of fostering unfettered scientific inquiry that is open to wherever evidence leads and is thus free to take "the world as it is." Dembski's two principal aims in this book are, therefore (1) to build a convincing case for the many explanatory and existential advantages of an infocentric paradigm switch that would replace the interaction of particles with the exchange of information as reality's most basic modality of operation, and (2) to supply the conceptual and theoretical sub-structure to support this rather radical move.

In the nineteen chapters separating his first and last chapters, Dembski identifies, refines, and deploys the conceptual tools required to forge the theoretical underpinnings of his metaphysics of informational realism, taking the reader on a fast-paced, often high-altitude journey through a vast array of heady mathematical, scientific, and metaphysical passes, along with a few exhilarating detours to various theological precipices. In this short work, he manages to engage and develop a whole host of concepts and theories in terms of their bearing on his informational realism project. The reader will become familiar with various interpretations of quantum physics, information theory, and probability theory, along with a few recently developed mathematical postulates such as the "no free lunch" and "conservation of information" theorems, as well as topics in the biological sciences, such as neo-Darwinist and intelligent design accounts of biological complexity, natural selection, teleonomic vs. teleological laws, and genetic algorithms. In the light of his informational realism metaphysic, Dembski also illuminates for the reader a number of issues in metaphysics, such as determinism, contingency, necessity, causal closure, multiple realization of supervening properties, embodiment, immateriality, randomness, and panpsychism—and even a few momentous theological issues, such as divine concurrence, providence, free will, miracles, resurrection, and immortality.

Despite the occasional abstruse mathematical theorem and a steady flow of abstract conceptual notions, *Being as Communion* is a surprisingly enjoyable read, due largely to the many interesting issues covered, the plentiful use of examples, and the clarity of Dembski's prose. And for those already familiar with the intelligent design movement, this book does much to clear away some long-standing misconceptions that have diminished its appeal. The book as a whole, however, can be somewhat frustrating. The internal logic of the progression of chapters and topics is not readily discernible. There were a number of better ways Dembski could have built his argument and organized his book to enhance its cogency, increasing significantly the ease of informational uptake of the book's message.

Leaving aside issues of improving the book's form, I will offer in closing a couple of comments on its content—one commendatory, two critical. I liked the book's burden, which I took to be that of forging a metaphysics capable of grounding an informationally porous universe to recover, legitimate, and sustain creation's enchantments: those meanings, values, and purposes uniquely given to human intelligences that have been progressively dispatched into the realm of epiphenomena ever since the rise of early modern science.

I struggled, however, with Dembski's failure to clearly separate materialism from physicalism. Unlike materialism, physicalism has no essential connection to matter; physicalism is committed only to those entities the best physics of the day deems the most explanatorily basic. One can therefore be a nonmaterialist and a physicalist. In fact, I would say that most physicists are nonmaterialist physicalists (could a materialist coherently embrace quantum physics?). I think the real demon Dembski is out to slay is not materialism (whether metaphysical or merely methodological) but ateleological physicalism.

My second problem is not unrelated. Dembski could have done a better job of helping his reader understand how his informational realism differs, if it does, from a flat-out metaphysics of idealism. Given that he contends reality is "information all the way down" (p. 198), understands God's mind to be the original and ultimate imparter of information to reality (p. 187), and embraces a co-ontologizing relational ontology of information (p. 167), it seems to me that Dembski's metaphysics is better construed as one of informational antirealism. Perhaps Dembski's use of realism here is more rhetorical or strategic, allowing him to adopt the likes of naturalist-nonmaterialist-teleologist-realist Thomas Nagel into the intelligent design family.

If you are someone who is drawn to the latest meme of *information*, and you are a theist, then Dembski's book is a must read. However, even if you are like me and not so taken with that meme (I find it too skeletal a notion to carry the semantic weight of "communion" in his title), and even if you are not a theist, you are nonetheless likely to find lots in this book to expand your mind.

Reviewed by Robert Doede, Professor of Philosophy, Trinity Western University, Langley, BC V2Y 1Y1.

TECHNOLOGY

THE INNOVATORS: How a Group of Hackers, Geniuses, and Geeks Created the Digital Revolution by Walter Isaacson. New York: Simon & Schuster, 2014. 488 pages, index. Hardcover; $35.00. ISBN: 9781476708690.

Walter Isaacson, the former chairman of CNN and managing editor of *Time*, has previously written biographies of Steve Jobs and others. In this latest book, he presents a fascinating and very readable account of key people in the development of both computers and the Internet, from Ada Lovelace and Charles Babbage in the mid-1800s to the beginning of 2014. What makes the book especially enjoyable to read is his focus on the backgrounds of these people and how they collaborated to produce the digital world we know today.

A common belief is that innovation results from the creativity of great individuals. While acknowledging the role played by such individuals, Isaacson frequently points out that innovations are more often the result of collaboration involving people of diverse talents. In his Introduction, he asserts that "the tale of their teamwork is important because we do not often focus on how central that skill is to innovation" (p. 1), while in his final chapter, he summarizes the lessons learned from a study of the history of computing and the Internet. He notes, "First and foremost is that creativity is a collaborative process. Innovation comes from teams more often than from the lightbulb moments of lone geniuses" (p. 479).

Another central idea that permeates the book is the notion of human-machine symbiosis: human minds working with computers to excel at a task by combining the things that humans do especially well and computers do poorly if at all, and vice versa. As an illustration of this, he cites a chess tournament held in 2005:

> Players could work in teams with computers of their choice…But neither the best grandmaster nor the most powerful computer won. Symbiosis did…The final winner was not a grandmaster nor a state-of-the-art computer, nor even a combination of both, but two

Letter

> American amateurs who used three computers at the same time and knew how to manage the process of collaborating with their machines. (p. 476)

A third notable observation that shows up repeatedly is that "the truest creativity of the digital age comes from those who are able to connect the arts and sciences" (p. 5). In the first chapter, Isaacson presents Ada Lovelace as such a person, and he comes back to her in the final chapter, entitled "Ada Forever." He also credits her with being the first to conceive of the idea that computing machinery might one day do more than just calculate, citing from the notes she made concerning the Analytical Engine:

> The Analytical Engine does not occupy common ground with mere "calculating machines" … In enabling a mechanism to combine together *general* symbols … a uniting link is established between the operations of matter and the abstract mental processes … The Analytical Engine weaves algebraical patterns just as the Jacquard loom weaves flowers and leaves. (p. 26)

One other thing that this reviewer found interesting is the number of key individuals who were sons of ministers. While Isaacson does not make an explicit point of this in his introduction or conclusion, this observation often arises in his presentation of the backgrounds of individuals. In particular, he attributes the culture of Intel, "which would permeate the culture of Silicon Valley" (p. 192), to Robert Noyce's background as a son and grandson of Congregationalist ministers, a denomination he describes as being characterized by "the rejection of hierarchy and all its trappings" (p. 189).

While the book covers a lot of ground, this reviewer found it surprising that one important innovation, the UNIX operating system, and one key individual, Ken Olsen, were not discussed at any length. But maybe that is just the prejudice of one reviewer! Nevertheless, the book is fascinating and very readable. While not explicitly dealing with issues of faith and science, it provides a very thorough overview of the origins and rise of personal computers and the Internet. The last chapter alone, "Ada Forever," is well worth reading for its discussion of artificial intelligence and human-machine symbiosis, as well as its summary of key lessons from the history of digital innovation.

Reviewed by Russell C. Bjork, Professor of Computer Science, Gordon College, Wenham, MA 01984. ✦

Letter

Thinking Consistently and Coherently about Truth

I came to Caltech to study science in the 1950s, bringing with me an evangelical Christian faith. I knew I'd acquire knowledge there that would conflict with what many people in church believed, but decided that since scientific truth is about the universe God created, I should always hold Christian faith and the truths learned through scientific inquiry in a consistent, coherent way, treating each with the respect it deserves as valid knowledge. That decision has borne lifelong fruit in a long academic career in secular universities.

I know or have known many Christians trained in the sciences, who have professional careers based on scientific knowledge, and who through life rely on such knowledge in their daily work. Some are engineers; some are medical doctors; some are secondary school science teachers; some are technical people whose skills employ scientific knowledge every day. But to my dismay I find that many of them are unable or unwilling to think consistently about truth in science and the truth they hold in Christian faith.

When scientifically literate Christians endorse recent-earth creationist propaganda themselves, or present it to others as a legitimate alternative to established scientific knowledge, they create a kind of chaos for rational discussion. I'm puzzled and troubled that time and effort must be taken listening to such propaganda (or trying to refute it). Currently an influential and popular source of creationist propaganda is the media empire run by a person named Ken Ham, and the "Answers in Genesis" media system Ham controls. As others have pointed out, Ham's empire is lavishly funded—to the tune of millions of dollars per year. My own life experience has taught me that when money and truth collide, truth often suffers.

It should not surprise anyone if all devotees of Ken Ham or other recent-creationist propaganda sources were uneducated persons without any knowledge of science. The real shocker is that some Christian people who repeat such propaganda to others have received scientific training adequate for their professions and daily work. It's reasonable to infer that they haven't really examined their belief-set for consistency and coherence as an account of the world we all live in. When goaded to desperation by gadflies like myself, some of these Christians even suggest that God may have created the world to "look old"—fooling us scientists and other naïve persons to follow the "evidence" showing its age. But this suggestion is truly blasphemous, because it implies that God is a liar.

The origins of recent-earth creationism are well known, and they are both theologically and scientifically suspect. Being a Christian does not require a scientifically trained person to defend or endorse anti-scientific arguments about the universe's age (and therefore ignore the scientific evidence for a 12–15-billion-year-old universe and an earth almost that old). This is especially relevant if such arguments contradict scientific knowledge on which we rely in daily life and work. In the first place, recent-earth creationist arguments have nothing to do with the gospel; in the second place, they are based on a naïvely literal interpretation of the Genesis creation accounts. So why, in spite of this, do some people with good scientific training and lifelong professional experience using it, still endorse or even believe propaganda that openly contradicts reliable scientific knowledge? So far, explanations I've come up with for this odd inconsistency have nothing to do with truth; they have far more to do with family relationships, smoothing over disagreements arising from different educational backgrounds, and so on. But carrying around worthless baggage cripples sound Christian apologetics, and with Elijah, I would ask the same harsh question: *how long will you go limping along with two conflicting opinions?* (I Kings 18:21).

Walter R. Thorson
ASA Fellow
Professor of Theoretical Chemistry (Emeritus)
University of Alberta ✦

American Scientific Affiliation

The American Scientific Affiliation (ASA) is a fellowship of Christians in science and related disciplines, who share a common fidelity to the Word of God and a commitment to integrity in the practice of science. Founded in 1941, the purpose of the ASA is to explore any and every area relating Christian faith and science. Perspectives on Science and Christian Faith is one of the means by which the results of such exploration are made known for the benefit and criticism of the Christian community and of the scientific community. The ASA Statement of Faith is at www.asa3.org → HOME/ABOUT → ASA BELIEFS.

American Scientific Affiliation Forums

We encourage members to submit comments and questions on the articles published in this journal on the ASA **PSCF Discussion Forum** at www.asa3.org → FORUMS → PSCF DISCUSSION.

The ASA home page/forums also contains links to four other members-only discussion groups. The **General Discussion** is for thoughtful discussion of various issues in science and faith. **Books** hosts a series of discussions on seminal books on science and faith. There are also forums for discussion about the **Annual Meeting** and **Education**.

An **Open Forum** is open to the public for dialogue on topics of science and faith at www.asa3.org → FORUMS → OPEN FORUM.

Canadian Scientific & Christian Affiliation

A closely affiliated organization, the Canadian Scientific and Christian Affiliation, was formed in 1973 with a distinctively Canadian orientation. The CSCA and the ASA share publications (*Perspectives on Science and Christian Faith* and the *God and Nature* magazine). The CSCA subscribes to the same statement of faith as the ASA, and has the same general structure; however, it has its own governing body with a separate annual meeting in Canada.

Canadian Scientific and Christian Affiliation, PO Box 63082, University Plaza, Dundas, ON L9H 4H0. Website: www.csca.ca.

How Do I Join the ASA?

Anyone interested in the objectives of the Affiliation may have a part in the ASA. Membership and subscription applications are available at www.asa3.org → HOME/ABOUT → WHO CAN JOIN?

Full membership is open to all persons with at least a bachelor's degree in science who can give assent to our statement of faith. Science is interpreted broadly to include anthropology, archeology, economics, engineering, history, mathematics, medicine, political science, psychology, and sociology as well as the generally recognized science disciplines. Philosophers and theologians who are interested in science are very welcome. Full members have voting privileges and can hold office.

Associate membership is available to interested nonscientists who can give assent to our statement of faith. Associates receive all member benefits and publications and take part in all the affairs of the ASA except voting and holding office.

Full-time students may join as **Student Members** (science majors) with voting privileges or as **Student Associates** (nonscience majors) with no voting privileges.

Spouses and **retirees** may qualify for a reduced rate. **Full-time overseas missionaries** are entitled to a complimentary membership.

An individual wishing to participate in the ASA without joining as a member or giving assent to our statement of faith may become a **Friend** of the ASA. Friends receive all member benefits and publications and take part in all the affairs of the ASA except voting and holding office.

Subscriptions to *Perspectives on Science & Christian Faith (PSCF)*, are available at $50/year (individuals), $85/year (institutions) and $20/year (student premiers).

How Do I Find Published *PSCF* Articles?

Articles appearing in *Perspectives on Science and Christian Faith* are abstracted and indexed in the *Christian Periodical Index; Religion Index One: Periodicals; Religious & Theological Abstracts*, and *Guide to Social Science and Religion in Periodical Literature*. Book Reviews are indexed in *Index to Book Reviews in Religion*. Present and past issues of *PSCF* are available in microfilm form at a nominal cost. For information, write to NA Publishing, Inc. PO Box 998, Ann Arbor, MI 48106-0998 or go to www.napubco.com.

Contents of past issues of *PSCF* are available at www.asa3.org → PUBLICATIONS → PSCF.

American Scientific Affiliation
218 Boston Street, Suite 208
Topsfield, MA 01983

Phone: (978) 887-8833
FAX: (978) 887-8755
E-mail: asa@asa3.org
Website: www.asa3.org