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

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Perspectives on Science and Christian Faith

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The View from Shepherd's Knoll ...

The "New Song" Symphony

I am writing this editorial from beautiful Hocking Hills State Park, near Logan, Ohio, where my wife and I are spending a week camping, while our two daughters are participating in a choral camp for children at Rosedale Bible College, near Columbus, Ohio. The events of the past days have merged the themes of music and nature in my consciousness. While camping we hear both sounds of nature as well as violin/viola music, when my wife and I as amateur musicians attempt to create pleasing harmony by playing hymns and simple music variations together.

Nature sings on multiple levels. The audible sounds of birds chirping, the gurgle of a stream cascading over rocks, and the crack of a thunderstorm are poetically described as nature's songs. In his book, *The Symphony of Creation: Science and Faith in Harmony* (Phoenix, AR: ACW Press, 2002), Steven Stoller uses a metaphoric symphony to describe the harmonious music that emerges when both science and faith investigate nature. Stoller writes:

> Nature is like music. Just as music needs both the science of sound and the spirituality of art, so nature needs both science and faith for its full comprehension. "Listening" to nature by merely analyzing the waveforms of its "sound" doesn't permit us to discern its full beauty and meaning. Only when science joins with spirituality do we appreciate the purpose and true grandeur of the universe.

As practitioners of both science and Christian faith, many of us resonate with Stoller's theme. Our harmony of science and faith may provide the "new song" for our secular culture as described by the Psalmist: "*Sing to the Lord a new song; sing to the Lord, all the earth*" (Psalm 96:1 NIV). This international "new song" declares to all peoples the glory and reign of the Creator.

Sometimes as singers of the "new song" we give up the attempt to sing harmoniously together; rather we are prone to sing solo, expecting others to applaud our individual recitals. In contrast a symphonic chorus creates a harmonious blend, when each musician attentively follows the text of the composer and the directives of the conductor, while responsively listening to the elements of intonation, modulation, and timbre that are emerging. Such a concert enlivens a musical score and creates attention in the listening audience. Does our part in the symphonic rendition of the Divine Composer's musical score harmoniously stir our culture? Can our culture hear the "new song"?

Singing along the way,
Roman J. Miller, *Editor*

In This Issue

The Plenary Presenters section includes two scientists who were featured in the 2002 Annual Meeting of the ASA. Francis Collins, Director of the NIH Human Genome project, illustrates how the elegance and the complexity of the human genome reflect the Creator's glory. Recipient of the 1964 Nobel Prize in Physics, Charles Townes describes how the interaction of science and religion provides a unified understanding of the purpose and nature of the universe.

In the Articles section, Ben Carter and Carlos Bovell in separate articles show that mathematics can illuminate theological and metaphysical insights. Glenn Morton and Gordon Simons argue that the random processes found in the genetics of various species are not a theological threat but are consistent with divine activities in biblical history.

Finally, in the Student and Early Career Scientists Corner a panel of six persons, who were featured in the 2001 ASA Annual Meeting, dialogue about the challenges for Christians who are beginning careers in science.

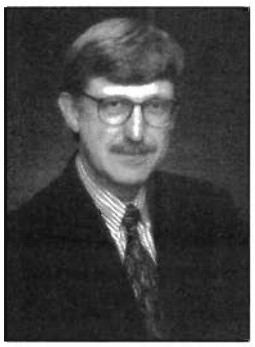
The Book Reviews section contains thirty reviews in eight categories. Four Letters responding to prior printed book reviews or articles conclude the issue.

Plenary Presenters

Faith and the Human Genome

Faith and the Human Genome

Francis S. Collins



Despite the best efforts of the American Scientific Affiliation to bridge the gap between science and faith, few gatherings of scientists involved in biology include any meaningful discussion about the spiritual significance of the current revolution in genetics and genomics. Most biologists and geneticists seem to have concluded that science and faith are incompatible, but few who embrace that conclusion seem to have seriously considered the evidence.

From my perspective as director of the Human Genome Project, the scientific and religious world views are not only compatible but also inherently complementary. Hence the profound polarization of the scientific and religious perspectives, now glaringly apparent in the fields of biology and genetics, is a source of great distress. Hard-liners in either camp paint increasingly uncompromising pictures that force sincere seekers to choose one view over the other. How all of this must break God's heart! The elegance and complexity of the human genome is a source of profound wonder. That wonder only strengthens my faith, as it provides glimpses of aspects of humanity, which God has known all along, but which we are just now beginning to discover.

From my perspective as director of the Human Genome Project, the scientific and religious world views are not only compatible but also inherently complementary.

We are just on the edge of a whole host of developments spurred on by genetics that are going to require careful and deliberative thought. Those of us who are blessed enough to have a foundation for how we decide what direction to go, namely our faith, will need to be deeply engaged, if the outcome is going to be one that Almighty God would be proud of. Psalm 8 refers to the interface between science and faith.

> *"O Lord, our Lord, how majestic is your name in all the earth! You have set your glory above the heavens. From the lips of children and infants you have ordained praise because of your enemies, to silence the foe and the avenger. When I consider your heavens, the work of your fingers, the moon and the stars, which you have set in place, what is man, that you are mindful of him, the son of man, that you care for him? You made him a little lower than the heavenly beings and crowned him with glory and honor. You made him ruler over the works of your hands; you put everything under his feet: all flocks and herds, and the beasts of the field, the birds of the air, and the fish of the sea, all that swim the paths of the seas. O Lord, our Lord, how majestic is your name in all the earth!" Ps. 8:1-9 (NIV).*

As a scientist I love that Psalm because it really does speak from David's heart and describes the glories of the heavens, the amazing features of biology, and yet presents the real message, "How majestic is your name in all the earth!"

For almost twenty years, I have been a member of ASA. This is the first time I have been able to come to an annual meeting. I confess that I am humbled to speak about the interface between science and faith, because many of you have written in very eloquent terms about the intricacies of how we synthesize those components. My own understanding is still a work in progress. You may find places where you would like to challenge me, and I hope you will. This organization has been a constant source of

Francis S. Collins *is a physician, geneticist, and current Director of the National Human Genome Research Institute at NIH. Raised on a small farm in Virginia, he obtained a B.S. in chemistry at the University of Virginia and a Ph.D. in physical chemistry at Yale University. He graduated from medical school at the University of North Carolina and completed a residency in internal medicine at Chapel Hill. Later, he returned to Yale for a fellowship in human genetics, and then joined the faculty at the University of Michigan in 1984. His genetic research team identified the genes for cystic fibrosis, neurofibromatosis, and collaborated with others to identify the gene for Huntington's disease. In 1993, Collins became the second director of the National Center for Human Genome Research, following in the footsteps of James Watson. In that role, Collins has overseen the successful completion of the Human Genome Project. He has been a member of ASA for over twenty years.*

This is an edited transcription of the presentation given Aug. 4, 2002, at the ASA Annual Meeting at Pepperdine University, Malibu, California.

The audio presentation is available on the ASA web site: www.asa3.org

encouragement to me over the course of those nearly twenty years.

Let's look at two very thought-provoking images that look very similar: the Rose Window from York Minster Cathedral, a beautiful stained glass window; and an unusual view of DNA, where you look at it, not from the side, but "down the barrel" so that the double helix in its spiral form is shown in a particularly beautiful aspect (see Figure 1). These images can represent two world views, which most people imagine are incompatible—the spiritual view and the scientific view. Alternatively, having those two world views synthesized within is a wonderful opportunity to appreciate each in a special way.

My Upbringing

I grew up in a home in the Shenandoah Valley of Virginia, where faith was not regularly practiced. My parents were very creative people, particularly in theater and the arts. They taught me at home until the sixth grade but not because of the desire to instill religious beliefs in me—as is now often the case in home schooling—but just to keep me out of hands of the county schools, whose teachers were perceived as being a little less than encouraging to the creative instincts of my mother's four boys. She inspired in me a desire to learn things. But I did not learn much about faith or gain a belief in God. I was sent to church at the age of six, for a very specific reason—to join the boys' choir in order to learn music. I remember an exhortation from my father, saying, "You're there to learn the music. There's going to be this other puzzling stuff about theology. Don't pay any attention to that. It will just confuse you." So I followed those instructions, and I learned a lot about music, but I had no clue what was going on in terms of the rest of those services.

When my friends in the dormitory at college quizzed me about what I believed, I realized I had absolutely no idea. It was fairly easy for me to decide I did not believe any of this stuff that some of the people were talking about—about Christ or other forms of religious faith. I assumed that it was all superstition. I had gotten along quite well without it and did not feel any particular need to embrace it.

I finished my undergraduate degree in chemistry and went on to work on a Ph.D. in chemical physics at Yale. After delving into that particular field and concluding that the only real truths were second-order differential equations, there seemed to be even less need for God. God did not seem to me like he would be a second-order differential equation. So I became a rather obnoxious atheist in graduate school. If you had gone to lunch with me, you would not have enjoyed the experience. I had absolutely no interest in matters of the spiritual life, because I did not think there was such a thing.

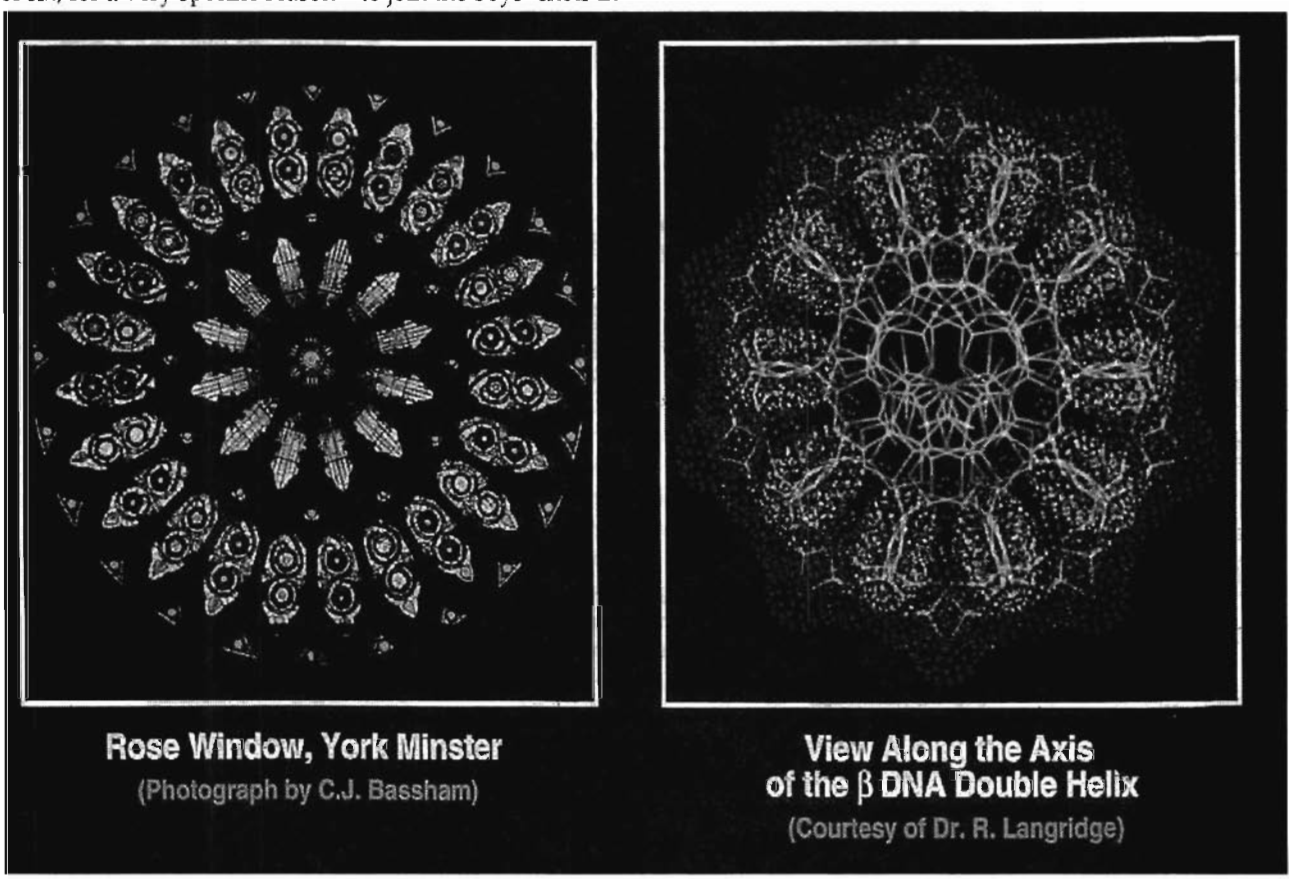


Figure 1.

Plenary Presenters

Faith and the Human Genome

As a scientist, I had always insisted on collecting rigorous data before drawing a conclusion. And yet, in matters of faith, I had never collected any data at all. I did not know what I had rejected. So I decided I had better be a little better grounded in my atheism. I had better find out what this is all about.

But then, I changed directions. Deciding that biology was a lot more interesting than I had earlier thought, I determined to go to medical school. I wanted to learn that particular discipline in order to apply my scientific instincts in a human health direction. As a medical student, I encountered many people going through terrible suffering, stricken down with diseases not of their own making. Yet I could not help but note that some of these people appeared to have incredible faith. They were not angry with God, which I thought they should have been. If they believed in a God and he let them get cancer, why weren't they shaking their fist at him? Instead, they seemed to derive this remarkable sense of comfort from their faith, even at a time of great adversity. That response really puzzled me. A few of my patients asked what I believed; I stammered and stuttered and realized I was too embarrassed to say, "I don't know."

Then something came to me. As a scientist, I had always insisted on collecting rigorous data before drawing a conclusion. And yet, in matters of faith, I had never collected any data at all. I did not know what I had rejected. So I decided I should be a little better grounded in my atheism. I had better find out what this is all about. I challenged a patient Methodist minister down the street. After listening to my questions and realizing I was not dealing with a very full deck of information, he suggested that I read the Gospel of John, which I did. I found that Scripture to be interesting and puzzling and not at all what I had thought faith was about. But still I was not ready to consider the plausibility of faith; I needed more of an intellectual basis to get past my own arguments about why this was just superstition. For that purpose, he turned me to the writings of C. S. Lewis in his classic book, *Mere Christianity*. (Even today *Mere Christianity* seems to be the very best book to put in the hands of a young seeker who is trying to figure out if there is rationality for faith.) So I read *Mere Christianity*, and my materialist view was quickly laid to ruins. Particularly compelling for me was Lewis' argument about the law of human nature: Why is it there? Why is it universal? Also his argument: Would not this be the place to look for evidence of a personal, perfect, and holy God if there was one?

Sociobiologists will argue that human nature is all, in some way, an evolutionary consequence. That just never seemed particularly compelling to me as an explanation for the moral law: that we know somehow intrinsically, and yet often do not obey. Here is a wonderful sentence from Lewis:

> We find out more about God from the moral law than from the universe in general, just as you find out more about a man by listening to his conversation than by looking at a house he has built.

I realized that my scientific life was looking at the house, while I had never considered the conversation (the moral law) as evidence of God. I needed to study the Creator. After struggling many months, I realized that if there was a God, he was holy and I was not. I realized for the first time just how flawed a person I was. I then recognized what Christ did by providing a bridge between God and all his holiness and me and all my unholiness. Finally I gave in and surrendered—not perhaps, like Lewis, the most dejected and reluctant convert in all England, which is how he described his conversion. A rush of warm emotion did certainly not afflict me either. Rather, it was very much like walking into a complete unknown. God is good, and over the course of many more years of learning—and I am still on that road—my faith has become the guiding light of my life.

My scientific world view began earlier. I got excited about science as a high school student. I then got excited about chemistry, went on to medicine, and ultimately got excited about genetics as a way to unravel all the difficult mysteries of medical illness. I certainly never imagined that a call would come, where I would be asked to move to the National Institutes of Health (NIH) and become, of all things, a federal employee, and to direct a project aimed at mapping and sequencing all of the letters of the human instruction book. It has been a truly remarkable moment in history, and a moment that we have essentially now just passed through. It has been nine years since I came to NIH. I have had an incredible ride, and it ain't over yet! In many ways, we are at the end of the beginning. Where we are going next, I think, will have even more profound impacts on medicine and on our society. As Christians,

we bring a special perspective on how to usher in this new revolution in a fashion that has the maximum benefits and is done in the most benevolent way.

The Future of the Human Genome Project

The Human Genome Project (HGP) has now been going on for twelve years. All of the original goals of this project have been achieved three years ahead of the projected deadline of 2005. I am happy to say (and this plays very well inside the Beltway) that the HGP has all been done for substantially less money than originally had been projected. The HGP is one federally funded project that is ahead of schedule and under budget!

The applications of the HGP are going to be across the board, in virtually every area of medicine, because virtually every disease has some genetic component. Scientists have tended to emphasize those disorders that are inherited in very strong genetic ways, like cystic fibrosis, Huntington's disease or sickle cell disease. But virtually everything, except maybe a few cases of trauma, has some genetic component—diabetes, heart disease, mental illness, asthma, high blood pressure, and cancer. All of these tend to run in families, which means there are glitches in the DNA sequence that predispose people to be at risk.

Furthermore, we realize that there are no perfect specimens. This is the biological equivalent of original sin. We are all flawed; we have all fallen genetically short of perfection. There is no perfect DNA sequence; there is error in all of us. We all have probably dozens of places in our DNA sequence where you wish you had a T (thymine) but you really have a C (cytosine). Consequently that change makes you at risk for some disease. You may never be bothered by many of those risks because you will not encounter the environmental trigger required to cause the disease or you will not have the mix of susceptibilities to push you over a certain threshold. However, we all have stuff in our genome that is lurking and we carry the probability that our specific genome is going to cause us some trouble. We are on the brink in the next ten years or so, of being able to find out what those probabilities are for each one of us. The enormity of that potential is really serious to contemplate.

Now fifty years since Watson and Crick unraveled the structure of the double helix, I think it is amazing to contemplate the elegance of DNA carrying information—this language that is shared by all life forms. This digital code allows, in a very easily copyable form, such a massive amount of information to be carried inside each cell of the human body. This double helix DNA is made up of base pair letters. The whole human genome consists of three

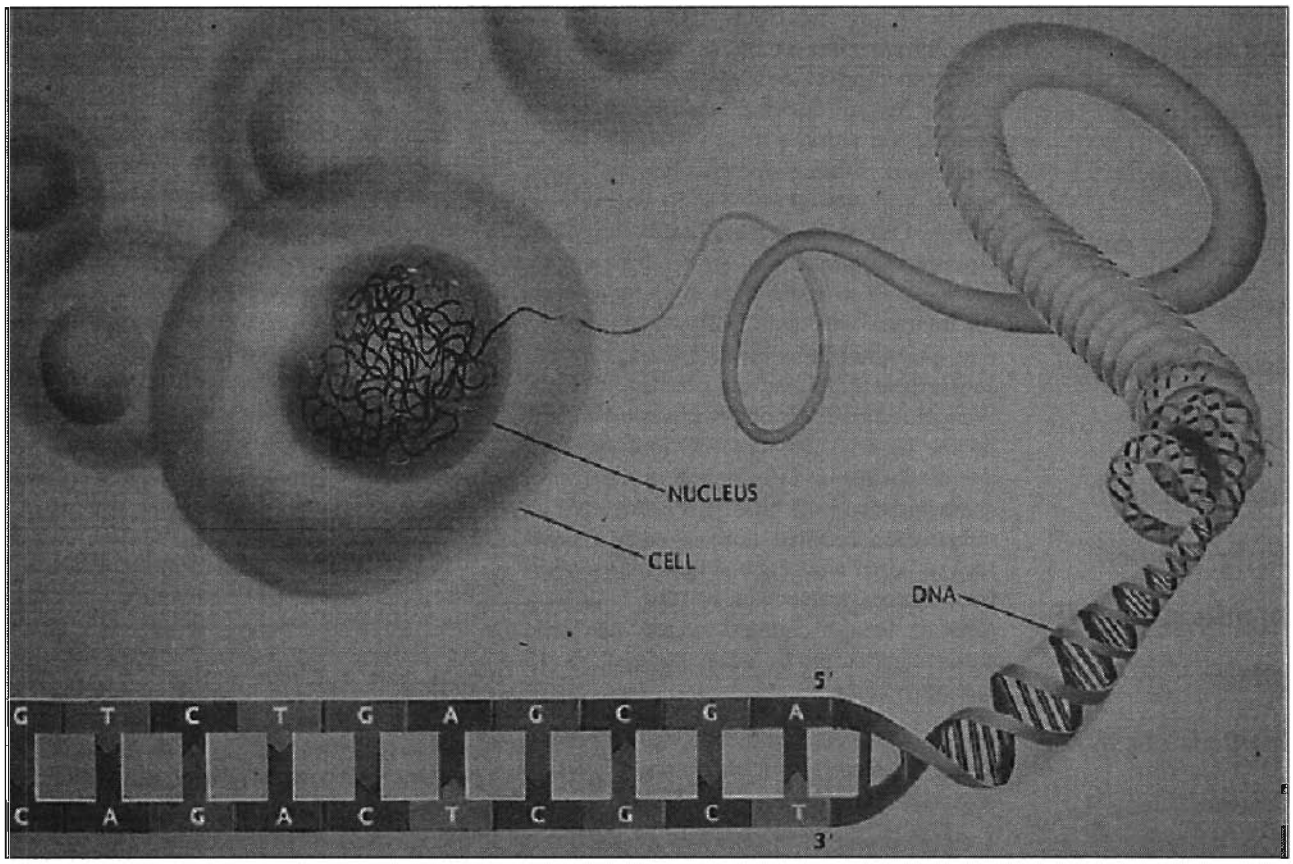


Figure 2. Double helix DNA is made up of base pair letters. The whole human genome consists of three billion of these base pairs all packaged inside of the cell's nucleus.

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billion of these base pairs all packaged inside the cell's nucleus (see Figure 2). While that is a huge number, it still seems surprising to me that it is a finite number. The three billion letters are able to direct all of the biological properties of a human being. Although there are a lot of biological properties in a human being, especially when you consider the complexities of development, yet this structure is sufficient.

The HGP aimed to read out all those letters and to develop techniques to enable us to understand what this language is all about—because otherwise it would all be gibberish. Thus while part of the success of the project has been reading out the letters, a major part has been developing other methods of understanding what's encoded within them.

We reached a significant milestone in 2001 with the publication in *Nature* of the longest paper it has ever published—over sixty pages of fine print, describing what we had learned with a first reading of a draft of the human genome sequence.[1] This was an exhilarating experience. I and about four dozen of my colleagues spent about six months doing almost nothing else but trying to figure out what we could learn from reading the human genome sequence. It is like reading the world's most incredible literature classic that no one else had ever read before, and getting to write the first critical review. Out of this we learned an incredible amount of things that were surprises! By the way, all of these data are available on the Internet. That availability of information was a cardinal principle of the international consortium that I had the privilege to lead. We wanted every bit of information released on the Internet. History will look back on the availability of information as a defining characteristic of the HGP. The release of this information enabled anyone with a good idea to begin working with the information immediately, rather than waiting for a long time or being required to put up large amounts of money in order to gain access to the information.

We discovered some pretty surprising things in reading out the human genome sequence. Here are four highlights.

1. *Humans have fewer genes than expected.*
My definition of a gene here—because different people use different terminology—is a stretch of DNA that codes for a particular protein. There are probably stretches of DNA that code for RNAs that do not go on to make proteins. That understanding is only now beginning to emerge and may be fairly complicated. But the standard definition of "a segment of DNA that codes for a protein" gives one a surprisingly small number of about 30,000 for the number of human genes. Considering that we've been talking about 100,000 genes for the last fifteen years (that's what most of the textbooks still say), this was a bit of a shock. In fact, some people took it quite personally. I think they were particularly distressed because the gene count for some other simpler organisms had been previously determined. After all, a roundworm has 19,000 genes, and mustard weed has 25,000 genes, and we only have 30,000? Does that seem fair? Even worse, when they decoded the genome of the rice, it looks as if rice has about 55,000 genes. So you need to have more respect for dinner tonight! What does that mean? Surely, an alien coming from outer space looking at a human being and looking at a rice plant would say the human being is biologically more complex. I don't think there's much doubt about that. So gene count must not be the whole story. So what is going on?

2. *Human genes make more proteins than those of other critters.*
One of the things going on is that we begin to realize that one gene does not just make one protein in humans and other mammals. On the average, it makes about three, using the phenomenon of alternative splicing to create proteins with different architectures. One is beginning to recover some sense of pride here in our genome, which was briefly under attack, because now we can say, "Well, we don't have very many genes but boy are they *clever* genes. Look what they can do!"

3. *The male mutation rate is twice that of females.*
We also discovered that simply by looking at the Y chromosome and comparing it to the rest of the genome—of course, the Y chromosome only passes from fathers to sons, so it only travels through males—you can get a fix on the mutation rate in males compared to females. This was not particularly good news for the boys in this project because it seems that we make mistakes about twice as often as the women do in passing our DNA to the next generation. That means, guys, we have

to take responsibility for the majority of genetic disease. It has to start somewhere; the majority of the time, it starts in us. If you are feeling depressed about that, let me also point out we can take credit for the majority of evolutionary progress, which after all is the same phenomenon.

4. *"Junk" DNA may not be junk after all.*
I have been troubled for a long time about the way in which we dismissed about 95% of the genome as being junk because we didn't know what its function was. We did not think it had one because we had not discovered one yet. I found it quite gratifying to discover that when you have the whole genome in front of you, it is pretty clear that a lot of the stuff we call "junk" has the fingerprints of being a DNA sequence that is actually doing something, at least, judging by the way evolution has treated it. So I think we should probably remove the term "junk" from the genome. At least most of it looks like it may very well have some kind of function.

Where do we go from this? In April 2003, which conveniently happened to be the fiftieth anniversary of Watson and Crick's DNA paper, we completed the whole human genome sequence. Talk about a milestone! The first draft was interesting but having the final sequence is of course the real point of the whole exercise.

For several years, we have been thinking about where to go next. Four areas of research are already under way and are going to expand considerably as we move into the next phase of genome research. These four areas are medical genomics, functional genomics, comparative genomics, and proteomics. Much work is now focused toward the medical applications and trying to make those happen. Although I do not have time to discuss each of these areas, proteomics is certainly a compelling opportunity that describes studying proteins on a global scale instead of one at a time just as we have been doing so successfully now for DNA and RNA in genomics. Functional genomics has many facets, for example, the use of DNA microarrays or DNA chips will give us the ability to understand how genes turn on or off as well as defining the pathways and networks that regulate gene expression.

Comparative genomics is both scientifically fascinating and highly relevant for the contentious discussions about evolution and faith. We have, in fact, not only sequenced the human genome; we also have sequenced a number of other organisms and a lot more are coming along very quickly. For instance, we now have a very advanced draft of the sequence of the laboratory mouse, the organism that is most extensively used by researchers in trying to understand human disease. Evolution tells us that humans and mice diverged about 80 million years ago. And yet, when you line up their sequences of the same homologous gene, you see very interesting evidences of similarity. Figure 3 is a complicated diagram showing this relationship. At the bottom is a schematic of part of chromosome 7 (CFTR is, by the way, is the gene for cystic fibrosis) but 500 kilobases away from that is a gene called CAPZA2 which is chosen at random. Across the top is a schematic of part of that CAPZA2 gene in the human. Each one of those funny looking symbols is one of these repetitive sequences. You need not concern yourself much about those; they are just different types of transposable elements and other types of repeats.

Now underneath there, what we are plotting is the similarity in the mouse homologue of this same region. How close is the sequence of the mouse to the human? Note that the scale goes from 50% to 100%. We are not bothering with things that are less conserved than that. So basically, this analysis allows you to look across and find a stretch where there is identity or close to identity over a stretch of 100 base pairs or so. Notice that each place there is an exon (numbered 2, 3, and 4), which is a protein encoding region

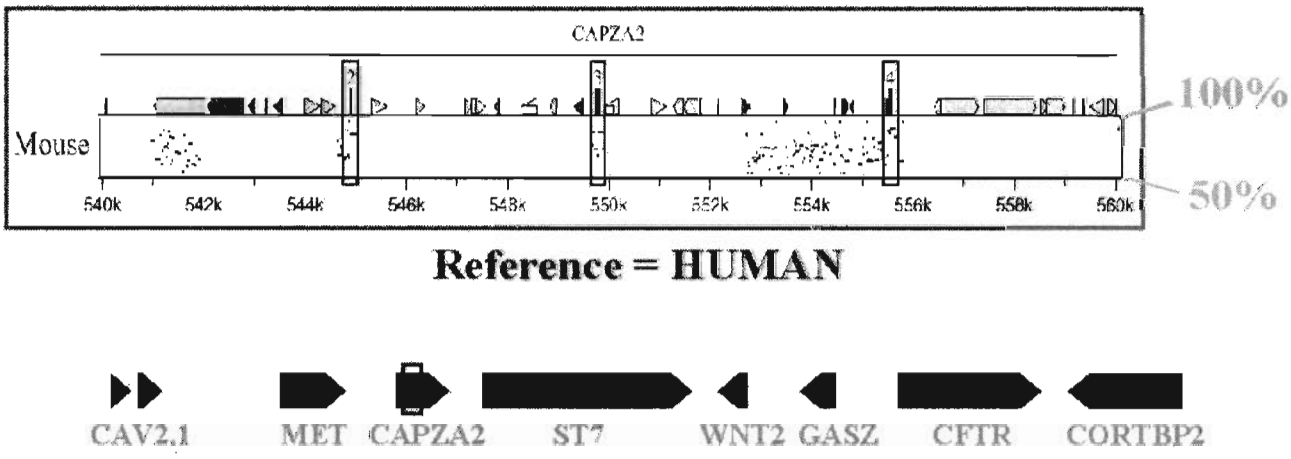

Figure 3 is a complicated diagram showing the relationship between humans and mice. At the bottom is a schematic of a small part of chromosome 7 (CFTR is, by the way, the gene for cystic fibrosis). About 500 kilobases away from that is a gene called CAPZA2. Across the top is a schematic of part of that gene in the human. The numbered boxes are the protein-coding exons.
Diagram courtesy of Dr. Eric Green.

Based on our current trajectory and on our understanding of the genome and its variations, we should be able to uncover the major contributing genes for common diseases in the next five to seven years.

of this gene, there is a little blip in the analysis that says the mouse region is strongly similar. Whereas in the introns, which lie between protein coding regions, there is less going on. But there are other interesting clouds of similarity that suggest maybe some other functional elements might be coding something important that we have not discovered yet. Certainly this kind of evidence is strongly in support of the evolutionary theory. I will come back to that in a bit.

It is not just a human/mouse comparison one can do. Eric Green at the Genome Institute has looked at this same region in many other species and, in fact, you can find this same CAPZA2 gene in everything from chimps down to zebra fishes and a lot of things in between (see Figure 4). Notice the pattern. The chimpanzee is almost 100% identical to the human, except the chimp has a deletion just before exon 2 that we do not have. Otherwise the match-up, as in most cases of human and chimp comparison, is about 98.5% to 99%. You can see that the baboon is starting to diverge. The cat and the dog and the cow all look a lot alike, and again if you look at the CAPZA2 exons, you will see that every one of those species has a nice conserved little segment there. But as you get further away to rats, mouse, chicken, two different kinds of pufferfish and then a zebra fish, about the only thing you see is the protein encoding regions, while the rest of the scattered noise goes away. Again, this is a very compelling kind of pattern in terms of what one would expect from evolution.

If you compare human and mouse regions where there are not close similarities, the matching is still above the statistical norm. One can identify lots of examples of transposable elements that are in the same place in the human and in the mouse, yet those transposers have been nonfunctional for more than 80 million years essentially as DNA fossils. It is very hard to see how that is *not* a very strong bit of evidence for a common ancestor for humans and mice.

In regards to medical genomics, I am going to make a prediction. Based on our current trajectory and on our understanding of the genome and its variations, we should be able to uncover the major contributing genes for common diseases in the next five to seven years. We have done really well finding the genes for diseases that are strongly inherited but we have not done so well for other conditions. That will change with the tools that the genome project has produced. Then the clinical implications will kick in. We will find the genes involved in susceptibility, those in turn will give us the ability to make predictions about who is at risk. For many of those conditions, a preventive medicine strategy of diet, lifestyle, and medical surveillance can be implemented to reduce risk.

Pharmacogenomics, another consequence of the HGP, is the ability to make a prediction about whether a particular drug is the right drug for you before you take it, or whether you are the one in one hundred people for whom the drug is going to give a side effect. Much of that variability in drug response is going to turn out to be DNA encoded. We are going to figure out how that works. So don't be surprised in five years if your physician will ask for a blood sample and do a DNA test before she writes the drug prescription. Ultimately, the goal of all this is to develop therapies that are more effective, with fewer side effects, then the often empirically derived therapies on which we now depend.

Therapeutics will be the ultimate medical payoff of our understanding of the genome—either as gene therapy or gene-based drug therapy. While gene therapy has gone through a pretty bumpy road over the course of the last three or four years, it is now looking more promising in at least a couple of conditions, mainly immune deficiencies and hemophilia.

My own view is that the greatest impact of this whole process is when genetic information is used to understand, at the most molecular level, the basic biological defect and then that information is used to develop a designer drug. One can already see that happening in a few instances, particularly for cancer. A most dramatic example is the drug Gleevec® (imatinib mesylate) that was recently approved by the FDA for leukemia. Gleevec's development resulted from this rational approach; as a drug, it puts almost all patients in remission with very few side effects.

That all sounds great. Where is it going to take us? Let me guess at that. If this all happens the way it is supposed to, by 2010, I think we will have an opportunity to individualize preventive medicine based on

DNA-based predictions of genetic risk. With available interventions for perhaps a dozen conditions to reduce the risk, that should be a really good thing. It will allow us to focus more of our energies on keeping people healthy instead of spending lots of money after people are already at death's door in the ICU, which seems to be largely what our medical care system is focused on at the moment.

Pharmacogenomics should be able to ensure that a drug is chosen appropriately for a patient, resulting in a reduction of adverse outcomes. However this raises some issues. Who is going to have access to this kind of new technology? Our current medical care system seems to turn a blind eye to those who do not have access. I see no evidence at the moment that that is changing. So will we be happy with an outcome where only those with financial resources and Ph.D.s have the ability to benefit from the new treatments? That should make all of us troubled. Will we solve the very vexing problem of genetic discrimination? Maybe you will find out that you are at risk for colon cancer, so you are the one who ought to have colonoscopy every year starting at age 45. However, suppose your health insurance agent says, "Well, you don't sound like a good risk any more. I am sorry, your policy has been canceled." That is happening right now. We need effective federal legislation to prevent that. There is major movement in that regard in the Senate, a little less in the House. The President of the United States has made public statements about the need for such legislation. This might be the year where it gets done. But the longer we go on without that protection, the more trouble we are going to be in.

Let's go another ten years. I think that by 2020 the therapeutic consequences of this revolution are going to be in full swing. We will have designer drugs available for diabetes, for Alzheimer's, for Parkinson's, for high blood pressure, and other conditions. You will probably get your entire genome sequenced, save it on a CD-ROM, and put it in your medical care record. That information could be incorporated into the decision making whether a particular drug is the right choice for you or what kind of preventive medicine strategy you should follow.

But there will be many debates about the ethical questions. What of the nonmedical uses of genetics? A paper in *Science* described a group from New Zealand who identi-

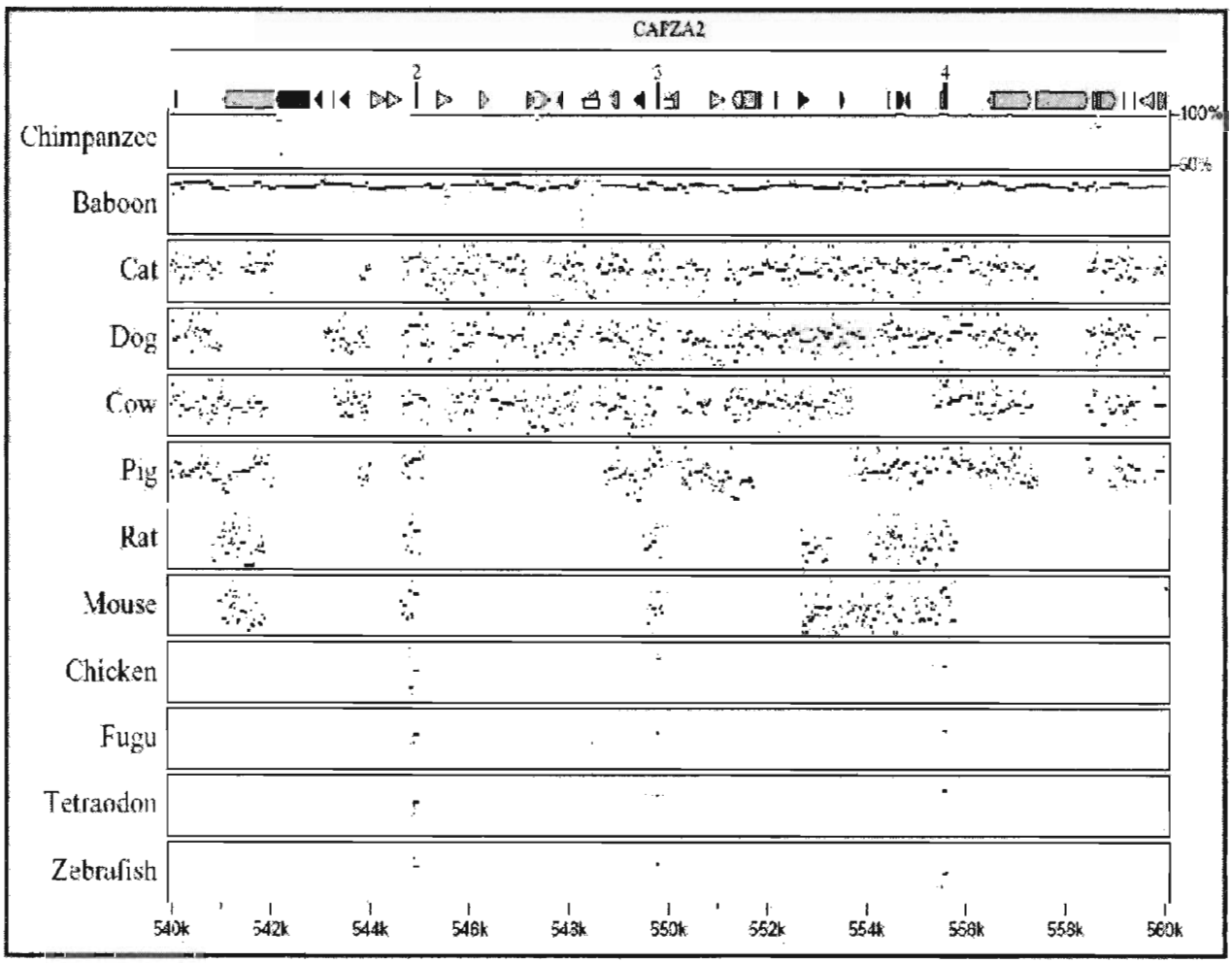

Figure 4. CAPZA2 gene in different species. *Diagram courtesy of Dr. Eric Green.*

A faith perspective is going to be needed more than ever. In fact, the bioethicists who debate these issues are all smart people, but many of them are not standing upon a foundation that has a solid sense of what is right and what is wrong. Christians are incredibly blessed to have that Rock upon which one can stand ...

fied a variant in a gene on the X chromosome that they claimed plays a major role in whether boys who are subjected to childhood abuse end up growing up to be criminals.[2] In their particular study, over 30% of those who had been subjected to childhood abuse and had this particular variant in the monoamine oxidase gene were convicted of criminal activities. This was a much higher risk than the abuse alone or the gene alone, but if you put the two together, then the risk goes way up. Can you imagine how that is going to get folded into our criminal justice system? Will that be a defense against criminal activity—"my genes made me do it," plus I had a bad childhood so I am not responsible? Or will this get used in a way to try to deny opportunities for those who have that high risk version of the monoamine oxidase gene because they might behave badly later on? These are serious issues lurking in the future—and not the very distant future.

A faith perspective is going to be needed more than ever. In fact, the bioethicists who debate these issues are all smart people, but many of them are not standing upon a foundation that has a solid sense of what is right and what is wrong. Christians are incredibly blessed to have that Rock upon which one can stand when you are trying to make a judgment about a complicated ethical issue. Certainly while that particular Rock makes some of our postmodern colleagues nervous, it should from our perspective put us in a special position to contribute to those debates in a highly meaningful way.

What is the Interface between Science and Faith?

I want to briefly turn to a question I have touched on a couple of times. Is there potential harmony between science and Christian faith? As ASA members and scientists who have a strong personal faith, how do we put these two things together? I will give you a bit of a personal view. After all, genetics is perceived by many as perhaps the area of science that is least compatible with faith. Regretfully a very polarized division separates the extremists: those who look at the science of the genome as a particularly dangerous way of misunderstanding God's providence, and those who by studying genetics have decided that there is no more need for God because they have discovered everything that matters in DNA.

Is this an irreconcilable conflict? Many of our colleagues seem to think so. But I do not have to tell you that this conflict does not make sense. Science explores the natural world. Faith explores the supernatural world. If I want to study genetics, I am going to use science. If I want to understand God's love, then that is where the faith world comes in. Does that make them separate and impossible to integrate into one person, one experience, one thought? Is Stephen Jay Gould right when he calls these "the non-overlapping magisteria"? No, from my perspective these two world views coexist in me, and in many of you, right now. We are not torn apart by that; we are not forced into contradictions. Rather, I believe that we are enriched and blessed. We have an opportunity to practice science as a form of worship. We have a chance to see God as the greatest scientist. As we discover things about the world, we can appreciate the wonders of God's creation. What a gift it is to be a scientist and be able to do that.

Why is the conflict then perceived to be so severe? Science and Christianity do not have a pretty history. Certainly conflicts tend to arise when science tries to comment on the supernatural—usually to say it does not exist—or when Christians attempt to read the Bible as a science textbook. Here I find it useful to recall that this is not a new debate, and I often refer back to the wisdom of St. Augustine. Augustine in 400 AD had no reason to be apologetic about Genesis, because Darwin had not come along. Augustine was blessed with the ability to look at Gen. 1:1 without having to fit it into some sort of scientific discovery of the day. Yet, if you read Augustine's interpretation of Gen. 1:1, it is a lot like mine. In fact, Augustine makes the point how dangerous it is for us to take the Bible and try to turn it into a science text. He wrote:

> It is a disgraceful and dangerous thing for an infidel [unbeliever] to hear a Christian, presumably giving the meaning of Holy Scripture, talking nonsense on these topics; and we should take all means to prevent such an embarrassing situation in which people show up vast ignorance in a Christian and laugh it to scorn ... If

> they find a Christian mistaken in a field which they themselves know well, and hear him maintaining his foolish opinions about our books [Scriptures], how are they going to believe those books in matters concerning the resurrection of the dead, the hope of eternal life and the kingdom of heaven, when they think their pages are full of falsehoods on facts which they themselves have learnt from experience and the light of reason?[3]

These are very strong and effective words. But the past century has not been a good one in terms of the polarization between the more evangelical wing of the church and the scientific community. We seem to be engaged in contentious, destructive, and wholly unnecessary debate about evolution and creation. From my perspective as a scientist working on the genome, the evidence in favor of evolution is overwhelming.

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What are the arguments in favor of evolution? Let me quickly describe two arguments. (1) The fossil record. Macroevolution has growing and compelling evidence to support it. Elephants, turtles, whales, birds often have been cited as species where transitional species have not been identified. That is no longer true. We have gained more in the fossil record in the last ten years than in almost the entire previous history of science. (2) The DNA evidence for evolution. I mentioned the ancient repeats we share with mice in the same location showing no conceivable evidence of function, diverging at a constant rate just as predicted by neutral evolution. One could only conclude that this is compelling evidence of a common ancestor or else that God has placed these functionless DNA fossils in the genome of all living organisms in order to test our faith. I do not find that second alternative very credible. After all God is the greatest scientist. Would he play this kind of game?

Arguments against macroevolution, based on so-called gaps in the fossil records, are also profoundly weakened by the much more detailed and digital information revealed from the study of genomes. Outside of a time machine, Darwin could hardly have imagined a more powerful data set than comparative genomics to confirm his theory.

So what are the objections then to evolution? Well, obviously, the major objection in many Christians' minds is that it is not consistent with Genesis. I find Gen. 1:1–2:4 powerful, but admittedly complex and at times difficult to understand with its seemingly two different versions of the creation of humans. Problematically, a literal translation of Gen. 1:1–2:4 brings one in direct conflict with the fundamental conclusions of geology, cosmology, and biology.

Professor Darrel Falk has recently pointed out that one should not take the view that young-earth creationism is simply tinkering around the edges of science. If the tenets of young earth creationism were true, basically all of the sciences of geology, cosmology, and biology would utterly collapse. It would be the same as saying 2 plus 2 is actually 5. The tragedy of young-earth creationism is that it takes a relatively recent and extreme view of Genesis, applies to it an unjustified scientific gloss, and then asks sincere and well-meaning seekers to swallow this whole, despite the massive discordance with decades of scientific evidence from multiple disciplines. Is it any wonder that many sadly turn away from faith concluding that they cannot believe in a God who asks for an abandonment of logic and reason? Again from Augustine:

> In matters that are obscure and far beyond our vision, even in such as we may find treated in Holy Scripture, different Interpretations are sometimes possible without prejudice to the faith we have received. In such a case, we should not rush in headlong and so firmly take our stand on one side that, if further progress in the search of truth justly undermines this position, we too fall with it.[4]

Again, written over 1600 years ago but right on target today!

What about Intelligent Design?

Here is an area where I think that probably some of you in the audience will disagree with me. The past ten years have seen the emergence of a new theory of how God has intervened in the development of living organisms. Intelligent Design proponents point to the complexity of multicomponent molecular machines as unlikely products of a random evolutionary process. The argument about irreducible complexity is an interesting one. And yet I must say, the more one looks at these supposedly complex and irreducibly complex structures (whether it is the flagella, the eye, or the clotting cascade), the more one begins to see some evidence of intermediate forms that could have had some selective advantage. While not offering strong evidence against Intelligent Design, the study of genomes offers absolutely no support either. In fact, I would say—and many others have said it better—a major problem with the Intelligent Design theory is its lack of a plan for experimental verification. I view Intelligent Design ideas as an intriguing set of proposals, but I certainly do not view them as the kind of threat to evolution that its most vocal proponents imply. Again, let us be careful of the "God-of-the-gaps" problem that Augustine was referring to. The disproof of an unnecessary theory like ID can shake

While not offering strong evidence against Intelligent Design, the study of genomes offers absolutely no support either. In fact, I would say – and many others have said it better – a major problem with the Intelligent Design theory is its lack of a plan for experimental verification.

the faith of those who are asked to equate their belief in God with their belief in the theory.

Another issue, however – one where I am very puzzled about what the answer will be – is the origin of life. Four billion years ago, the conditions on this planet were completely inhospitable to life as we know it; 3.85 billion years ago, life was teeming. That is a very short period – 150 million years – for the assembly of macromolecules into a self-replicating form. I think even the most bold and optimistic proposals for the origin of life fall well short of achieving any real probability for that kind of event having occurred. Is this where God entered? Is this how life got started? I am happy to accept that model, but it will not shake my faith if somebody comes up with a model that explains how that the first cells formed without divine intervention. Again, watch out for the God-of-the-gaps. However, I think it is noteworthy that this particular area of evolution, the earliest step, is still very much in disarray.

How Do We Put These World Views Together?

I arrived at my synthesis of this before I knew of the ASA and before I read some of the wonderful articles in its journal that advanced the view, which we generally call theistic evolution. God who is not limited in space or time, who created the universe, chose the remarkable mechanism of evolution to create plants and animals of all sorts. (By the way, notice in Genesis how plants appear before animals and fish before birds – which is precisely what science tells us.) Most importantly God chose this means in full knowledge that it would ultimately give rise to creatures with whom he could have fellowship and relationship, whom he would imbue with the moral law and a longing to seek him, to whom he would ultimately reach out to by himself becoming flesh and walking amongst us. Furthermore, as God is not limited by natural laws, he on occasion has performed miracles which science is unable to judge, since they fall outside the natural realm. Those miracles include many signs and wonders in Old Testament days. But most importantly to my Christian faith is the literal and historical resurrection of Jesus Christ from the dead, which is the absolute cornerstone of what I believe.

I find that synthesis completely satisfying. It brings together what I know about Christ from reading about him, from my prayer life, and what I know as a scientist about the natural world. Furthermore evolution is not a stumbling block in any way as long as one reads Genesis as Augustine did, and does not insist upon reading this as a science textbook.

Where We Are Going in the Future?

Let me finish with a quick glimpse of where we are going in the future as we contemplate our own instruction book and dream of what we might be able to do with that to alleviate suffering and to better the lot of humankind. There are a number of ethical issues that are raised by this. Is this a treasure chest or Pandora's box?

One message that this raises comes from Prov. 19:2: "It is not good to have zeal without knowledge." Some observers are getting pretty worked up about genetics and the dangers of it, but are worrying about the wrong things. As scientists we have a great obligation to explain ourselves, what our science is about, and what it can and cannot do. The time for a geneticist or in fact any scientist to go into the lab and close the door and let somebody else worry about the consequences of scientific advancement has passed.

Advances in genomics raise serious ethical issues, but offer potential solutions. (1) Genetic discrimination can be solved with effective policy implementation. (2) Unequal access to new advances needs to be addressed by a change in the U.S. health care system. (3) Genetics and race brings potential prejudices. We are learning that we are 99.9% identical at the DNA level. Most of our differences pre-existed in the founder population from which we are all descended. The notion that you can draw a precise boundary around any particular group and say, "They are different" is not supported by science. That understanding ought to be a very strong argument in the contentious debates about genetics and race, while also diminishing the opportunity for prejudice. (4) Genetic technology brings a major ques-

tion, "Where are we going to draw the boundaries between treating terrible diseases and enhancing character traits of the next generation?"

You have probably all seen "designer baby" scenarios presented on prime time TV or in Hollywood movies. Most of those are not very realistic, since the environment heavily influences the enhanced characteristics portrayed in those scenarios—intelligence, athletic ability, physical attractiveness, or musical talent. While genetics may change the odds a little bit, genetics alone is not going to determine the outcome. Thus the wealthy couple that decides to spend tens of thousands of dollars in taking advantage of an embryo selection program in order to have a son whose going to play first violin in the orchestra, score touchdowns for the football team, and get A+ in math is likely to experience a disappointing outcome, when their sixteen-year-old is up in his room listening to heavy metal music and smoking pot. Because the parents forgot that environment is important also, they are going to wonder, "What happened here?"

It may be our saving grace that while many of those enhancement scenarios are not stopped because of ethical concerns; they are stopped because they do not work. Meanwhile, we really do have to watch out for genetic determinism. I recently saw an article in the religious literature suggesting that spirituality might be in your genes and consequently the people who go to church are those who are somehow hard-wired to seek after God and those who lack those genes, do not. I do not think that idea is supported by the data!

Scientists who are Christians have a critical role to play in this genomic revolution both as scientists and as contributors to the ethical discussions. I hope the ASA and other organizations like it will step up to that challenge. In that regard, I would like to read another quotation written about one hundred years ago by the Princeton conservative theologian Benjamin Warfield. It is a wonderful exhortation to Christians; it could well be the motto of ASA.

> We must not then as Christians assume an attitude of antagonism toward the truths of reason or to the truths of philosophy or the truths of science or the truths of history or the truths of criticism. As children of the Light, we must be careful to keep ourselves open to every ray of light. Let us then cultivate an attitude of courage as over against the investigations of the day. None should be more zealous in them than we. None should be more quick to discern truth in every field, more hospitable to receive it, more loyal to follow it whithersoever it leads. It is not for Christians to be lukewarm in regard to the investigations and discoveries of the time. Rather, as followers of the Truth, indeed we can have no safety in science or in philosophy save in the arms of Truth. It is for us, therefore, as Christians to push investigation into the utmost, to be leaders in every science, to stand in the band of criticism, to be the first to catch in every field the voice of the Revealer of Truth who is also our Redeemer. All truth belongs to us as followers of Christ, the Truth. Let us at length enter into our inheritance.[5]

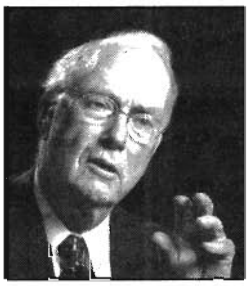
I think scientist-believers are the most fortunate. We have the opportunity to explore the natural world at a time in history where mysteries are being revealed almost on a daily basis. We have the opportunity to perceive the unraveling of those mysteries in a special perspective that is an uncovering of God's grandeur. This is a particularly wonderful form of worship. ✹

Notes

[1]"Initial sequencing and analysis of the human genome," *Nature* 409, no. 6822 (2001 Feb 15): 860–921.
[2]Avshalom Caspi, et al., "Role of Genotype in the Cycle of Violence in Maltreated Children," *Science* 297, no. 5582 (2002): 851.
[3]St. Augustine, *The Literal Meaning of Genesis*, Book 1, Chapter 19.
[4]St. Augustine, *The Literal Meaning of Genesis*, Book 1, chap. 18, in *Ancient Christian Writers* 41, translated and annotated by John Hammond Taylor, S.J. (New York: Paulist Press, 1982).
[5]Benjamin Warfield, *Selected Shorter Writings* (Phillipsburg, NJ: P & R Publishing, 1970), 463–5.

The Convergence of Science and Religion

Charles Townes



Science and religion are often viewed as necessarily separate aspects of our beliefs and understanding. But I see religion as an attempt to understand the purpose of our universe and science as an attempt to understand its nature and characteristics, so that the two are necessarily closely related. The so-called anthropic principle for the physical constants and recent discoveries in cosmology such as the "Big Bang" are at least suggestive of such a relationship. We furthermore try to understand each of these fields with all our human resources: intuition, observations, logic, and esthetics, with science and religion having different emphasis on these resources yet nevertheless using all of them. Science has undergone revolutions in the post, which have rather completely changed our views, and yet science of the past has often maintained an important validity. It still faces many inconsistencies, and we must be open to new changes with deeper understanding and yet the continued validity of present science as an approximate model. Can we expect similar changes and deepening of our human understanding of religion? I discuss the parallelism and increasingly strong interaction of science and religion, which I visualize, along with the possibility of their ultimately merging into a more unified understanding of both the purpose and the nature of our universe.

"I see religion as an attempt to understand the purpose of our universe and science as an attempt to understand its nature and characteristics."

First, let me try to define what we generally mean by the two words "science" and "religion." I believe we can say that science is the attempt to understand the structure of our universe and how it works—including ourselves, being part of this universe. Religion is an attempt to try to understand the meaning and purpose of this universe—including our own lives. One might of course, even ask whether there is any meaning or purpose? And, if so, what is it? If there is a meaning or purpose, this must very much affect the nature of the universe.

Science and religion have interacted over many generations, at times very strongly. Sometimes they have agreed; sometimes they clashed. In the early days, outstanding religious leaders were often also society's best philosophers and scientific scholars. Notable clashes between science and religion have grown, however, in western civilization during the last two or three centuries as science has developed rapidly. One of these clashes occurred as a result of the development of deterministic science, involving scientific laws which it was assumed could in principle predict all subsequent events and leave no room for divine action. Another clash occurred over Darwin's evolutionary ideas, pitting creation against mere chance development. To some, these scientific developments appeared to destroy human ideas about the beauty and sacredness of our world. For example, in 1798, William Wordsworth wrote the poem, "The Tables Turned," which contains the following lines:

> *Sweet is the lore which Nature brings;*
> *Our meddling intellect*
> *Mis-shapes the beauteous forms of things:—*
> *We murder to dissect.*

Charles Townes, *a member of the National Academy of Sciences, received the Nobel Prize for Physics in 1964 for his work in quantum electonics. He is the inventor of the maser, a device which amplifies microwaves, and co-inventor of the laser which amplifies visible light. During World War II, Townes helped develop radar bombing systems at Bell Laboratories. After the war, he joined the faculty of Columbia University, where he had the idea leading to the maser. Then, following a brief appointment as vice president of the Institute for Defense Analysis (Washington, DC), Dr. Townes became provost and professor of physics at Massachusetts Institute of Technology. Since 1967, he has been professor at the University of California (Berkeley). Charles serves on the advisory board for the ASA; he is an avid diver and enjoys snorkeling in the Bahamas.*

This is an edited transcription of the presentation given Aug. 2, 2002, at the ASA Annual Meeting at Pepperdine University, Malibu, California.

Scientific ideas do sometimes appear to make mundane the real beauty of our world. On the other hand, there is another view expressed by Alexander Pope in 1732, when he wrote ("An Essay on Man," Epistle 1):

He who through vast immensity can pierce,
See worlds on worlds compose one universe,
Observe how system into system runs,
What other planets circle other suns,
What varied beings people every star,
May tell why heaven has made us as we are.

Astronomy has indeed on occasion elevated our thoughts and inspired religious thinking.

Science of the nineteenth century did seem in some ways to be quite inconsistent with religious thinking. Determinism was contrary to religious views and determinism seemed a very firm part of science at that time. Evolution led to the view that the creation of life, and humans, was simply a natural accident.

Parallels in Science and Religion

My own view is that how the universe is constructed and how it works, which is the scientific question, must be related to its purpose, the religious question. Furthermore, I think there is a very general similarity between science and religion which is usually not overtly recognized. This comes about in part because we humans want to try to understand, and we use all our human resources and available methods in the understanding of both religion and science. Even though we have the impression that science uses experimentation but religion does not, and we might think religion uses faith but science does not, such impressions are not realistic. Actually, science depends inherently on faith. We do not generally talk about faith in science, but rather we talk about postulates. For example, if you drop a pencil, it will fall at a particular rate. We generate physical laws that predict this will always happen. But in fact, we do not know for sure that it will do exactly the same tomorrow. We assume it will from our faith in or our postulate of the constancy of scientific laws.

Gödel provided a theorem that shows mathematically how faith is necessary in science. His theorem considers the case where to prove something we make a certain set of postulates, then we accept normal mathematical logic and use that logic to deduce things from the postulates. But Gödel proved that we can never be sure that the postulates are even self-consistent.

Einstein had a faith that the laws of gravity and the laws of electricity, magnetism, and radiation could be united. He worked on that for twenty years at least during the latter part of his life. Although he never succeeded, his devotion of twenty years working at this task represented strong faith and commitment.

What about experiments? In religious thinking we are likely to recognize the importance of observations, which are quite parallel to experimentation. Astronomy is in fact usually not like our concept of laboratory experimentation but rather it primarily involves observation. In religion we observe how people behave. What makes a wonderful person? What makes life meaningful and happy?

Science depends inherently on faith. We do not generally talk about faith in science, but rather we talk about postulates.

Then there is intuition. We probably do not realize how frequently scientists use intuition. Often scientists think, "Well, this is the way it really ought to be." When it was discovered that light was wave-like, since known waves moved along on something like the ocean surface or a string, scientists thought there must be something throughout the university which they called the ether and that light was a wave on that ether. People worked and worked trying to discover ether. The Michaelson-Morley experiment was such an attempt, which showed that actually there could not be anything like what had been intuitively thought to exist.

There is the intuition that the universe has always been the same. Why? Because how can anything start from nothing? The universe always seems to us to be the same now, and it presumably has always been the same. It could not have had a beginning. That idea also seems to have been wrong. We now know that there was a unique moment in the past when the universe started from something immeasurably small and it has been growing ever since. We have used and continue to use our intuition in science, and we use it in religion.

And there is revelation. One wonderful story that I always enjoy is of Auguste Kékulé the chemist, who tried hard to figure out how molecule benzene could be shaped. Kékulé kept thinking about it, and as he sat by the fireplace one night in 1866, he dreamed that he saw a snake, which coiled around and took its tail in its mouth. Suddenly he could recognize the answer, "That's it! It's a circle!"

I could say the same thing about the maser and the laser. I tried very hard to find new ways of producing radiation, other than by electronic vacuum tubes. I wanted to produce very short wavelengths, which standard techniques could not do. I worked on it for several years. One morning early I sat in a park, wondering, "Why haven't

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I been able to do this? There must be a way." Suddenly I had the idea! And out of it grew the maser and the laser. Where did that idea come from? Inspiration, or revelation if you like.

Think even of Christ. After wandering forty days in the wilderness, undoubtedly thinking over what the future might be, he came out of there knowing what to do.

Consider aesthetics. Many scientists say, "This equation is beautiful! It must be right!" In his classic poem, "Ode on a Grecian Urn," John Keats wrote: "Beauty is truth, and truth beauty." In science there is the same feeling.

Both science and religion are human understandings, and as a result they can change. Determinism was very firmly believed by scientists in the nineteenth century, but then came quantum mechanics. New science was generated.

What about logic and reason? Science tries very hard to use logic and reason. We try to use all our human abilities and these are important ones. The same thing is true in religion. We observe how people behave. We think about how we feel. We read the Bible and think about how people behaved in the past, and we apply our reason and logic to these observations.

Both science and religion are human understandings, and as a result they can change. Determinism was very firmly believed by scientists in the nineteenth century, but then came quantum mechanics. New science was generated. Quantum mechanics says: "Particles are not just particles but they have associated waves. Atoms behave like waves in many cases. A thing is not a particle or a wave; it's a combination." The uncertainty principle, which results from quantum mechanics, says: "We cannot precisely determine position and motion at the same time." We now recognize that this uncertainty means the future is not predictable. With such a change in our philosophy and thinking, determinism disappeared. As quantum mechanics and the lack of determinism were beginning to be understood, many scientists were puzzled. Albert Einstein himself frequently is quoted as having said: "God doesn't play dice."

Relativity has also now convinced us that there is no fixed thing in this universe. You cannot say, "The earth is going around the sun and the sun is not going around the earth." It's just convenient to say, "The earth is going around the sun," because it makes a rather simple picture. But it is equally correct in principle to say the sun goes around the earth. We no longer believe that any point in the universe is absolutely fixed. Relativity changed all that.

Then there's the "Big Bang." We now know there was a unique moment when everything was very small. We could call it the moment of creation. Many excellent scientists have fought this position very hard, believing that there could not have been any such unique moment. But now almost all are convinced.

Dark energy is also changing our views. Apparently, the expansion of the universe is speeding up. Physicists generally attribute this to a new cosmological force, associated with "dark energy." But perhaps it is because the force of gravity is changing a bit. We are always working with postulates, and must not think that we understand it all.

Intelligent Planning and the Anthropic Principle

A general feeling that's been growing rather rapidly in the last few decades is the idea of intelligent planning. As we understand our universe more and more, we recognize it is very special. That bears on one of the basic differences between science and religion. Religion has generally taken the position that there is something very special about us as humans and about our universe. We are God's creation, especially made. Scientists frequently say, "No, it's all accidental; there's nothing special about us." However, it has become increasingly clear that we are here only because the laws of physics have certain particular values. Here are some of the things that may be associated with intelligent planning of our universe.

- The sun's intensity is very constant—lucky for us! The earth is at the right distance from the sun to provide the temperatures needed for life. The large moon encircling the earth protects us from comets. These things could, in fact, just be happy accidents, because there are billions of stars in our galaxy and there are billions of galaxies. So, while many stars and planets are unsuitable for life, even a small fraction could allow a number of sources for life, and many scientists believe there are many stars supporting life in our universe. This may be true, even though the probability for any sin-

gle one is relatively small, perhaps as is the probability for the initiation of life.

- Assuming a suitable star and planet, what is the probability that life can form? If indeed it is a random process of molecules coming together in just the right way, the probability is very small. I have made a rough calculation, assuming about thirty amino acids must come together accidentally in just the right way. This seems likely a minimum number in order for self-replicating life to form. If we assume the whole earth is covered with a layer three feet thick of miscellaneous amino acids, it would take approximately 10 to 20 billion years for the right combination to accidentally come together, so the probability of such accidental formation of life is small. Perhaps there are special molecular forces that tend to favor the molecules assembling in a particular way, which would increase the probability of life formation—another possible aspect of intelligent planning.
- That our sun, or any star, can be such a constant source of energy for so long is hardly an accident. The properties of nuclear reaction and gravitation must be just right. Nuclear reactions must take place to provide the sun's energy, but if they are too abundant the sun would expand and blow-up—as many stars do, particularly the very old stars. If gravity were a little too strong, the sun could also be unstable. The laws of physics need to be carefully balanced.
- For the approximately one hundred different chemical elements we have on earth to be here, in particular for the important elements carbon and oxygen to exist, the electrical and nuclear forces must be just right and balanced. Fred Hoyle, who discovered how carbon and oxygen could be formed by nuclear processes within stars, was much impressed. Although he was something of a religious skeptic, Hoyle wrote in the Caltech alumni journal:

  > Some super-calculating intellect must have designed the properties of the carbon atom. ... A common sense interpretation of the facts suggests that some super-intellect has monkeyed with physics ... the facts seem to me so overwhelming as to put this conclusion almost beyond question.

Many scientists now recognize that indeed we and our universe are quite special. The only way we can see to avoid the idea of intelligent planning is that there may be a very large, almost infinite, number of universes, each with its own characteristics and physical laws, and of course life began in one which had just the right characteristics. There are some problems however, with such a postulate. One is that we do not know why or how the physical laws should vary randomly from one universe to another. Another is that we know of no way in which we can detect the existence of these multiple universes. It is essentially a postulate, which cannot be clearly tested and hence is not normal science.

Intelligent planning of the universe and human life still leaves plenty of problems with our present understanding. We do not see any way in which God can now intervene in our universe, as is assumed by a religious view. Quantum mechanics introduced uncertainty, so that our lives are not completely deterministic. However, experimental tests of what is known as Bell's principle seems to show that there can be no unknown force which intervenes and determines what happens. This appears to prove that there is no room for divine action.

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Present science also seems to say there is no way we can have free will. Even though an individual's future is not completely determined by physical laws according to the uncertainly principle, whatever happens is only a matter of his or her past make-up, and the random choice of quantum mechanics. Some theologians postulate that this problem is solved by "emergence." If we put together a system of atoms, we can see crystals and other complex structures emerging. The postulate is that somehow free will similarly emerges out of complexity. However, this would be contrary to our present idea of the characteristics of atoms—they can perhaps produce surprising results, but none that contradict their own properties. So while science says we do not have free will, I do not know any scientist that does not think he or she has *some* free will and can make choices.

What is consciousness? Nobody can really define a conscious being. One scientist friend of mine says "a conscious being is one that has purpose, can sense the world around it, and can take action in accordance with what it senses." To me, this sounds like a mousetrap must be considered a conscious being. We have trouble with this concept.

Science is fantastically successful at some things, but there are other things that we do not understand. Zero point fluctuations are an example. Quantum mechanics seems to be remarkable successful, but it predicts a very large amount of radiation energy throughout the universe, which is normally undetectable, but which should give our universe a very large energy density and a large expansionary force. We seem to have evidence that these

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are not present. The problem is simply set aside for the present because in so many other respects quantum mechanical predictions are remarkably correct. Another problem is that gravitational theory and quantum mechanics appear to be inconsistent, yet we accept both. Still another is that most of the matter in the universe appears to be "dark matter," that is, matter we cannot detect and cannot identify. Then there is the Higgs particle. Present theory says this particle must exist, but it has not yet been detected in spite of many tries. Some are beginning to think that perhaps it does not really exist.

In science we continue to recognize inconsistencies and to discover new laws, some of which revolutionize our conceptions. However, those things we have previously tested and thought correct are often still useful. Consider Newton's laws for particle motion and the resulting determinism. In principle, quantum mechanics has revolutionized our view and shown these ideas were not correct. Nevertheless, we still teach Newton's mechanics as part of physics. It is an excellent approximation for large objects and we use it widely. Our views have changed, but the old ideas are still useful. They both served and continue to serve good purposes. We should expect that, if our understanding of the religious aspects of life and our world improve, our views may well change. But at the same time, present ideas may be good and useful approximations. Thus, as in science, our religious ideas cannot be expected to be completely correct; we must not be hesitant to try to advance our religious understanding and even somewhat change our outlook.

Summary

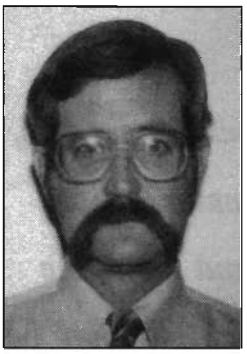
In science and in religion, we use all our human abilities to understand—faith or postulate; experiments or observations, intuition, revelation, esthetics; and logic or reason. Furthermore, things we understand about science, or how the universe works, may well shed light on its purpose. Recent discoveries in cosmology and in quantum mechanics are interesting not only to scientists, but also to philosophers and theologists, and are bringing the thoughts of all these into healthy interaction.

Recognizing that there are many aspects of science as well as religion that we do not understand, that there are inconsistencies within science as well as between science and religion, and that we have no absolute proofs in science or in religion, what kind of position can we take? I believe it important to use all our human gifts and powers to understand as well as we can, to make decisions on what we conclude and believe is mostly likely correct, and then act firmly and with faith on these, our best conclusions. As we study more, we will find out more, and I believe science and religion will come increasingly closer together. ✹

Mathematics and Metaphysics

Ben M. Carter

In this paper, I argue that metaphysics, logic, and mathematics, as systematic investigations into the nature of order and knowledge, have much in common, and that mathematics as the way science quantifies data can be the vehicle science uses to investigate ultimate questions. Then referring to the work of George Lakoff and Rafael Núñez, I ask whether mathematics expresses something innate in the universe or something innate to the structure of the human brain. In raising this question, I argue that if the universe itself is mathematical, then dualism is affirmed and materialism falsified. However, if mathematics only expresses the cognitive structure of the human brain, as Lakoff and Núñez maintain, then it is compromised as a reliable guide for understanding the ultimate nature of the cosmos. In the later case, it follows that science will be unable to address metaphysical questions in any compelling way.



Physicist Brad Keister has observed that while the Reformers made significant contributions to the development of the scientific method, secularists have appropriated that method as their own in their struggle against a religious world view. Therefore, he argues, it is incumbent upon secularists to construct a world view which is not only consistent but "allows for a system of inquiry based on rational thought."[1]

Secularism, because it rejects transcendent reality in favor of an immanent one, adopts de facto a materialistic world view. In this paper I wish to examine one of the significant problems a thoroughgoing materialist would confront in constructing a world view that is both consistent and allows for rational inquiry. The problem is this: as a philosophical theory, materialism regards all phenomena in the universe, including those of mind, to be composed solely of matter in motion.[2] However, to quantify its observations and generalize about such matter in motion, science employs reason and more specifically mathematics. To compel assent, reason and mathematics must be universal, but the universality of both is precisely what materialism undermines.

The Question of Order

Metaphysics, logic, and mathematics are all investigations into the nature of order and the principles of knowledge.

Metaphysics involves the exploration of the ultimate tenets of knowledge, the ultimate causes of existence and change, and the principles of order that determine the interrelations of the universe.

Logic is the science that investigates the principles of correct (deductive) or reasonable (inductive) inference.

Mathematics is the systematic investigation of magnitude, the relationships between figures and forms, and the relationships between quantities expressed symbolically.

A mathematical formula displays in symbolic form a relationship whereby the value of one variable can be found from one or several other variables. Many mathematical theorems are exhibited as formulas, and many scientific conclusions are embodied in mathematical formulas as well. Thus the use of mathematics in science supposes that at some basic level, the material cosmos operates according to mathematical principles.

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In metaphysics, mathematics, and logic, the axioms must be true within the system employed, that is, they must be at a minimum non-contradictory, otherwise the conclusions based on those axioms will not be compelling.

matical, has a strong metaphysical component. Both mathematics and logic are problem-solving systems and may be used to unravel issues that appear in either physics or metaphysics.

In metaphysics, mathematics, and logic, the axioms must be true within the system employed, that is, at a minimum, they must be noncontradictory, otherwise the conclusions based on those axioms will not be compelling. Ideally, once the premises are granted or established, the argument that follows must be necessarily true providing no errors are made as one unfolds the argument. Hence the truths of metaphysics, mathematics, and logic are system-dependent truths. However, there is this important difference: while metaphysics purports to be about the universe, mathematics and logic do not. Both are constructs of pure abstraction. Mathematics, like pure reason, gives no set of data preference. When doing pure mathematics, a mathematician does not profess to say anything about physical reality. Mathematics is instead an exploration of relationships between concepts. Thus mathematics and pure reason are not dependent on the universe in whatever form it might take.[3]

The universe is a contingent reality. It unfolds in an orderly way (thus meaningful generalizations can be made about it), but the particular forms it assumes cannot be fully grasped apart from their history. The universe is as it is, but within certain limits it might have been different. We have discovered that the universe is far more complex than we initially supposed, but we also have discovered that the principles underlying that complexity seem to be fairly simple. Modern empirical science, to study the complexities of the universe, attempts to reduce them to modules that it can investigate piecemeal in an effort to determine the simple principles underlying the selected phenomenon. In this investigation, mathematics has become increasingly important.

Mathematical models do not provide complete descriptions of natural phenomena. Rather they are attempts to establish the boundary conditions of phenomena.[4] In doing this, mathematics forces us to make our assumptions explicit and allows us via calculations to extrapolate those assumptions beyond our immediate perceptions.[5] Thus mathematics, because it allows us to explore relationships between conceptualized quantities even if they can be expressed only symbolically, enables us to model phenomena that exist beyond our everyday experience.[6] This process can seem very mechanical as the psychologist Thomas Gilovich points out. He observes that to protect a researcher from manipulating the meaning of data, the scientific method is designed to make the researcher "rigid and 'unintelligent,'" and he writes: "As scientists we willingly sacrifice some 'intelligence' and flexibility for the benefit of objectivity."[7] In this way, mathematics allows science to draw conclusions that, while they may be counter-intuitive, are quite reasonable given the data, the automatic nature of the calculations, and the assumptions made while establishing the data's boundary conditions. Hence, if the principles of mathematics are not necessarily true, then its use as an investigative tool is severely compromised.

There are two key points I wish to make here. First, like metaphysics, science is interested in the principles of order that determine the interrelationships of the universe, but insofar as science relies on empiricism, it is unable to plumb ultimate causes. As a conceptual tool, mathematics helps science move toward more ultimate explanations, that is, mathematics can enable science to address metaphysical concerns. We see this happening as scientific findings are applied to questions of origin (e.g., whence the universe, whence life, whence ethics) or the nature of existence itself.

Second, mathematics and logic, precisely because they deal in necessary truths, suggest that reality cannot be reduced to the physical since the physical exists contingently. John Barrow describes this in another way, as mathematics being bigger than physical reality,[8] since "mathematical existence allows anything to 'exist,'"[9] but what is logically possible need not exist physically.[10] Thus, attempts to use mathematics and logic to explain the physical mean that science, because it assumes a necessary/contingent dichotomy, implicitly models reality in a dualistic way. We see then that pure materialism cannot provide a rational account of the universe, and, insofar as it tries, it is self-refuting.

The Problem of the Particular

Within a pluralistic framework, being or existence is expressed in many particular and distinct ways, that is, things exist within limits and each limited thing's existence is not necessarily identical with any other limited thing's existence. Rather the essence of each thing, if a thing can properly be considered to have an essence, is defined by its limitations. Its essence is the limiting principle of both a limited thing's being and accidents. Our universe with its quasars, wasps, planets, tobacco smoke, and chocolate would seem to constitute a pluralistic framework. Given such a framework, an obvious question occurs to philosophers: how does one attain to certain knowledge of a thing within that environment?

To resolve that problem, Plato (427–347 BC) proposed that the universe was created as an immaterial formal realm interfaced with a material chaotic one. When Plato introduced the idea of Forms, he was not trying to address ontological concerns as much as epistemological ones. The question that concerned him was how he knew a thing is what it is. Plato also recognized that without the ability to generalize, knowledge would be reduced to a mere catalogue of particulars. The idea that a formal realm gave coherence to a disorderly chaos of particulars was his solution to the problem. His proposal meant not only that he could give an account of identity, it also meant that he could justify generalizations. In this elucidation of identity and generalization, Plato created a viable theory of knowledge.

In Chapter 26 of his *Republic*, Plato emphasizes the eternal character of mathematical objects and describes geometry as the study of the eternally existent. He includes both geometry and solid geometry among the five sciences that turn the soul's eye from the material world to objects of pure thought. Certain elements of geometry had been mastered by the Egyptians and Babylonians, and Pythagoras (c 582–c 500 BC) did much to advance the subject. Alfred North Whitehead in *Science and the Modern World* remarked that "the generality of mathematics is the most complete generality consistent with the community of occasions which constitutes our metaphysical situation."[11] As such mathematics describes general conditions that transcend any set of particular entities, and it is these absolutely general conditions that concern logic.[12] Whitehead went on to argue that abstract logic "is nothing else than the exhibition of the whole pattern of general conditions involved in the pattern derived from [one's] selected postulates."[13] And this, Whitehead argued, meant that the harmony exhibited by logical reasoning is established as a general aesthetic in the prevailing conditions that comprise any specific event.[14] Whitehead credited Pythagoras as the first person "who had any grasp of the full sweep of this general principle."[15]

Plato was one of those philosophers who built on the work of Pythagoras as did Plato's most famous student Aristotle. Around 300 BC, Euclid, a geometrician who lived in Alexandria, published his *Elements*, a systematic arrangement of the geometry of his day based on postulates that held true in ordinary three-dimensional space. Thus Plato's realm of Forms was given extensive rigorous definition and geometry's meta-physical dimensions were secured.

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The metaphysical side of reason and mathematics was made even more explicit when the neo-Platonists identified reason with the universal *logos*, and Christians incorporated that concept into the person of Christ. Mathematics and reason became a window into the mind of the Christian God. Galileo Galilei, voicing a perspective that spanned the mid-sixteenth to the mid-seventeenth century, is very categorical in his assessment here. Believing that, in certain areas, the human intellect was capable of a level of knowledge that was on a par with the divine, he wrote:

> I say that the human intellect understands some things so perfectly and it has such absolute certainty of them that it equals nature's own understanding of them; those things include the pure mathematical sciences, that is, geometry and arithmetic about which the divine intellect knows infinitely more propositions since it knows them all, but of those few understood by the human intellect I believe that its knowledge equals divine knowledge in its objective certainty.[16]

Mathematics, according to Galileo, symbolically expressed the conceptual framework of the universe and did so in a way that was necessarily true via a process that was necessarily reliable.

In urging science to abandon the idea of Formal reality, Francis Bacon undermined Plato's achievement and reintroduced the epistemological dilemma Plato had resolved. However, by measuring and quantifying, and by employing the automatic processes of mathematics and reason, science allowed for meaningful generalizations and in effect retained formal reality. In its systematic investiga-

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tion of magnitude expressed in science's concern for accurate mensuration, mathematics resolved the problem of identity. In its systematic investigation of relationships, mathematics resolved the problem of generalization. In modern empirical science, mathematics in effect took the place of Plato's Forms.

This should not be surprising. As the historian of myth Giorgio de Santillana has pointed out, science has its origins in the myth of invariance,[17] an invariance willed by God and accessible through God's mathematics. "[W]e have," he claims, "been living in the age of Astronomical Myth until yesterday."[18] Indeed, many mathematicians from Pythagoras to Georg Cantor (1848–1918) believed the mathematical exploration of infinity had theological significance and saw in such research a way to harmonize mathematics and religion.[19]

To reprise, mathematics as described above seems to imply a dualistic cosmos since it assumes the reality of mathematical integrity, an integrity that is undistorted by any configuration or expression of the material domain. The material, though structured by mathematics, cannot impact it. Mathematics must remain inviolable since its value as a means of attaining to the truth rests upon its inviolability. This classic vision of mathematics recapitulates the sacred and profane partitioning of reality with mathematics assuming the sacred role. Mathematics in such a scenario, while accessible to the human brain, is, as Galileo believed, firmly situated in the mind of God. But even if there is no God, mathematics must remain distinct from the world if it is to be useful because it provides an absolute standard against which mundane phenomena are quantified. If mathematics itself is simply another mundane phenomena, it loses its modeling value. Thus whether God does or does not exist, mathematics in this classical formulation implies dualism.

If, however, we assume that our perceptions are fundamentally conceptual in nature, as neurobiological research suggests they are, and if we assume that mathematics is fundamentally conceptual in nature, then might not the interfacing of these two orders of concepts create an illusion so powerful that we would not be able to escape from it and might not even be aware that it is an illusion save when it generates apparent contradictions in (what would seem to us to be) extreme circumstances? To put the question another way: what if mathematics itself were embodied in the structures of the human brain but not expressed in any fundamental way in the cosmos? What if mathematics, like other forms of human reasoning since Kant, might have only limited abstractive value? And if the materialist is right, what grounds would the materialist have for asserting that mathematics enjoys a privileged position in the acquisition of knowledge?

In *Where Mathematics Comes From*, George Lakoff and Rafael Núñez make such an argument. They seek to launch the discipline of mathematical idea analysis from a cognitive perspective.[20] They are concerned with how the cognitive superstructure of a nexus of mathematical ideas is constructed,[21] and ask where mathematical ideas come from and whether they can be analyzed from a cognitive perspective.[22] They aspire to tell the reader what human mathematics, conceptualized via the human brain and mind, is like.[23] The book is not concerned just with what is true, but also with the nature of mathematical truth: what mathematical ideas mean, how they can be understood, and why they are true.[24] As such, the authors seem to have embarked on an intellectual voyage not unlike Foucault's attempt to exhume the archeology of knowledge. They ask the central question: "What is the cognitive structure of sophisticated mathematical ideas?"[25] The book is not about conscious, goal-oriented mathematical cognition, but about mathematical cognition of an automatic, unconscious sort.[26] The authors seek to explore how the general cognitive mechanisms used in everyday nonmathematical thought can create mathematical understanding and structure mathematical ideas.[27] Because the human conceptual system is known to use metaphors, much of the book is concerned with metaphor.[28]

Lakoff and Núñez try to make the case that human mathematical reasoning works in the way that other human abstract reasoning works: via sensory-motor grounding and metaphorical projection.[29] The point is not the mathematical analysis of mathematical concepts but the cognitive or conceptual

analysis of mathematical concepts.[30] They want to understand how mathematical ideas are conceptualized via metaphor and to give an account in terms of human cognition of the ideas the metaphors are meant to express.[31] They argue that their theory of "embodied mathematics" describes what mathematics really is.[32] Since they believe that mathematical ideas have a precise structure that can be discovered and explored, they have written *Where Mathematics Comes From* as a first step in that process of discovery and exploration.[33] Thus they are addressing mathematics from the perspective of conceptualist/structuralist philosophy.

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Lakoff and Núñez argue that mathematics is a human creation and that any mathematics we can know is limited and structured by the human brain and human mental capacities. Therefore all of our mathematics is human mathematics and as such must be brain- and mind-based mathematics.[34] Ideas can be created only by, and instantiated only in, brains [there is an assumed identity between mind and brain].[35] Mathematics does not exist objectively apart from the mind [brain].[36] It is not *mind-free*; instead mathematics are grounded upon a conceptual, mind-based substructure.[37] The human brain is not a general purpose device. Human concepts, including mathematical concepts, are highly structured and limited because of the structure of the brain itself, the human body, and the world in which we live.[38] The only access we have to any mathematics at all is through concepts in our minds that are shaped by our bodies and brains and realized physically in our neural systems. For any embodied beings, the only mathematics that can be known is embodied mathematics, that is, the mathematics that our bodies and brains allow us to know.[39]

According to Lakoff and Núñez, there is no difference between human mathematical concepts and mathematical concepts.[40] Human mathematics is not transcendent nor is it part of the physical universe. Rather it is a creation based on metaphors derived from our experience of external objects.[41] But though we create mathematics, mathematics is not arbitrary. Mathematics is based on the fundamental conceptual mechanisms of the embodied human mind as it has evolved in the world.[42] Every concept we have must somehow be characterized in the neural structure of our brains, and every bit of thinking we do must be carried out by neural mechanisms of exactly the right structure to carry out that form of thought.[43] For example, our mathematics of calculation, and the notation we do it in, is chosen for bodily reasons. The very idea of a linearly ordered symbolic notation of mathematics arises from the peculiar properties of our bodies.[44]

Lakoff and Núñez note that mathematics has changed enormously over time, that forms of mathematics often vary from community to community across the mathematical world, and that mathematicians often differ in their interpretations of mathematical results.[45] They argue that mathematical ideas can be impacted by culture (the Greek idea of essences is one key example they use)[46] or by technology (floating-point arithmetic used in computers is their key example here).[47] They argue that subject matters in mathematics tend to have multiple versions for historical reasons and that there is no way to predict what new forms of mathematics mathematicians will invent.[48] Because mathematicians live at specific times and base their work on the work of earlier mathematicians, mathematics evolves over time. Thus the progress of mathematics is nonlinear, and mathematical results can be inconsistent with one another.[49] Such inconsistencies express the different potentials in the different metaphors mathematicians employ.[50] Thus human mathematics is not monolithic. It embraces distinct versions of disciplines which, though internally consistent, can be mutually inconsistent.[51] In all of this, they see evidence of the contingent quality of mathematical concepts. In other words, mathematics is a schematic representation of how the brain/mind works, our mathematical models are projections of that schematic representation, and "there is no way to know whether theorems proved by human mathematicians have any objective truth."[52]

It would follow from this that, like logic, mathematics so conceptualized cannot really assist us in constructing any exhaustive model of reality. As Immanuel Kant and his contemporary disciples like psychologists Steven Pinker and Thomas Gilovich have pointed out, the human mind seems to be constructed so as to enable us to identify general principles that work well enough to empower us to survive and reproduce, but it does not seem particularly well adapted for tasks like detailed analysis. And indeed we do seem prone to all kinds of conceptual mistakes. Traditionally scientists have relied on mathematics to assist them in overcoming such mistakes, particularly in data analysis or in modeling conditions beyond our immediate experience. But if Lakoff and Núñez are correct, not only would mathematics be fundamentally unreliable for such a task, difficulties inherent in mathematical extrapolations would not be immediately obvious though they might become so as we began to explore possibilities (from our perspective) on the "edges" of things: while trying to make sense of data derived from the cosmic or the subatomic

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levels, while addressing questions of divine foreknowledge, while speculating on time-travel scenarios, while puzzling over the existence of free will, and so on. We naturally ask such questions, but lack the capacity to arrive at any final resolution concerning them.

Conclusion

This then is the dilemma to which Brad Keister pointed and which the secularist must address: if all there is, is matter in motion, and if awareness is simply a peculiar expression of certain configurations of matter, what, beyond mere pragmatism, compels us to accept any purely materialistic resolution of ultimate questions? The materialist simply has no way to address such queries. The data the materialist employs are too artificial, the process of analysis too inherently limited, to compel one solution over another. Indeed, materialism is revealed not as a rational alternative to dualistic or theological models of the universe but as an oddly irrational one, an alternative that begins by limiting its options for no obvious reason,[53] and then, having limited them, insists that all solutions must be subsumed under a regime so truncated that it cannot even address our questions. This represents a leap of faith that might have intimidated Kierkegaard himself! On the other hand, if one rejects the Lakoff/Núñez model of mathematics, then one ultimately embraces a de facto dualism and falsifies materialism. Thus the materialist is tossed on the horns of a dilemma. If he is right, he cannot prove it. If he can prove it, he is wrong.

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In a *New York Times* article on black holes, Dr. Raffael Bousso of the University of California at Santa Barbara, describing the holographic principle first articulated in 1993 by Dr. Gerard 't Hooft of Utrecht and later developed by Dr. Leonard Susskind of Stanford University, said: "We clearly see the world the way we see a hologram. We see three dimensions. When you look at one of those chips, it looks pretty real, but in our case the illusion is perfect." Susskind added as clarification for the reporter, "We don't read the hologram. We are the hologram."[54] This means that it is a fundamental mistake to attempt to imagine the universe as it appears to God,[55] and that our models of the universe, even those models based on mathematics, are forever doomed to reflect the holographic perspective of the observer. The materialist, if he is right, is condemned to be trapped forever within a near perfect illusion, one he may know is there, but one he cannot in principle transcend. ✹

Notes

[1]Brad Keister made this comment while addressing a conference organized by InterVarsity Graduate and Faculty Ministries and held between October 13–15, 2000, at the University of Saint Mary's of the Lake in Mundelein, Illinois. See "What Are the Research Needs in Science?" *Perspectives on Science and Christian Faith* 53, no. 4 (December 2001): 270.

[2]So far as I am aware, the best overall contemporary defense of this principle is Francis Crick's *The Astonishing Hypothesis* (Old Tappan, NJ: Simon & Schuster, 1994). In this book Crick argues that a person's mental activities can ultimately be reduced to the behavior of atoms, ions, and molecules as they are constituted in neurons and glial cells. The book is valuable as an insightful and critical discussion of the strengths and weaknesses of this thesis, and contains a wealth of experimental data which neuroscientists, the vast majority of whom, Crick assures us, are thoroughgoing materialists, interpret as justifying this position.

[3]Susanne K. Langer, *Philosophy in a New Key* (New York: A Mentor Book, The New American Library, 1951), 27–8.

[4]Robin Dunbar, *The Trouble with Science* (Cambridge, MA: Harvard University Press, 1995), 99.

[5]Ibid., 113.

[6]Ibid., 142.

[7]Thomas Gilovich, *How We Know What Isn't So* (Old Tappan, NJ: Simon & Schuster Inc., 1991), 58.

[8]John Barrow, *The Book of Nothing* (New York: Pantheon Books, 2001), 149, 164–5.

[9]Ibid., 286.

[10]Ibid., 284.

[11]Alfred North Whitehead, *Science and the Modern World* (New York: The Free Press, 1925), 25.

[12]Ibid.

[13]Ibid., 26.

[14]Ibid.

[15]Ibid., 27.

[16]Quoted in Michael Hardt and Antonio Negri, *Empire* (Cambridge, MA: Harvard University Press, 2000), 72–3. John D. Barrow also quotes this passage in *The Book of Nothing*, p. 86, taking it from Galileo, *Dialogue Concerning Two World Systems*, trans. S. Drake (Berkeley: California University Press, 1953), 103–4.

[17]Giorgio de Santillana, *Hamlet's Mill* (Boston: Gambit, Inc., 1969), v.

[18]Ibid., vi.

[19]George Lakoff and Rafael Núñez, *Where Mathematics Comes From* (New York: Basic Books, 2000), 162–3.

[20]Ibid., xi.

[21]Ibid., xiv.

[22]Ibid., 2.

[23]Ibid., 3.

[24]Ibid., 8, 338.
[25]Ibid., 15.
[26]Ibid., 28.
[27]Ibid., 29.
[28]Ibid., 100.
[29]Ibid., 101.
[30]Ibid., 170.
[31]Ibid., 273.
[32]Ibid., 346.
[33]Ibid., 375.
[34]Ibid., 1, 4.
[35]Ibid., 33.
[36]Ibid., 343.
[37]Ibid., 373, 376.
[38]Ibid., 1, 4.
[39]Ibid., 346.
[40]Ibid., 3.
[41]Ibid., 349, 364.
[42]Ibid., 9.
[43]Ibid., 347.
[44]Ibid., 86.
[45]Ibid., 349.
[46]Ibid., 107, 161, 357.
[47]Ibid., 360–1.
[48]Ibid., 355.
[49]Ibid., 359.
[50]Ibid., 265, 278, 333.
[51]Ibid., 352, 354.
[52]Ibid., 2.
[53]Perhaps at one time the materialist could plausibly claim that the tangibly physical was the obvious place to begin if we wanted to develop a valid model of reality, but that proposition, always questionable, has become even more so. Today cosmologists claim that about seventy percent of the universe is made up of dark energy and about twenty-five percent is made up of dark matter. That means matter as we know it comprises only about three to five percent of the density of the observable universe. Thus there is no longer any justification for giving our material state central position when we construct cosmic models, indeed there is every reason not to accord it such primacy.
[54]Dennis Overbye, "Hawking's Breakthrough Is Still an Enigma," *The New York Times*, January 22, 2002, sec. D, pp. 1, 4.
[55]Ibid., sec. D, p. 4.

Books Received and Available for Review

(Contact the book review editor if you would like to review one of these books. Choose alternate selections.) Richard Ruble, Book Review Editor, *Perspectives on Science and Christian Faith*, 212 Western Hills Drive, Siloam Springs, AR 72761. ruble@tcainternet.com

Celia Deane-Drummund, ed., *Re-ordering Nature: Theology, Society, and the New Genetics*, Continuum Books, 368 pages, 2003

Paul Copan, ed., *The Rationality of Theism*, Routledge, 290 pages, 2003

W. J. Elliott, *A Place at the Table: A Journey to Rediscover the Real Jesus*, Doubleday, 420 pages, 2003

George A. Erickson, *Time Traveling with Science and the Saints*, Prometheus Books, 177 pages, 2003

Wayne Grady, *The Bone Museum: Travels in the Lost Worlds of Dinosaurs and Birds*, Four Walls Eight Windows Publishers, 291 pages, 2003

Philip Hefner, *Technology and Human Becoming*, Fortress Press, 97 pages, 2003

Colin Humphreys, *The Miracles of the Exodus: A Scientist's Discovery*, Harper, 350 pages, 2003

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Paul Kurtz, ed., *Science and Religion: Are They Compatible?* Prometheus Books, 368 pages, 2003

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S. G. Post, *Unlimited Love: Altruism, Compassion, and Service*, Templeton Foundation Press, 232 pages, 2003

Samuel Powell, *Participating in God: Creation and Trinity*, Fortress Press, 238 pages, 2003

Proceedings from the ITEST Workshop in Sept. 2002 in Belleville, IL, *Advances in Neuroscience: Social, Moral, Philosophical and Theological Implications*, Itest Faith/Science Press, 230 pages, 2003

Wade Rowland, *Galileo's Mistake: A New Look at the Epic Confrontation Between Galileo and the Church*, Arcade, 295 pages, 2003

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Ralph Wood, *Contending for the Faith: The Church's Engagement with Culture*, Baylor University Press, 218 pages, 2003

Todd Wood, *Understanding the Pattern of Life: Origin and Organization of the Species*, Broadman & Holman Publishers, 225 pages, 2003

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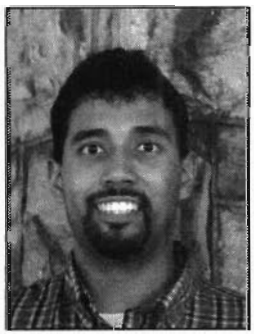
Pairing and Plus-ing the Godhead: An Algebraic Analogy

Carlos R. Bovell



This essay is an exercise in the integration of mathematics and theology. Its purpose is to show the usefulness of mathematics with regard to theological discourse. The author explores the problem of the Trinity and illuminates certain factors that contribute to our failure in comprehending it. An algebraic analogy is employed that (approximately) represents the doctrine of the Trinity. The analogy serves to illustrate the means by which humans innately group and combine individual objects. Such combining and grouping, it is argued, obtains by means of a pairing mechanism. This binary mechanism, though capable in most mathematical enterprises, is inadequate when one considers the relations within the Trinity. Moreover, the very operations that define our means of arithmetic conception fail to apprehend the divine perichoresis.

Taking as an example a mathematical exploration of the Christian doctrine of God, I will show that math is able to enlighten theological discourse.

Commonplace in contemporary Christian academia is the investigation of the advantage of a "Christian perspective" to such-and-such academic discipline and this-or-that academic problem. Practitioners of this reformational approach to general knowledge also have extended their line of inquiry to mathematics.[1] The converse application, however, is very seldom explored. Can there be any advantage to a "mathematical perspective" of Christian theology? Can mathematics inform theological problems? These questions may appear threatening to some and arcane to others, but a little creativity may deliver more than a mean theological yield. To date, those who have undertaken the integration of math and theology have produced mainly historical studies and excursions into cosmology. This essay endeavors to convince readers of the serviceability of mathematics for specific areas of theology proper. Taking as an example a mathematical exploration of the Christian doctrine of God, I will show that math is able to enlighten theological discourse. The argument below propounds an inherent limitation upon our mathematical (or better, arithmetic) faculties. By introducing these limitations along with the generic nature of basic algebraic algorithms, we can gain certain insights into what the problem of the Trinity specifically entails.

Many explanations have been given for the Church's inability to fully understand the doctrine of the Trinity. One Asian theologian "contextualizes" the doctrine, finding fault with the Greek logical axiom of noncontradiction, and posits that an Asian "both/and" type logic is better equipped to apprehend the doctrine. One Christian philosopher claims that it is because we lack appropriate conceptual categories to describe the triune God that we cannot fully explain him.[2] Neither claim delves deeply enough into the nature of the problem at hand.[3] This essay aspires to a more precise explanation for the incomprehensibility of the Christian doctrine of God. While being mindful that the doctrine of God is sacred territory, I will argue that the binary limits of our arithmetic processes will forever keep humans from comprehending the Trinity. By integrating insights from theology, mathematics, and cognitive science, I will argue that humans' arithmetic capacity is designed in such a way that we cannot cognitively assimilate the historic doctrine of the Trinity.

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Belief in the Trinitarian God of Christianity and in the incarnation of the second person of the Trinitarian God is what distinguishes Christianity from every other religion. If these two inseparable doctrines are relinquished, then Christianity reduces to simply one of myriad forms of expression of the human religious impulse. The orthodox creeds, then, are of singular importance to Christianity. The "Athanasian" Creed has been said to entail at least the following propositions:

1. The Father is God.
2. The Son is God.
3. The Holy Spirit is God.
4. The Father is not the Son and the Son is not the Holy Spirit and the Holy Spirit is not the Father.
5. There is one and only one God.[4]

Many have dismissed the above propositions as contradictory or unintelligible. For present purposes, we will presume the non-contradictory status of the above five statements.[5] It is the business of non-intelligibility that may find a few answers here. The charge of non-intelligibility means to say that even if the propositions are not formally contradictory, they do not contribute anything meaningful to one's understanding of God.[6] Non-intelligibility implies that the doctrine of the Trinity is so difficult or obscure that its content (whatever it is) is vacuous. I will argue that though the doctrine teaches an articulate, coherent reality (it is intelligible), Christians will always fall short of complete cognitive assimilation (it is not comprehensible). We will see that this failure seems to occur on account of binary tendencies in our innate process of collecting and combining individual objects and on account of the very nature of the arithmetic processes themselves.

Trying an Equation

The situation at face value is such that Christians assert that the Christian God is three-in-one and one-in-three. A simple way of trying to present such a belief in terms of numeric operations yields: 1 + 1 + 1 = 1, where the first "1" represents the Father, the second the Son, the third the Spirit, and the fourth the total number of existing gods.[7] There are at least two immediately obvious options open to the learner of arithmetic that would relieve her of this absurdity. The first and most obvious is to correct the sum by replacing the one with a three. Though this adjustment would satisfy arithmetically, when we recall the theological assertion that the arithmetic equation is supposed to represent, it is at once jettisoned as impermissible. The second option is to amend what lies on the opposite side of the equality symbol by emending the numerals in any number of ways. One suggestion that seems to commend itself is to reason that 1 + 1 + 1 is not an entirely accurate representation because what the first "1" is, the second is also; what the second "1" is, the third is also. Therefore, given our peculiar circumstance, it is legitimate to rewrite the equation as 1 + 0 + 0 = 1, since the second and third 1's are the same as the first. In other words, it is not technically the case that we have three different 1's here, but the same 1 repeated three different times. Thus, it is not right to say we have three because in the end, there is only the one and same 1.[8] The ground covered here, albeit in a grossly simplistic manner, has shown with what ease one can arrive at the ancient opposite errors of (1) polytheism and (2) monarchianism.

The situation at face value is such that Christians assert that the Christian God is three-in-one and one-in-three.

To maintain our bearings in what follows, it might prove helpful to rewrite these twin perils in alternate forms that would include other possible formulations of the same unorthodox scenarios. Let us say, then, that if any formulation can be reduced to either of the following two formulas then they have ceased to reflect the historic Trinitarian confession. Accordingly, we will remember:

(1) $F +^9 S + \text{Ħ} = \Theta \leftarrow \rightarrow \Theta \bmod 3 = 0$ or

(2) $F + S + \text{Ħ} = \Theta \leftarrow \rightarrow F = \Sigma = \text{Ħ}$, where $F + F + F = F$.[10]

Moreover, F, S, and Ħ can signify only one of an object.[11] In other words, we are ruling out the possibility that F can be a sum of more than one object. Therefore, F = 2 oranges cannot be true; F can only be one of whatever it is that F is and likewise with S and Ħ. The same, however, cannot automatically be said to hold for Θ since it is F + S + Ħ by definition. Indeed, the task at hand is to make this hold for Θ also without lapsing into (1) or (2).

In the case that one has x + y + z, it is only possible to simplify the expression if one variable can be rewritten in terms of another[12] or, better still, if all three of the variables could be rewritten in terms of a fourth. Perhaps, the latter strategy can prove serviceable. Let F be an apple, S an orange, and Ħ a pear. F + S will not reduce to anything but an apple and an orange respectively. We can recognize the two objects separately, but we lack a linking variable to conjoin them (i.e., we cannot say we have two apple-oranges). Still, if there existed a fourth variable that could hold F, S, and Ħ in common, we might be able to progress a bit. Let us rewrite F, S and Ħ in terms of a fourth variable Π. (Normally, a new variable v, for example, would be introduced such that $v = 2x + 5$, $y = 5v$ and $z = v^2$ and the like in order to manipulate x, y and z in terms of v. For our purposes, we must unfortunately trade these quantities for a conceptual analogy to this standard algebraic algorithm. Instead of the algebraic expressions [2x + 5, etc.], we will call upon various categories [e.g., fruit], as described by

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Aristotle, for example.[13]) Let ∏, therefore, denote any type of fruit. Now it appears that ∏ can rightly be substituted for any of F, S or Ħ. Hence, F + S + Ħ = ∏ + ∏ + ∏ = 3∏. So we have moved along to the following:

(1a) $3\prod = \Theta \leftarrow \rightarrow \Theta \bmod 3 = 0$ or

(2a) $3\prod = \Theta \leftarrow \rightarrow \prod = \prod = \prod$, where $\prod + \prod + \prod = \prod$.

On account of our substitution above, it seems that (1a) is unavoidable and (2a) is impending, if we overreact to the threat of (1a). (1a) *is* inevitable if Θ is divisible at all.[14] Fruit, as we have constructed it, is divisible and it is evident that we have not only three types of fruit, but three individual fruits. Θ (whatever it is), in other words, is three and not one, divisible into three "smaller" parts. Θ, for us, is the number of gods that exist; there is only one divine substance. The Christian faith, however, holds that God is indivisible; he is utterly simple. Or is he?

The Christian faith ... holds that God is indivisible; he is utterly simple. ... It is only on account of our frailties that we must conceive God in such complexity. In reality, he is utterly simple.

Gregory of Nazianzus wrote: "For they are divided without division, if I may say so; and they are united in division." Gregory confesses that he speaks of a paradox, but we must explore the paradox a little further to accomplish our goal. The Cappadocian Father must have meant, among other things, that "God is divisible in a way that is different from the way that he is indivisible, and he is a unity in a way that is different from the way that he is divisible." This is quite a mouthful, but it is an important mouthful nonetheless. The significance lies in the implication that there are different "ways" to God. But before inquiring of these different "ways," it is appropriate to remember that "we can speak of simple things only as though they were like the composite things from which we derive our knowledge."[15] It is only on account of our frailties that we must conceive God in such complexity. In reality, he is utterly simple.

If there are different "ways" to God (i.e., the ways in which he is divided are not the same ways in which he is united), then it becomes apparent that the relation that obtains in our formulas is not strictly accurate. Not only is the relation (=) inaccurate, but the operation (+) may be also. Nevertheless, we will continue to employ the operation while qualifying the relation.

When a Christian affirms that 3∏ = Θ (that F, S and Ħ are the one God), it may be the case that the Christian considers God to be three in ways that are different from the ways in which he is one. In other words, 3∏ = Θ is not an adequate rendering of the theological confession. When one writes ½ = 2/4 = 3/6, etc., one is expressing the fact that each term refers to the same exact quantity. For our purpose (for better or for worse), we have lapsed from quantities to categories, but the same relation is implied by the "=" symbol we are using at present. 3∏ = Θ, therefore, might be understood to convey that 3∏ and Θ refer to the exact same category (and not necessarily quantity), yet this is contrary to the orthodox description. The matter can be set in bolder relief by realizing $3\prod = \Theta \leftarrow \rightarrow 3\prod - \Theta = 0$ must be true if the equals symbol signifies its normal "equal quantity" relation. With equal *quantities*, the difference is always zero. Can it likewise be said that if you were to subtract the *category* "substance" from the *category* "person" that the result would be zero?[16]

We are already familiar with this problem. Earlier we saw that we could not add one apple and one orange. The same would be the case if we sought to subtract one orange from one apple; we are forced to hold the tension between the two objects without reducing them to one type. In order to continue, we saw that we must search for another variable in terms of which the others could be expressed. Thus, we are forced to keep the "persons" and the "substance" in tension without reducing one category into another, for no extant category will ever become available for useful deployment. This is the impasse of the mystery beyond which humans cannot progress. Still, it is well known that by using mathematics, humans can sometimes proceed beyond that which would ordinarily impede him.[17]

Examining the Operation

Some readers may be of the opinion that we have abandoned our quest too hastily and that 3∏ = Θ or F + S + Ħ = Θ should be revisited. Surely other possibilities abound, but, as mentioned above, it is not the varied possibilities that are of interest. It is the *operation* that merits scrutiny. Revisiting the formulas will lead invariably to (1a) or (2a), and the

reason for these outcomes lies in the operations involved. It should be clear that every restatement of the "Athanasian Creed" can be expressed in either of these forms:

(3) $3\prod = \Theta$ or

(4) $F + S + \text{Ħ} = \Theta$.

Since (4) is the commonest, it will occupy our attention from here on out.[18]

As we have implicitly surmised above, "Father *and* Son *and* Holy Spirit" is not technically the same as "Father *plus* Son *plus* Holy Spirit." The concept behind the word *plus* has the intrinsic connotation of bringing together the objects under consideration (whether abstract or concrete) and combining them in such a way that there appears a "new" object (the sum). By contrast, to simply "*and*" objects together means to collect the objects in question without necessarily combining them in any particular way. In other words, the collecting stops short of combining (i.e., there is a mere collection in the end and not a sum). The "obvious" meaning of *plus* is notoriously difficult in that it is not always clear how the "new" object relates to the initial objects prior to their being "*plus*-ed." Fundamentally and non-trivially, it is at least understood that the whole is greater than its parts.[19] Inherent in this relation is a notion of *measurement*, and not only measurement, but also a *method* by which one is able to ascertain a measurement. Both the method and the resulting measurement normally require spatial and temporal considerations including density, locality, velocity, temperature, span, height, weight, form, and so on. Even when dealing with abstractions, corresponding abstract equivalents to measurement and method obtain; a similar mental process along a suitable calculus is used. It is this very act of "measuring" that occurs prior to, during and after *plus*-ing that proves inadequate when applied to the Trinity.

The phrase "during *plus*-ing," aside from its awkward construction, may come as a surprise to some. Is there really a "during *plus*-ing" phase to adding one plus one? A child is given one animal cracker and then another. Immediately, it is obvious to her (whether she can articulate it or not) that she no longer has one but two. Prior to *plus*-ing she had only one cracker; subsequently she had two. Whence this "during *plus*-ing" stage? That is just the problem. Practically speaking, when adding one plus one (or anything at all), there is no "during *plus*-ing" stage. One may object that when a student adds 27 + 18 and resorts to scrap paper in order to affect the computation he is experiencing the "during *plus*-ing" stage, but this is not true. The busy student only *appears to experience* the "during *plus*-ing" stage with the help of his stationery aids. We must not confuse the time taken or the materials used with the actual act of *plus*-ing.[20] Though the entire computation may take a student five or ten seconds, real *plus*-ing takes (or better, lasts for) but an instant. "Seven plus eight is fifteen" is the first act of *plus*-ing involved in the given exercise. Or if the student resorts to the bane of his tutor—counting on his fingers—he will proceed: "Seven. Eight, nine, ten ... fifteen!" Thus we have eight instances of *plus*-ing to accomplish the first step of the exercise.[21]

What possible relevance does this have for the Trinity? It is pertinent in every way. The crucial feature that precludes a more comprehensive understanding of the doctrine of the Trinitarian God lies in the *measurement* process (utilized by all humans) mentioned earlier. Granted, it is not "seven plus eight" with which Christian believers must wrestle constantly, but with a situation that is actually much simpler and very similar to "*one plus one plus one.*" This is not to claim that God is linear or piecemeal, but rather that the measurement process which humans instinctively apply to all objects is the same in both "seven plus eight" and "one plus one plus one."

It is this very act of "measuring" that occurs prior to, during and after plus-ing that proves inadequate when applied to the Trinity.

The measurement process that I have in mind is akin to what Brian Butterworth calls "numerosity."[22] This term refers essentially to cardinal numbers. Determining numerosity (i.e., determining exactly how many of something there are) requires the ability to specify individual objects and then to organize them into a collection. These abilities are innate; some scientists are now arguing that infants along with many different types of animals possess a sort of "number sense."[23] This innate sense is limited to distinguishing among one, two, and three of a given thing.

More specifically, though, I have in mind what I call the *pairing mechanism*. In their study, Lakoff and Núñez have posited a "pairing capacity" whose function it is to match a person's count to the corresponding object in a given collection since the count must be distinguished from the collection of objects.[24] The *pairing mechanism* propounded here, by contrast, is the process by which a person pairs an already counted item (or a cumulative sum) with the next item to be counted. Whereas Lakoff and Núñez are concerned with the pair that has one member in a source domain (object collection) and a second member in a target domain (arithmetic), I am concerned with relating a pair of objects that are both within the same domain (be it source or target). In other words, instead of focusing on the "cognitive mechanism that enables us to sequentially pair individual fingers with individual objects" (speaking of counting on one's fingers),[25] I am focusing on the mechanism that pairs two individual objects (or a running sum

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and an individual object or even two running sums) together in order that they might then be combined or *plus*-ed. The best example of what is meant here is the algebraic explication of the associative property of addition:

$$(a + b) + c = a + (b + c).$$

Notice that the only difference between the two sides of the equation is that different pairs are set apart by parentheses. The function of the two sets of parentheses is to signify which two terms are meant to be combined first each time. It matters not whether one adds (a + b) and then c (as on the left) or first adds (b + c) and then a (as on the right). The two sums will be equal. These parentheses signal the reader to pair terms in a particular manner. The process that the parentheses describe is the *pairing mechanism* set forth here.

A theological corollary to the natural employment of an innate "pairing mechanism" is that if God demonstrates a plurality of any sort, humans would automatically consider a duality first and then proceed from there.

Pairing and *plus*-ing are not the same action. Pairing is logically first, even if in simple cases they seem to obtain simultaneously. In order for any *plus*-ing to occur, objects (concrete or abstract) must first be brought "together," organized or *measured*. The pairing mechanism is an inherently binary operation. I posit that it can only operate on a single pair of objects at any given time (whether the pair consists of two single objects, a collection considered jointly as a single collective and a single object, or two collectives). Though operations many times give the appearance of being far more complex, it will always be the case that it can be reduced to the repeated organization of pairs of objects if carried out by humans. Multiple examples of this can be found in the algorithm known as the order of operations. To arrive at a solution or an equivalent expression of a given expression, if a choice exists as to which operation should be applied first, one must work through parenthesis first, then exponents, then multiplication, and so on. Algebraic expressions of virtually every sort must be approached with this algorithm.

Consider $5 \cdot 3 + 4 + 5 \cdot 7 - (2 \cdot 2 \cdot 2)^2$. All operations here are binary; only two numbers can be "operated on" at a time. Every act of "combining" is at its most fundamental level the exercise of the pairing mechanism. Within the parenthesis, for example, we have three two's being multiplied ($2 \cdot 2 \cdot 2$). One with a familiarity with these types of exercises may simply count the two's and know from memory that $2^3=8$, but recall that memorization circumvents the actual operation. The analogy will not hold for rote memorization since memorization is more an act of association than combination.[26] However, if one approaches the parenthesis by means of the operations themselves, he would combine two of the two's ($(2 \cdot 2) \cdot 2$) and then combine the product (4) with the last two to get a final product (= 8).[27] The same holds for 15 + 4 + 35: two numbers would be paired together and that sum then would be added to the third. The pairing mechanism is inherently binary which may explain why most (I would argue all) operations are also binary. Thus, mathematics has been used to uncover an implicit limitation within many (if not all) mental gathering processes.

These tacit processes extend to Christian discourse as well. For example, a theological corollary to the natural employment of an innate "pairing mechanism" is that if God demonstrates a plurality of any sort, humans would automatically consider a duality first and then proceed from there. In other words, a bi-une God is easier to recognize than a tri-une one. This is precisely what has happened historically. Both the Father and the Son were soon recognized as somehow being God where the Father was not the Son and the Son was not the Father.[28] The precise nature of their relationship (or at least what their relation was not) took centuries to establish before moving on to consider a third divine person, the Holy Spirit.[29] I think that the proposed pairing mechanism contributed in large measure to the order of theological discovery. The reason that the early church first wrestled with the relationship between the Father and the Son and then that among the Father, Son, and the Holy Spirit is because the early church leaders were limited by the pairing mechanism. If it is unclear how the pairing mechanism would help us better *understand* a bi-une God, minimally, we can say that it causes us to *recognize* a bi-une God more easily. Insofar as the pairing mechanism assists us in recognizing a bi-une God, it would assist us in understanding him. By definition, however, the *binary* pairing mechanism offers no assistance whatever in recognizing our *tri*-une God. To the extent, therefore, that it hinders us from recognizing our God, it is an impediment to our understanding him.

Applying the Observations

In the last section, it was suggested that most operations are binary, or at the very least, that they are approached as if they were on account of the employment of a pairing mechanism. We will now apply these observations to the earlier discussion of the Trinity. (4) F + S + Ħ = Θ is the equation with which we will resume.

It was surmised that, based on categorical failures, there existed an impasse beyond which we could not explore. A new problem that emerges is that the pairing mechanism that we naturally and necessarily employ as an early step in combining objects is fundamentally inadequate for the present task. The inherent binary nature of the pairing mechanism does not have the range for the Trinitarian formula. It is not enough to combine F and S and then consider (F + S) + Ħ. Nor will F + (S + Ħ) or (F + Ħ) + S suffice. The Patristic idea of perichoresis, or the interpenetration of the Father, Son and Holy Spirit, prohibits each of these isolated combinations.[30] In fact, the only combination that is consistent with perichoresis is (F + S + Ħ), and this at once ceases to be the essential grouping of pairs. Therefore, it is not only a categorical failure that stands in the way, but also an operational failure. The operation needed here is one that acts upon three objects simultaneously, but it is one with which we are unfamiliar, and (based upon the binary limitations that have been placed on our pairing mechanism) may be one that we cannot discover or invent or, in the least, properly perform. If this is the case, it follows that we are unable to combine (F + S + Ħ) in a single stroke for it is without our binary parameters. Hence, we can expect our descriptions of the Trinitarian God of Christianity to be necessarily either broad and vague (and in many ways inexplicable) or inaccurate and erroneous as were those espoused by the heretics. The *plus*-ing that Christians need is one that involves the gathering of triples and not that of pairs. If what I have argued is true, then the intercourse between mathematics and theology has discerned an inestimable hindrance to the appreciation of the doctrine of the Trinity.

Furthermore, the binary restriction is not the only problem that humans face in understanding the Trinity. A salient feature of the *plus*-ing operation itself, beyond its binary approach, is not able to mirror the relations of the Trinity. Above, a distinction was made between *plus*-ing and *and*-ing. Whereas the former involves a sum that subsumes the objects that were considered separately prior to the operation, the latter does not always result in a sum. The sum is a collective entity that considers all objects together without reference to their individuality.

It was also pointed out that there are three phases to *plus*-ing: before-, during- and after-. The after- phase will have obtained whenever a sum is apparent and the individual objects are not. The before- phase includes all that is done in preparation for the calculation of a sum (i.e., when individual objects are present and the sum is not). The during- phase was defined as that instant when *plus*-ing actually occurs. The problem was that a during- phase never really seems to exist. The final connection to make here is that in order to properly conceive of the Trinity, we must recover that during- *plus*-ing stage. That is, we should seek out the instant when the objects under consideration are no longer merely individual objects but are not yet a full sum either. Rather, they are neither individual objects (strictly speaking) nor a sum. This is the closest we can come to the idea of interpenetration. In other words, (F + S + Ħ) needs to be combined as a triple (not by pairs) in such a way that they are *plus*-ed, but the combining process must freeze itself in the during- stage.[31] That elusive moment when (F + S + Ħ) is combined must be preserved in a "snapshot" and not allowed to pass by, else the sum will formally result and the individuals will disappear. The measurement of (F + S + Ħ) at that precise moment would allow for a more faithful understanding of the Trinity.[32] However, such precision is a perennial chimera. Alas, in the end, it may be the case that a certain amount of illusion lies at the foundations of arithmetic.[33]

Conclusion

To sum up, there is no real problem with the doctrine of the Trinity. The doctrine is not contradictory nor non-intelligible. The Christian church has effectively articulated the doctrine of the Trinity in her creeds; the reality described is a legitimate one that involves no contradiction. Still, Christians (and non-Christians for that matter) do and will continue to have problems with the doctrine of the Trinity. It describes a wondrous God whom we cannot cognitively assimilate. The human arithmetic capacity is designed in such a way that its tendencies account for a significant part of why the historic doctrine of the Trinity cannot be properly appreciated. This is due, it was argued, to the inadequacy of a binary pairing mechanism that humans inevitably employ when contemplating the three persons of the Godhead. Moreover, the moment in which the actual operation obtained proved elusive. The conclusion was drawn that even with the expansion of the pairing mechanism to an equivalent that worked with triples, the nature of the *plus*-ing operation itself fails to accurately reflect the nature of the Trinity. Therefore, humans will always have a problem understanding the Trinity.

These conclusions were couched within the contours of a broader argument that proffered the usefulness of mathematics for theology proper. The analogy presented above, for example, can be applied to both the economic and imminent Trinities insofar as the latter is revealed in the former.[34] An imaginative and careful mind should be able to find other creative ways to incorporate mathematics into theological discussions.[35] The present exercise was an attempt at such incorporation: an algebraic exposition of

Article

Pairing and Plus-ing the Godhead: An Algebraic Analogy

A "mathematical perspective" can prove quite useful to Christian theologians, even if it only plays a negative role ...

the Christian doctrine of God. In due course, legitimate obstacles were identified that reflect inherent limitations upon simple, everyday operations. Obviously, this is not to say that these limitations are the *only* reasons that the Trinity remains incomprehensible or that an algebraic analogy was the *only* way to isolate these features. Nor has it been claimed that mathematics can "solve" the problem of the Trinity. Suffice it to say that a "mathematical perspective" can prove quite useful to Christian theologians, even if it only plays a negative role (as it did here). So, without being impious, the next time someone asks, "Can any good thing come from mathematics?" we should give more credence to the reply, "Come and see." ✹

Notes

[1]E.g., Russell W. Howell and W. James Bradley, *Mathematics in a Postmodern Age: A Christian Perspective* (Grand Rapids: Eerdmans, 2001).

[2]The conclusions of Jung Young Lee, *The Trinity in Asian Perspective* (Nashville: Abingdon, 1996); and Stephen T. Davis, *Logic and the Nature of God* (Grand Rapids: Eerdmans, 1983), respectively. Interestingly enough, it seems that not a few unwary evangelicals unwittingly lend credence to Lee's both/and claim. For instance, in trying to explain the relationship of the Old Testament to the New Testament, G. Goldworthy writes:

> It is generally recognized that the relationship of the two Testaments is one aspect of the unity and diversity ... within the canon ... This is one form of a philosophical and theological issue which underlies all attempts to understand reality: the relationship of the one to the many, of unity to plurality.

He continues:

> While the natural tendency is to solve these problems by allowing unity or diversity to dominate (an either-or solution), the Christian gospel suggests a distinctively Christian perspective embracing both unity and diversity (a both-and solution).

A problem arises, though, when he attempts to demonstrate the Christian pedigree of "both/and solutions" by appealing to Chalcedon:

> The apostolic understanding of Jesus pointed to the mystery of the one person who was both fully God and fully human. It required a "both-and," rather than an "either-or" approach. Later the church formalized this perspective in the doctrine of the incarnation, and particularly in the formula of the Council of Chalcedon in AD 451.

He adds:

> *The doctrine of the Trinity is the epitome of 'both-and' formulation. God is conceived as both one and many (three). The early heresies about God tried to define his being in ways that compromised either the unity of the three Persons or their distinctiveness"* (G. Goldsworthy, "Relationship of the Old Testament and New Testament," in *New Dictionary of Biblical Theology: Exploring the Unity and Diversity of Scripture*, ed. T. Desmond Alexander, et. al. [Downers Grove, IL: Inter-Varsity, 2000], 82–3, from the section "Unity and diversity in the history of interpretation"; italics are mine).

The selection of such language is, perhaps, due to the cavalier (even though conservative) anti- modern drive of the dictionary as a whole. Though his way of wording his explanation is unfortunate, his point is easily grasped. Even so, the paragraphs just cited may lead to misunderstanding, for I suspect that if he were pressed for further explication, Goldsworthy would readily admit that God is *either* one person *or* three, one God *or* three, etc. In other words, his "both/and" solution is metaphorical only. It would have been better if he had clarified what he meant by "an either-or solution" by removing the ambiguity between the fallacy of bifurcation and the law of non-contradiction.

[3]Davis' observation concerning categories is right as far as it goes. Still, there seems to be more involved with Trinitarian parlance than namely a lack of appropriate categories. For the shortcomings of both Davis' and Lee's conclusions, see notes 16 and 17 below. [Note to the reader: With hopes of improving the readability of the main argument, many such ancillary arguments and explanations are confined to endnotes.]

[4]See, for example, John S. Feinberg, *No One Like Him* (Wheaton: Crossway, 2001), 438, and Davis, *Logic and the Nature of God*, 132–44.

[5]Leeway might be granted in the referent of "God" (e.g., "The Father is not God as such; for God is not only Father but also Son and Holy Spirit," etc. (A. J. Augustus, *Systematic Theology* 1, 605), or better, in the function of "is" (predication in (1), (2) and (3) and existence in (4)).

[6]It is important to remember that Christians do not believe these five statements on account of logical inventiveness or theological imaginativeness, but precisely because they believe them to be revealed by God in Scripture. Since these statements are believed to be a part of God's self-disclosure, it is no cause for alarm if they survive as mysteries.

[7]It seems proper here to acknowledge works that I have consulted. In a chapter devoted to the problem of the Trinity, Cartwright refines Peter Geach's relative identity and reviews its aptitude when applied to Trinitarian language (Richard Cartwright, *Philosophical Essays* [Cambridge, MA: MIT Press, 1987], 187–200). Geach, for his part, sees a need to establish identity in relation to a specific "something": "X is the same so-and-so as." What follows attempts to build upon Geach's suggestions (*Logic Matters* [Berkeley: University of California Press, 1972]). I first learned of Geach's application of relative identity to the Trinity through Peter van Inwagen's *God, Knowledge and Mystery: Essays in Philosophical Theology* (Ithaca: Cornell Press, 1995). Though I have not seen his name in the literature, it seems to me that the entire Christian tradition is heavily indebted to the medieval (dare I say patristic?) theologian Boethius (c. 480–524), for his *Theological Tractates*. His discussions concerning identity with reference to the Trinity are invaluable and anticipate contemporary explorations in relative identity.

[8]If I call out for pizza three times in one night, though the pizzeria may in a sense say that it had three customers, the fact still remains that I am a

single customer. Cf. Bertrand Russell, *The Principles of Mathematics* (New York: W. W. Norton, 1996), 135: "When we say 1 + 1 = 2, it is not possible that we should mean 1 and 1, since there is only one 1: if we take 1 as an individual, 1 and 1 is nonsense, while if we take it as a class, the rule of Symbolic Logic applies, according to which 1 and 1 is 1."

[9]Readers who are mathematicians may be uncomfortable with the use of "+" here. They are free to substitute "□," "◊" and the like, understanding that we are considering an abstract commutative and associative operation for the sake of illustration. For the benefit of non-mathematicians, the ordinary "+" symbol has been retained. Equations (1) and (2) are, after all, mock trials with real addition. At the appropriate time (note 16 below), a brief rationale is given for the use of "+." In section "Examining the Operations" below, nuances between "+" and "and" are discussed in some detail, especially with respect to the Father, Son, and Spirit relations.

[10]"mod n"is the operation under which x is divided by n with or without remainder. For example, "100 mod 10" is 0 since 10 divides 100 without remainder. In the same manner, "101 mod 10"is 1 since 10 divides 101 with remainder 1. So Θ mod 3 = 0 would indicate that Θ is divisible by 3. It is the duty of this formula (1) to detect a form of polytheism, namely "tri-theism." The "mod" function was chosen because it facilitates future qualifications with minimal revision.

[11]As hinted at above, the variables were chosen with the following in mind: F denotes the Father, S the Son, Ħ the Spirit and Θ God. However, initial trials will involve other substitutions.

[12]This line of inquiry does not seem promising since to express the latter two variables in terms of the former is what got us to (2) in the first place.

[13]This has no noticeable effect on the argument since it is the nature of the operation itself (or any operation for that matter) and not the quantities employed that are later called upon to argue my point. The coefficients are what interest us here. An infinite number of combinations would provide the desired coefficients. For example, x = 2v, y = v and z = 0 yields the target 3v = q. The description of F as being only one of whatever F is does not nullify these types of substitutions. Even if it did, the myriad that take the form F = ½v+9, S = 2v-1 and Ħ = ½v-8 and the like accomplish the desired result. The ambiguous function of the equals symbol will be discussed briefly below.

[14]Θ has intentionally been left undefined. What Θ might be need not detain us here, at least, as far as the fruit analogy goes. It is without the limits of this essay to rehearse the long journey to the final formulation of the Christian doctrine of God. Briefly, for us, 3∏ will refer primarily, *but not exclusively*, to *tres pragmata kai tria proswpa* (three realities and three persons) and Θ will refer primarily, *but not exclusively*, to the divine *ousia* (substance). The equations aim to approximately depict the whole Godhead. It is agreed that every analogy of the Trinity falls short of that which it purports to represent. Each variable here should technically include the substance and the persons since, though the substance and the persons can be distinguished, they cannot be separated. It is only for the sake of the argument that one side of the equation focuses on the persons and the other on the substance. For the categories "person" and "substance" as adapted by the Fathers, see Christopher Stead, *Divine Substance* (Oxford: Oxford University Press, 1977), 241 for Greek above.

[15]Aquinas, *Sum. Th.* 1.3.3.1; for Gregory, see *Orat.* 5, *On the Holy Spirit*, 14.

[16]Herein lies the reason for opting for an arithmetic or algebraic analogy and not one solely based upon symbolic logic and set theory as is commonly done by philosophers. Discussions that incorporate set theory into analyses of the Trinity (e.g., those that search out the implications of Relative Identity) tend to obfuscate the nuances that distinguish equality (and there are several headings under equality) and identity. Perhaps, attempting to answer questions of equality before establishing different kinds of identity amongst the persons of the Godhead would further illuminate the exact nature of the paradox. I am willing to admit a certain degree of inadequacy in the arithmetic alternative presented here (for starters, it is not "purely" arithmetic), but the perceived inadequacies by no means invalidate its didactic utility. Arithmetic and logic have fuzzy bounds; the activity of one is very often the activity of both. Variables in algebra, after all, often stand for bare mathematical concepts (e.g., "real number") and, for all intents and purposes, not for a hypothetical set of discrete quantities (e.g., [-∞,∞]). A preponderance of algebraic work abstains from discrete quantities altogether. The same can be said for the "+" sign as well. The "+" sign, at times, can be a "stand-in" for any other operation that a practitioner can imagine (assuming it is commutative and associative). For this reason, the conclusion of the present argument, in my judgment, survives unscathed. For a similar view concerning the use of concepts and operations in algebra, see W. W. Sawyer, "Algebra," in *Mathematics in the Modern World: Readings from Scientific American*, ed. Morris Kline (San Francisco: W. H. Freeman and Co., 1968), 102–10.

[17]In this case, mathematics may prove especially useful by exploring the realm of "what if?" If a pertinent category does exist or will exist in the future, we will not be able to employ it in order to reduce the tension. Such employment will either collapse into (2a) above or simply return us to our initial point of departure at the beginning of this essay. For example, let us imagine that a satellite in the near future is able to transmit an ultraviolet photograph of a physical relation (infinitesimally high-speed electrons or what have you) that obtains within the sun that no scientist has encountered to date or has ever even thought possible. Let it be supposed that they assign a category, "*f*abric ŵarp" or some such name, to encapsulate the essence of the phenomenon. If we were to posit that "*f*abric ŵarp" is such a category that it were to categorically subsume both "person" *and* "substance," we may try to substitute in $f\hat{w}$ as follows for each: $3\,f\hat{w} = f\hat{w}$ (or $f\hat{w} + f\hat{w} + f\hat{w} = f\hat{w}$, which is, of course, (2a)). This is no help at all, and is, in fact, worse than 3∏ = Θ, for it leaves us with an absurdity since its single solution is "zero." For this purpose, Davis' observation above (that we lack the categories to proceed any further), though revealing, is not definitive, for if we did have the categories, they would not afford resolution.

[18]Once again, the objection might be raised that the divine substance is not merely the three persons of the Godhead considered collectively, but is a substance itself and not a combination of persons. In other words, the divine substance exists *along side* the persons so that what is really taking place is this: F + S + Ħ + Ð = Θ, where Ð is the divine substance and Θ is the Trinitarian God. The objection is noteworthy, even if the "arithmetic" representation of it is quite problematic. (Incidentally, Lee's "both/and" approach in *The Trinity in Asian Perspective* seems to fall prey to the error of this equation. His contextualized "Asian" Trinitarian God is, unfortunately, nothing but a *quaternium quid*.) The objection has force because Christians recognize a distinction between substance and person and between person and person. However, if Θ is the whole Godhead (i.e., the Christian Trinitarian God), Θ is not simply substance, but the whole God. We must remember that the Ðivine substance is essential to each variable—it is not only essential to Θ, but also to each of F, S, and Ħ. In other words, what is intended by F + S + Ħ = Θ is more accurately reflected by F Ð + S Ð + Ħ Ð = Ð (F + S + Ħ) = Θ. This alternate form, however, was judged to be too cumbersome for an essay of this length. It is hoped that the simpler equation will suffice to analogously present the point that is being made.

[19]It is arguable that there may be times when the result of a *plus* will be no different from that of an *and*. When this occurs, one can claim that no *plus* ever really took place or that the nature of the objects was such that the *plus* did take place but that it did not have its usual effect on the objects. A similar scenario arises in discussions concerning the relations between classes or sets and their terms. For example, is a set just its members or something more? For a critical discussion on a set's relation to its terms, see J. R. Lucas, *Conceptual Roots of Mathematics* (New York: Routledge, 2001), 311–39.

[20]Recording the numbers, crossing out digits, "carrying," etc. are only preparation for each of the instances where the student actually brings the two numbers together mentally and comes away with his sum. After all, "... mathematical notation no more *is* mathematics than musical notation is music ... It is in its performance that the music comes alive; it exists not on the page but in our minds." The same can be said of math (which Devlin does say in the sentences that follow. Keith Devlin, *The Math Gene, How Mathematical Thinking Evolved and Why Numbers are Like Gossip* [New York: Basic Books, 2000], 9).

[21]For good measure, lest anyone begin to worry, it should be noted that the following does not apply to adding machines, computers and the like because a programmed abacus does not *experience* anything! In a similar vein, rote memorization is discounted for it circumvents the very process upon which we are attempting to focus. If one objects that everyone counts from memory, we need only substitute an unfamiliar multiple (counting by three or eight, etc.) to find an analogous operation. If that still fails to satisfy the objector, he will still agree that counting does at least demonstrate the use of a pairing mechanism (see below).

[22]Brian Butterworth, *What Counts: How Every Brain is Hard-wired for Math* (New York: Free Press, 1999), 10.

[23]See Stanislas Dehaene, *The Number Sense: How the Mind Creates Mathematics* (Oxford: Oxford University Press), 1997.

[24]George Lakoff and Rafael E. Núñez, *Where Mathematics Comes From: How the Embodied Mind Brings Mathematics into Being* (New York: Basic Books, 2000), 51.

[25]Ibid.

[26]To the degree that counting is performed from memory, the analogy seems to weaken because it involves more of an associative capacity (associating one entity with another and recognizing an ordered relationship between numbers) than a faculty for combining (one combined with one is two, two combined with one is three). Nevertheless, the pairing mechanism can then be identified with Lakoff and Núñez's "pairing capacity." To reiterate, counting from memory circumvents the *plus*-ing operation, but requires some sort of pairing. Counting by other multiples than one may prove analogous.

[27]The same holds for "shortcuts." If the shortcut circumvents the operation entirely, it is back to memorization. Many shortcuts, though, inevitably proceed through the required operations, only at some simpler level.

[28]See, for example, Larry W. Hurtado's "The Binitarian Shape of Early Christian Worship," pages 63-98 of his *At the Origins of Christian Worship: The Context and Character of Earliest Christian Devotion* (Grand Rapids: Eerdmans, 1999).

[29]For these and other developments, see J. N. D. Kelly, *Early Christian Doctrines*, rev. ed. (New York: HarperCollins, 1978).

[30]See the excellent work, G. L. Prestige, *God in Patristic Thought* (London: SPCK, 1959), especially pp. 282–300.

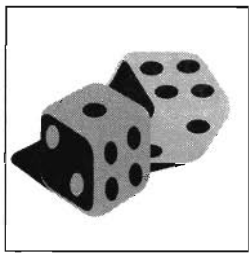
[31](F + S + Ħ), with parenthesis (as opposed to without parenthesis) means to signify the all-at-once-ness of the original F + S + Ħ. The parenthesis will serve to remind us that it will not do to add from left to right or in any other binary way; rather, an immediate measurement of the triple is required.

[32]As already mentioned, I am not at all convinced that this dilemma is forced upon us by "either/or" logic or solely by a lack of appropriate categories. The dilemma is caused by the fact that God is three in a way that we cannot fully appreciate. The dilemma is caused by the fact that there is no way for us to "freeze" the during-*plus*-ing stage in order to observe or experience how a combination can obtain that comes after a mere gathering of objects, yet before the final sum. The snapshot must be of a time when F, S, and Ħ combine with each other in such a way that: if one were to look for F, one would find that S and Ħ inhere in F; if one were to look for S, that F and Ħ inhere in S; and if one were to look for Ħ, he would find that F and S inhere in Ħ. Such an operation would be unique, but it seems that the operation could not exist within time. It is time that causes *plus*-ing to have a prior to, during and after phase. The fact that all operations are performed "in time" causes the result to have the lasting influence. But if the analogy presented here is in any way valid, it appears that it is the process itself, or the actual act of *plus*-ing as we have termed it, that is the dimension of the operation that would need to obtain as a constant, long-lasting reality. And this is impossible "in time." An act endures for but a moment (or for an indefinitely short span, as some would argue), but this act would need to endure for an eternity (or, at the very least, endure for long periods of time at the command of an individual perceiver). It is not a repeated act that will do here or a long act comprised of many smaller ones, but one act performed at one time that obtains continuously throughout time. For this to be achieved it seems that it would have to be performed "outside" time; moreover, in order to view it, one would also have to do so from "outside" time. Of course, I digress too much; the metaphysics of time is a fascinating and perplexing study in its own right.

[33]"I distinguish what I call objective from what is handleable or spatial or actual. The axis of the earth is objective, so is the centre of mass of the solar system, but I should not call them actual in the way the earth itself is so. We often speak of the equator as an *imaginary* line; but it would be wrong to call it a *fictitious* line; it is not a creature of thought, the product of a psychological process, but is only recognized or apprehended by thought." (Gottleb Frege, *The Foundations of Arithmetic*, 2d ed., trans. J. L. Austin [Oxford: Blackwell, 1980], 35.) It may be the case that arithmetic itself, though not a "creature of thought," is similarly only recognized by thought but not fully apprehended by it.

[34]For an overview of the issues that pertain to the various views, see "Economic Trinity, The" in Michael O'Carroll's fine work *Trinitas: A Theological Encyclopedia of the Holy Trinity* (Wilmington, DE: Michael Glazier, Inc., 1987), 94–6. I consider the economic Trinity to be an ontological "subset" of the immanent Trinity, but not a proper one.

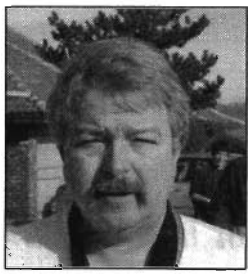
[35]For example, devise an analogy that attempts to illustrate the divine perichoresis.



Random Worms: Evidence of Random and Nonrandom Processes in the Chromosomal Structure of Archaea, Bacteria and Eukaryotes

Glenn R. Morton and Gordon Simons

One of the central debates in Christian apologetics concerns the role of chance and randomness within living systems and the presumed incompatibility of chance with complex organisms containing high informational content. In order to address this issue, the chromosomal organization of genes for ten different species of varying levels of complexity was examined for evidence of randomness in the gene structure. The results show an interplay of random and nonrandom processes with the more complex eukaryotes evidencing more randomness in their genetic structure than is found in the simpler prokaryotic organisms: bacteria and archaea. While almost all anti-evolutionary views reject any role for chance or randomness in biology, we find that the Bible supports a much more compatible perspective.



Glenn Morton

Biology and chance

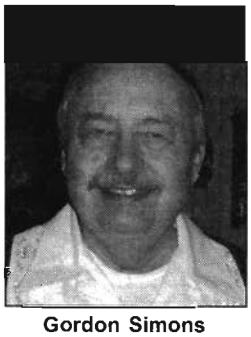
One of the philosophical issues about which Christians have debated over the past century concerns the role of chance in the biological realm. Many Christians have rejected any role for chance. The conservative creationist Henry Morris states: "Chance and design are antithetical concepts."[1]

It is not only Christians opposed to evolution who reject chance in the biological realm. Rejection of chance in the biological realm is a common trait across religious and theological boundaries. The Jewish anti-evolutionist, Lee Spetner writes: "The information required for large-scale evolution cannot come from random variations."[2] (While noting that this second quote uses the word *random* rather than *chance*, we will not attempt to infer whether the author meant to convey a distinction. A discussion of terminology appears later.)

A member of the Reunification Church, Jonathan Wells wrote: "Furthermore, the integrated complexity of developmental programs cannot plausibly be attributed to chance."[3]

And even Islamic anti-evolutionists take the same position:

> Laboratory experiments and probabilistic calculations have definitely made it clear that the amino acids from which life arises cannot have been formed by chance. The cell, which supposedly emerged by chance under primitive and uncontrolled terrestrial conditions according to evolutionists, still cannot be synthesized even in the most sophisticated, high-tech laboratories of the 20th century.[4]



Gordon Simons

A major objective of the Intelligent Design movement has been to show that chance cannot work. Dembski states: "Now a little reflection makes clear that a pattern need not be given prior to an event to eliminate chance and implicate design."[5]

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Article

Random Worms: Evidence of Random and Nonrandom Processes in the Chromosomal Structure of Archaea, Bacteria and Eukaryotes

God ordered or allowed the use of [chance] at critical places in the biblical history. If God is incompatible with chance in his dealings with this world, it seems odd that he allowed and commanded the use of such systems.

There are many other Christians of varying theological persuasions who reject the role of chance in biology.[6] Indeed, if this position is not the majority position in conservative Protestant theology, then it is very close to it.

Finally, we observe that Christians appear much more troubled by assertions of chance in biology than by chance in the nonlife sciences, for instance, in physics with the decay of nuclei.

The Bible and Chance

One of the difficulties raised by the rejection of chance in nature lies in the fact that God ordered or allowed the use of such systems at critical places in the biblical history. If God is incompatible with chance in his dealings with this world, it seems odd that he allowed and commanded the use of such systems. The *Urim and Thrummim* which the priest carried is widely believed to have been a tool for casting lots before the Lord.[7] The Hebrews believed what Prov. 16:33 says: "The lot is cast into the lap, but every decision is from the Lord." Proverbs 18:18 would indicate that the Jews thought God was the true decision maker when chance was involved. That verse says: "Casting the lot settles disputes and keeps strong opponents apart." In 1 Chron. 24:1-5, 1 Chron. 24:31, and 1 Chron 25:8, David cast lots to determine the order of the service for the sanctuary officials. God used the chance lots of the sailors to identify Jonah as the source of their troubles (Jon. 1:7). In Lev. 16:8, God told the Israelites to cast lots for the sacrificial goat. God told Joshua to cast lots in order to identify Achan, the guilty keeper of the Canaanite booty. In Josh. 18:8, we see Joshua casting lots for the assignment of land to the various tribes. In Acts 1:24-26, the disciples used chance, the casting of lots, to determine who should take over the apostolic ministry of Judas. Because of the biblically widespread use of chance to determine God's will, it is truly amazing that many modern Christians reject chance in biology as being totally incompatible with God's control.

If God cannot control chance, how can he control the lots above? God predetermined the result yet used a tool of chance. If God cannot use chance, then one must logically conclude that God did not foreknow how the land would be divided among the tribes, that God did not foreknow that Jonah would be picked, that God did not foreknow that Achan was the one who would be chosen or that Matthias would step into the apostolic line. This is a position which basically says that God is not omnipotent or omniscient. If God can use chance in his dealings with Israel and the early church, then why do we say he has no ability to use chance in biology? God can, has, and does control the stochastic process even if we do not understand how it happens.

One thing Christians must keep in mind is that our perspective on chance is not God's. Humans are not always able to distinguish between appearance of chance and the actuality of chance. But we cannot say that God is equally so limited. The molecules in a gas move according to deterministic laws, but the Maxwellian distribution of their velocities gives the appearance of chance. On the other hand, quantum phenomena appear to be the actuality of chance. But that might not be the view from God's perspective given the biblical references above. In biology, we see the fertilization of an egg as the result of a random or nearly random event. A single sperm may have only a one in fifty billion chance of being the "lucky" winner of the race to the egg. Yet God proclaims through Jeremiah: "Before I formed you in the womb I knew you, before you were born I set you apart" (1:5, NIV). If God were unable to control chance, why would he make such a statement?

Biological Evidence for Chance?

In the past, it has been difficult to actually test the chance hypothesis in biological systems. The discussion has revolved too often around debatable probability arguments. The standard argument says that there are too many possible combinations in proteins, or too many possible combinations in DNA/RNA for working sequences to be found by random mutation. These arguments are based on the assumption that very few sequences out of the entire ensemble of possibilities would be capable of performing the sought for task. Examples are legion but Gange provides a good one. He says:

> Hemoglobin contains two trains totaling 574 cars—each selected from among twenty kinds of amino acids. The num-

> ber of ways we can assemble these hemoglobin trains is so vast that it is a trillion trillion (repeat twenty times more) times the entire number of stars in the universe, despite this, only one combination known to man carries oxygen most efficiently in your blood.[8]

The weakness of this argument is that Gange cannot prove the last phrase. How can he *know* that only one combination carries oxygen most efficiently? How can he *know* that hemoglobin is it? Since he has no way of comparing the efficiency of hemoglobin against all other possible molecules of that length, much less comparing it to molecules of shorter and longer length, his argument rests upon an untested assumption. On the evolutionary side, this argument is difficult to counter because, like Gange, one too cannot search and find a more efficient molecule so the argument boils down to an opinion about what is unobserved and what is unknown about biological molecules. One can have an opinion about such matters, but neither side can say much worth listening to scientifically.

Genome-sequencing projects provide a way to look at the genetic organization of various organisms ... These data provide an excellent platform from which to examine the role of randomness.

Is there a way to break out of this opinion-dominated trap? We believe there is, and the genome-sequencing projects provide a way to look at the genetic organization of various organisms. The genomes of hundreds of organisms have been sequenced in various mapping projects. These data provide an excellent platform from which to examine the role of randomness. If random processes have been active in the genome, then the structure of the chromosome should be consistent with what is expected from a random process. If there is no evidence for random processes and the genome is organized via nonrandom processes, then predictions from nonrandom models of the genome should be possible. In this article, we will test the role of randomness and nonrandomness by looking at the organization of the genes along the chromosomes.

We have examined the genetic organization for six bacteria from five species, two species of the archaea, and a plasmid found in *E. coli*. These organisms in general have one circular chromosome, the only exception being *Vibrio cholerae* which has two chromosomes, the second of which originally may have been a plasmid. At a more complex level, we also have examined the sixteen chromosomes of yeast; the eight chromosomes of the fruitfly, *Drosophila melanogaster*; and the six chromosomes of the nematode, *Caenorabditusus elegans*. We also examined but rejected as too incomplete at this time, the human genome. The results of our study show some interesting features of genetic organization relating to the central philosophical question of this article—What is the role of chance in biology?

Definitions

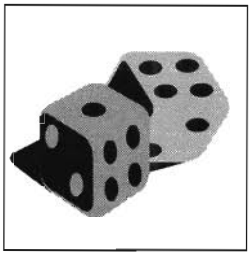
Here we will discuss *chance* and *randomness* in their varying usages.

It seems plausible to us that the widespread rejection of chance (and randomness) within the biological realm among various religious peoples is due to a widespread perception that the word chance rules out God as the causative agent—that it leaves no room for any understanding of intelligent design. In contrast, we have observed that the Bible conveys no such concern: chance mechanisms are fully under the sovereign control of God. Or, at the very least, they are never at odds with his permissive intents.

Russian mathematician A. N. Kolmogorov, in 1933, is credited with providing the first axiomatic definition of probability—a definition precise enough to gain the widespread acceptance of mathematicians, yet comprehensive enough to be applicable to a wide range of phenomena.[9] His definition of probability places on a firm foundation the notions of *chance, randomness, random variables, random processes,* and a variety of related concepts, making possible a rigorous development of the subject of probability.

Mathematical treatments of probability date back to the seventeenth century when French mathematicians Blaise Pascal and Pierre de Fermat analyzed various questions of gaming and gambling. Over the intervening centuries, the subject has engaged the serious attention of many well-known scientists and mathematicians, among them Huygens, Jacob Bernoulli, Abraham de Moive, Pierre de Laplace, Chebyshev, Markov and von Mises. Also, the subject of statistics uses probability theory at its foundation. Early uses of statistics to model biological phenomena trace back to Gregor Mendel[10] and, more recently, to R. A. Fisher, who published widely on such subjects as eugenics, Mendelian inheritance, "Darwinian Evolution by Mutation," "The Evolution of Dominance," and much more. Moreover, he contributed widely, in fundamental ways, to the development of statistical tools and concepts.

So presently there is in place a widely applicable set of mathematical and statistical tools and concepts for modeling and analyzing biological structures and phenomena from a probabilistic perspective. However, a serious lack of understanding of these tools and concepts among nonscientists exists. In particular, most Christians lack a clear conceptual understanding of chance. Still, we believe it safe to assert that most Christians do have a fairly



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Random Worms: Evidence of Random and Nonrandom Processes in the Chromosomal Structure of Archaea, Bacteria and Eukaryotes

For the purposes of this article, we will opt for an intuitive definition of randomness. In particular, we will take random to mean a process relating to or being defined by events with a particular probability distribution. In this definition, there is no theological implication at all.

well-developed perception of what can be summarized by the phrase "chance mechanism" (such as dice, the roulette wheel, and coin tossing). Below, we will appeal to this intuitive understanding.

For the purposes of this article, we will opt for an intuitive definition of randomness. In particular, we will take *random* to mean a process relating to or being defined by events with a particular probability distribution. In this definition, there is no theological implication at all. We think this is an important point to realize about probability in the theological context. Saying that something has a definite probability of occurrence is not saying that something is totally unpredictable. Probabilities allow the prediction of the system behavior for a large number of iterations. If I have a coin, I can predict with a great deal of certainty that after two million flips of the coin, there will be very close to a 50-50 split between heads and tails. Probability and prediction are not totally incompatible.

We must place another caveat on what is meant by randomness. Randomness can only be measured against a model of randomness, i.e., a stochastic process or system. Such a process or system is inherently a mathematical "recipe" for manipulating the random occurrences and producing an output. The output may be determined from the input random events only after a complex calculation. To start simply, a coin is a simple 2-state stochastic (probabilistic) system. The die used on board games is a 6-state stochastic system. In these two examples, the probability of occurrence for each of the different states is identical, ½ and 1/6 respectively. But that does not have to be the case. One can manipulate the probabilities on a die and have an unequal probability among the six choices. These are termed "loaded dice." Loaded dice will output a sequence of numbers that appears nonrandom if compared to the normal unloaded dice.

Other stochastic systems can be even more complex. The chance of a particular outcome might depend upon the state of affairs at the time the die is rolled. These are called Markov chains. The probability of an outcome depends upon the system state that exists *at the time.* While not subject to random chance, we do see an illustration of this type of behavior in languages. If, in a sequence of English letters, the letter q is the current state of affairs, one can be nearly 100% certain that the next letter is a u. If one counts the symbols, one will generally find that e is a more common (higher probability) letter than z. Cryptologists use such frequency analysis to decipher coded texts. They arrive at a probabilistic model of what letters are intended by the coder. Probability models are also used in computer networks to avoid bottlenecks. Therefore, probabilistic models are not incompatible with engineering design.

How does one decide if a given sequence is random or influenced by a stochastic system? First, randomness is something that cannot be proven. After comparing a sequence of numbers with a given stochastic process, all one can ever really say is that the sequence is consistent with it being randomly generated by a particular stochastic process or that it is inconsistent with such a process. Secondly, if one is trying to decide if the numerical sequence 2,2,1,2,1,1,1,2 ... is random one needs to be sure that this sequence is the output of a 2-state stochastic system. If such a sequence was the outcome of a 6-sided die, the outcome is entirely *nonrandom when compared to an equal probability six-state system.* But if one has a Markov chain with heavy probability weighting for 1's and 2's, if the current state is a 1 or 2, then this output is entirely consistent with such a stochastic process. Thus, when examining the patterns seen in the gene strings, we need to examine several different probability models.

Chromosomal Organization

A chromosome consists of four nucleotides laid out in a double helix. This is the lowest level of organization for the chromosome. There are higher levels. Sequences of nucleotides are functionally connected forming a gene. Genes are systems of nucleotides which perform the function of providing information for the construction of proteins. This is not the end of the organization seen in the genome. At a still higher level of organization, the genes are strung out along the chromosome in groups of genes which all have the same transcription direction. The transcription direction is the direction in which the cellular machinery must read the

gene in order to recover the proper protein information. There are two complementary strands of DNA in organisms, and genes can be found on either strand. Genes found on one strand are transcribed in one direction along the chromosome, and genes found on the opposite strand are transcribed in the other direction. Groups of genes with the same transcription direction are called *gene clusters* or *strings*. We will use the latter term, and to our knowledge this term is new.

A string is merely the consecutive genes transcribed in the same direction. It is the strings which will form the basis for our analysis. Intuitively, to a nonbiologist, it would seem that it really should not matter which direction a gene is transcribed. As we will see, this is not what is observed in the strings. Direction does matter and the amount it matters depends upon the organism.

As noted above, a gene lies along a chromosome and the biochemical machinery reads the nucleotide sequence of the gene and eventually translates that information into a protein. The gene can be read only in one direction by the machinery. But that direction is not constant for all genes on a given chromosome. Approximately half of the genes are transcribed in one direction and the other half in the opposite direction. For instance, *M. genitalium* has 297 genes which must be transcribed in the positive direction and 225 which must be transcribed oppositely in the negative direction. These genes are organized into 86 different strings—contiguous genes which must be transcribed in the same direction at the same time. String length is merely the number of genes in a string. Figure 1 below shows the string lengths for *M. genitalium*, the organism that, until recently, was the shortest known genome.

When one lists the sequence of numbers which represent the number of genes in a string, a question presents itself of immense philosophical importance to the issue of chance and randomness in biology. Is this sequence of numbers random or not? If it is random, then it would be clear evidence of random or chance processes occurring in biology and would directly speak to the issues raised in this article. If they are not random, but are ordered, then they would support the claims of the apologists that chance and random processes are not involved in biological organisms.

Why do gene strings exist? In the process of converting the information contained in DNA into proteins, a gene is first copied into mRNA which then in turn is read by the ribosome which produces the protein. If many mRNA copies of a gene are made, the ribosome will produce many copies of the protein. Two genes that are next to each other on the same DNA strand are transcribed into mRNA together. In these cases, the ribosome receives an mRNA molecule encoding for several proteins. The ribosome will recognize each mRNA separately and produce the correct protein. This is a useful procedure as it allows genes which are linked to the same biochemical processes to be transcribed together and allows the cell to operate efficiently. If several enzymes are required for a given reaction, this procedure ensures that all the proteins are created together. As we will see, this procedure only applies to the bacteria and archaea and not to the "higher" eukaryotes.

The Probability Models Compared with Gene Strings

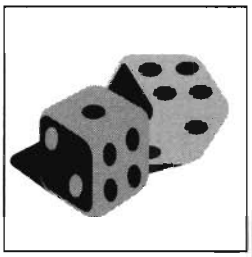
We downloaded the huge flat files for the organisms listed in Table 1 from the National Center for Biotechnical Information and extracted the relevant gene string data arranged in chromosomes.[11] In the case of *D. melanogaster*, the full genome is not sequenced. The gene containing regions have been sequenced but regions of repeats have not. Thus, they are listed in Table 1 in scaffolds, which are regions of the contiguously sequenced data. It appears that groups sequencing *D. melanogaster* will maintain this format for the final version.

Using standard statistical techniques,[12] three different stochastic models were compared with the gene data. The reader is referred to Hutchison, et al. for the technical details of each model.[13] We will describe each of the models in nontechnical terms hoping to give the reader a basic understanding of the issues. As mentioned above, randomness can only be ascertained by comparing the sequence of numbers with a stochastic model. If a given model does not produce a sequence that matches the observed string size distribution, then the model is wrong and another model must be found.

Model 1 is the simplest. In this model, we compared the chromosomal organization with a statistical model which assumes a probability distribution similar to that of a coin-

Strings 1–20	10	5	15	3	2	1	3	2	8	1	5	8	1	2	14	1	29	1	19	1
Strings 21–40	5	2	1	1	66	1	3	1	2	1	2	3	20	1	20	1	6	9	9	1
Strings 41–60	5	13	1	9	6	1	3	19	1	11	2	9	1	14	3	8	3	2	3	1
Strings 61–80	2	1	1	3	2	1	3	1	3	2	3	1	1	26	1	14	4	4	5	13
Strings 81–86	2	1	1	4	1	11														

Figure 1. String length in *M. Genitalium*, the numbers represent the numbers of genes in a row with the same orientation.



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In Table 1 we list the number of genes per string (n/s) and then the 3 standard deviation range for each entry. When we compare the string lengths observed with the expected range for the coin-flip model, we see significant deviations from that in Table 1 among the archaea and bacteria. ... The clear conclusion is that this random model totally fails to account for the bacterial data.

Genome	Model 1 Strain	Domain	# Genes n	# Strings s	n/s	3 Standard Deviation Range
Mycoplasma genitalium	G-37	Bacteria	522	86	6.07	1.73-2.26
Bacillus subtilis	168	Bacteria	4222	1092	3.78	1.91–2.09
Escherichia coli	K12	Bacteria	4405	1292	3.41	1.91–2.09
Escherichia coli	157:H7	Bacteria	5410	1472	3.68	1.91–2.08
Vibrio cholerae 1	N16961	Bacteria	2769	876	3.16	1.88–2.11
Vibrio cholerae 2	N16961	Bacteria	1115	398	2.80	1.82–2.17
Aeropyrum pernix	K1	Archaea	2746	1612	1.70	1.88–2.11
Archaeoglobus fulgidus	DSM4304	Archaea	2486	738	3.37	1.87–2.12
Campylobacter jejuni		Bacteria	4102	1094	3.75	1.91–2.09
Plasmid F		Bacteria	111	32	3.47	1.43–2.57
	Chromosome					
Saccharomyces cerevisiae	1	Eukaryote	112	62	1.80	1.43–2.57
Saccharomyces cerevisiae	2	Eukaryote	446	237	1.88	1.72–2.28
Saccharomyces cerevisiae	3	Eukaryote	186	84	2.21	1.56–2.44
Saccharomyces cerevisiae	4	Eukaryote	856	467	1.83	1.79–2.21
Saccharomyces cerevisiae	5	Eukaryote	309	151	2.04	1.66–2.34
Saccharomyces cerevisiae	6	Eukaryote	145	72	2.01	1.50–2.50
Saccharomyces cerevisiae	7	Eukaryote	609	319	1.91	1.76–2.24
Saccharomyces cerevisiae	8	Eukaryote	295	149	1.97	1.65–2.35
Saccharomyces cerevisiae	9	Eukaryote	233	126	1.84	1.61–2.39
Saccharomyces cerevisiae	10	Eukaryote	416	220	1.89	1.71–2.29
Saccharomyces cerevisiae	11	Eukaryote	355	189	1.87	1.68–2.32
Saccharomyces cerevisiae	12	Eukaryote	571	313	1.82	1.75–2.25
Saccharomyces cerevisiae	13	Eukaryote	513	273	1.88	1.74–2.26
Saccharomyces cerevisiae	14	Eukaryote	438	225	1.94	1.71–2.29
Saccharomyces cerevisiae	15	Eukaryote	597	319	1.87	1.75–2.25
Saccharomyces cerevisiae	16	Eukaryote	519	289	1.79	1.74–2.25
Caenorhabditis elegans	1	Eukaryote	2411	1140	2.11	1.88–2.12
Caenorhabditis elegans	2	Eukaryote	2962	1384	2.14	1.89–2.11
Caenorhabditis elegans	3	Eukaryote	1788	834	2.14	1.85–2.14
Caenorhabditis elegans	4	Eukaryote	2453	1149	2.13	1.87–2.12
Caenorhabditis elegans	5	Eukaryote	4325	1961	2.20	1.91–2.09
Caenorhabditis elegans	X	Eukaryote	2643	1208	2.18	1.88–2.11
	What are called Scaffolds					
Drosophila melanogaster	1	Eukaryote	1119	594	1.88	1.82–2.17
Drosophila melanogaster	2	Eukaryote	672	378	1.77	1.76–2.23
Drosophila melanogaster	3	Eukaryote	596	297	2.00	1.75–2.24
Drosophila melanogaster	4	Eukaryote	1034	555	1.86	1.81–2.18
Drosophila melanogaster	5	Eukaryote	1699	910	1.86	1.85–2.14
Drosophila melanogaster	6	Eukaryote	116	66	1.75	1.44–2.55
Drosophila melanogaster	7	Eukaryote	28	15	1.86	0.86–3.13
Drosophila melanogaster	8	Eukaryote	568	313	1.81	1.74–2.25
Drosophila melanogaster	9	Eukaryote	286	174	1.64	1.64–2.35
Drosophila melanogaster	10	Eukaryote	264	148	1.78	1.63–2.36
Drosophila melanogaster	11	Eukaryote	1756	952	1.84	1.85–2.14
Drosophila melanogaster	12	Eukaryote	142	80	1.77	1.50–2.50
Drosophila melanogaster	13	Eukaryote	2953	1593	1.86	1.90–2.11
Drosophila melanogaster	14	Eukaryote	48	24	2.00	1.14–2.86
Drosophila melanogaster	15	Eukaryote	86	44	1.95	1.35–2.65
Drosophila melanogaster	16	Eukaryote	63	28	2.25	1.24–2.76
Drosophila melanogaster	17	Eukaryote	1787	978	1.83	1.85–2.14
Drosophila melanogaster	18	Eukaryote	53	28	1.89	1.18–2.82
Drosophila melanogaster	19	Eukaryote	30	17	1.76	0.90–3.10

Table 1. Genome Data.

flip and see if such a statistical model can explain the observed chromosomal organization. It assumes that the transcription direction for each gene has a probability of 0.5 and that the probabilities are independent of each other. This flip-of-the-coin model would predict that the average number of genes on a string should lie near 2 per string. That is not what is observed in chromosomal organization. In Table 1 we list the number of genes per string (n/s) and then the 3 standard deviation range for each entry. When we compare the string lengths observed with the expected range for the coin-flip model, we see significant deviations from that in Table 1 among the archaea and bacteria. If the string lengths are consistent with this model, the n/s value has approximately a 99% chance of falling between the 3-sigma values. The clear conclusion is that this random model totally fails to account for the bacterial data. However, the gene strings of the "higher" eukaryotes, like yeast and *C. elegans*, are clearly more randomized when measured against this model. Indeed, they seem to lie within the statistically predicted values given by this flip-of-the-coin model, or nearly so. This is a surprising result when the above statements are taken into account. Moreover, a slight modification of this flip-of-the-coin model yields a very compelling fit for each of the three eukaryotes, a fit that is good enough to pass a demanding goodness-of-fit test. The standard flip-of-the-coin model assigns p = 0.5 as the probability that a given space between adjacent chromosomes is a transition point. The modification for *D. melanogaster* is to assign p = 0.541 (the very same value of p for all 19 scaffolds!). Comparable, excellent fits are possible for yeast, with p = 0.530 (the same value of p for all 16 chromosomes!), and for *C. elegans*, with p = 0.463 (the same value of p for all six chromosomes!). The quality of the fits under p = 0.5 are not good enough to pass the demanding statistical test referred to above. We will return to the philosophical implications of this below.

Does this mean that the bacteria are incompatible with random chance when their gene strings are examined? Two other models were tested attempting to determine if a stochastic model could reasonably match the observed gene string length.

Model 2 starts with the observed data for each species—the number of genes and the number of strings. Labeling the space between two strings as a transition point, the number of transition points is equal to the number of strings (except when there is only one string—and no transition point). Model 2 next distributes the transition points randomly among the n available spaces between the genes. Then the distribution of the resulting string lengths is compared with the actual string lengths of the chromosome. In turn, the distribution of string lengths

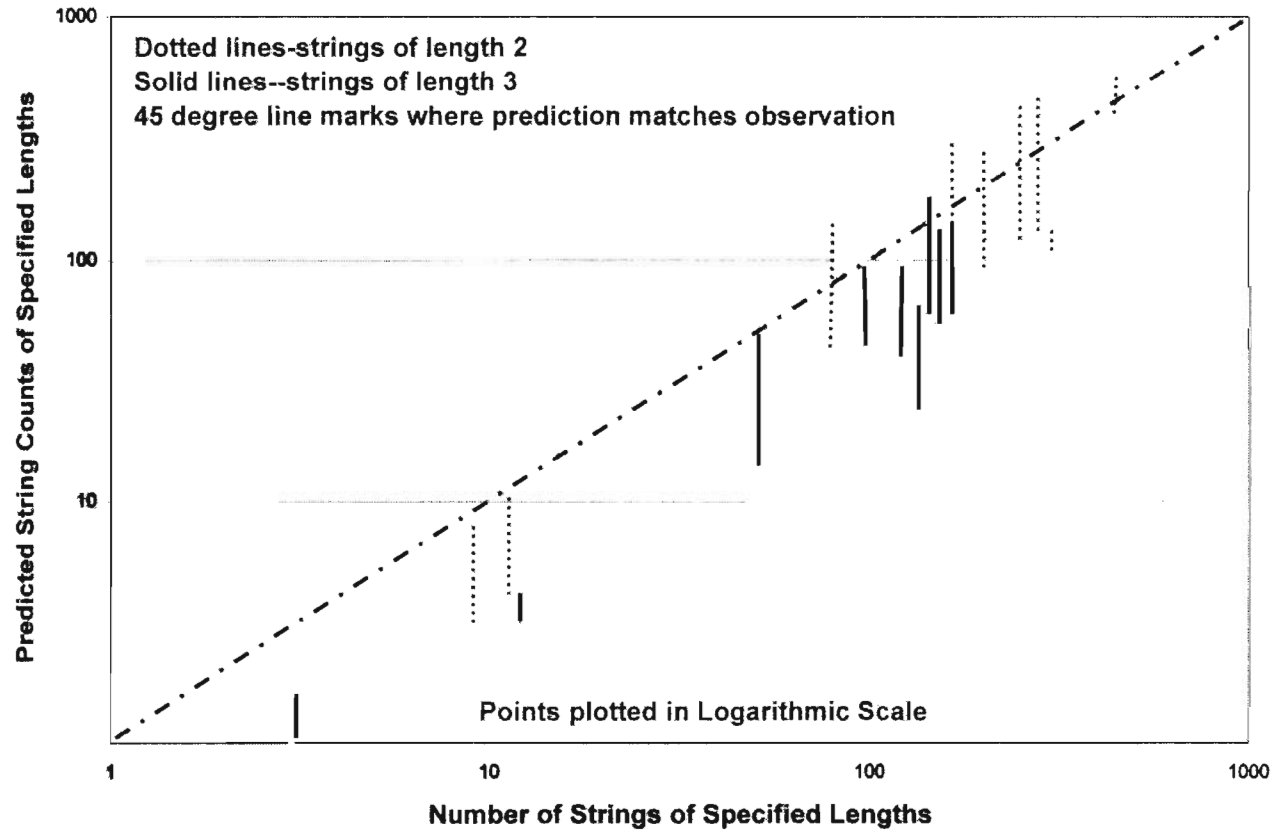

Figure 2. The results of Model 3.

Bacteria appear to have a genetic structure that is decidedly nonrandom. And one might be tempted to conclude that life indeed is a nonrandomly organized phenomenon. ... But this does not explain why the more complex eukaryotes studied here fit Model 1 (the flip-of-the-coin model) so well, ...

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is compared with that in the genome. This could be called the slice-and-dice model where the sequence of genes is randomly cut and every other segment inverted. This model underestimates the actual number of strings of length 1 a bit, estimates the strings of length 2 approximately correctly, and overestimates the number of strings of length 3 a bit, and fails to account for the extraordinary length of the longest strings found in the chromosomes. There is more variability in the string lengths of bacteria than can be accounted for by randomness described by Model 2.

Model 3 assumes that the orientations of the genes (and hence the length of each gene string) correspond to the signs of n correlated (mean zero, variance one) Gaussian random variables. Placing reasonable mathematical constraints on the correlations leads to a set of three equations with four unknowns. The values of these unknowns precisely determine the distribution of the string lengths. One can solve these equations numerically to obtain a range of solutions, and, thus, a set of possible string-length distributions. It is observed in Figure 10 of Hutchison, et al. and Figure 2 in this article that these fit the observed data well.

Implications of this Work

The most obvious implication is that bacteria appear to have a genetic structure that is decidedly nonrandom. And one might be tempted to conclude that life indeed is a nonrandomly organized phenomenon. This certainly fits the preconceptions of many Christian apologists and laity who see randomness as a threat to a particular theological position. Many apologists claim that order found in biology is evidence of God's design.[14] But this does not explain why the more complex eukaryotes studied here fit Model 1 (the flip-of-the-coin model) so well, and a slight modification extremely well. This goes against the common claim by apologists that "the information required for large-scale evolution cannot come from random variations"[15] and "... the integrated complexity of developmental programs [cannot] plausibly be attributed to chance."[16]

Why is it that *C. elegans*, a nematode that is more complex than bacteria, possesses a genetic structure that appears more randomized than the much simpler bacteria and archaea? *C. elegans* has a nervous system, muscle cells, a hypodermis, an excretory system, and a specialized reproductive system. As we saw above, the bacteria have the genes for entire biochemical systems located in the same string; from the yeast to the *C. elegans* and on up to humans (whose incomplete and early genome information has been examined by the authors), there is no such order (imposed by need), and the gene's transcription direction is free to be mutated randomly. It is hard to avoid the conclusion that the more complex organism is more "randomized."

The data we present here has implications to the common belief that random mutations and selection cannot improve a system. Such views are illustrated by that of Davis and Kenyon who said:

> A mutation in a coding gene, then, can be looked at as a random change in functional information. As a unit of functional information in the cell, a coding gene is much like a word (a unit of meaningful information) in a book. What do you think would happen if we randomly changed the letters in some of the words in this book? Would the book be improved? On the contrary, it is probable that random changes in the words of this book would decrease rather than increase the meaningful information they carry.[17]

The mathematically more randomized state of the eukaryote gene strings we examined is not quite the equivalent of randomly changing the letters in this article, but it is the equivalent of randomly reversing the direction in which the words are read. While the reading of the sentence, "Information is hurt by random reversal of the word directions" is made more difficult by laying it out as "noitamrofni si truh yb modnar lasrever fo eht drow snoitcerid" the same procedure applied to genes and gene systems seems to make for more complex beings—yeast, nematodes, fruit flies, and humans. This clearly shows that one ought not draw the analogy between words and genetic systems too closely. Words are not genetic systems and genetic systems are not words.

For those who truly understand information theory, the above results should not be

surprising. Hubert Yockey has stated that it is mathematically fundamentally impossible to tell the difference between a random sequence and one that codes for an organism![18] Indeed, the higher the information content of a sequence the more random the sequence will appear from a mathematical point of view. This is what we see with the gene strings of the higher organisms.

The ability of the modified coin-flip model to fit the observed gene string patterns seen in living systems calls into question the efficacy of William Dembski's methodology for determining design. Dembski wrote:

> Even so, complexity (or improbability) isn't enough to eliminate chance and establish design. If I flip a coin 1,000 times, I'll participate in a highly complex (i.e., highly improbable) event. Indeed, the sequence I end up flipping will be one in a trillion trillion trillion ..., where the ellipsis needs 22 more "trillions." This sequence of coin tosses won't, however, trigger a design inference. Though complex, this sequence won't exhibit a suitable pattern. Contrast this with the previous sequence representing prime numbers from 2 to 101. Not only is this sequence complex, but it also embodies a suitable pattern. The SETI researcher who in the movie *Contact* discovered this sequence put it this way: "This isn't noise, this has structure."[18]

Dembski, like us, wants to conclude that living systems are designed. But Dembski's methodology for determining design, by his own admission, excludes anything that has the structure of a coin-flip model, which is exactly what we find in the patterns of the gene strings. Are we to conclude from this that the cells are not designed? No! What we can conclude is that Dembski's model is inadequate to the task he intends. Once again, as Yockey notes, organized sequences will appear the same as randomly generated sequences. As an example, consider the sequence "yjrvsyonstrfdjoty" which is a Caesar substitution cipher for "thecatintheredshirt." Both sequences contain the same meaning and semantical information. The only reason the latter, decrypted sequence does not look randomized is because of years of training in how to read letters in that order.

Conclusions

We have presented evidence for both random and nonrandom features of the chromosomal structure. The asymmetries in the gene directionality and the bacterial deviations from the predictions of our models must be due to nonrandom forces and mechanisms required for life to exist. But at the same time, there is already much evidence that the chromosomal organization of the eukaryotes is nearly consistent with a simple flip-of-the-coin model and show more randomization than do the bacteria and archaea.

It must be concluded from our study that many of the apologetical statements about living systems do not find unequivocal empirical support. The observation that the chromosomes of more advanced animals appear more random does not support the concept that information and randomness are incompatible. The higher informational content of the higher organisms will most assuredly be measured as greater randomness.

Many of the apologetical statements about living systems do not find unequivocal empirical support.

Secondly, the failure to find a completely suitable stochastic model for the bacteria and archaea does not mean that randomness does not operate on their chromosomal arrangement. What it means is that there are functional limitations caused by the differences in how bacteria and archaea, on the one hand, and eukaryotes, on the other, process the DNA's information into protein. Those differences cause bacteria to appear less random, but this also means that they appear more ordered. And since order is a property of static things (like highly ordered, but totally inert, mineral crystals), more order in a living system is an indication of less complexity.

Methods for determining design need to be robust enough to conclude that the structure of a cell is designed. If it cannot, then one of two propositions therefore must be true: (1) either the cell is not designed; or (2) the methodology is flawed. We prefer to believe that the current Dembski methodology is flawed.

The preference for short gene strings, which our data demonstrates, may have implications for origin of life issues. It shows that life at this level of structure is built up of repetitive, simpler systems which are amalgamated into the larger unit. Contrary to the perception that higher organisms should use larger and more complex organizational systems for their genomic information, they actually use a system of gene strings which are small and simple rather than large and complex.

Finally, Christian apologists need to incorporate chance and randomness into their world views. It is clear that the Bible teaches that God controlled chance and randomness at several crucial junctures in history. If he did this, then the controlling of chance and randomness in biology should be equally possible. Apologists should not ignore the observational fact that as we go from simple creatures to the more complex organisms, chromosomal organization appears to be much more influenced by random processes. Indeed, chromosomal structure at the complex end

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of the spectrum matches the predictions of very simple stochastic models. It does no good to claim that chance or random processes cannot produce more complex organisms, when those very organisms are measurably more random than are the simpler creatures.

In conclusion, we should all remember what God said to Job: "'Will the one who contends with the Almighty correct him? Let him who accuses God answer him!' Then Job answered the LORD: 'I am unworthy—how can I reply to you? I put my hand over my mouth. I spoke once, but I have no answer—twice, but I will say no more'" (40:2, NIV).

It seems to us that God is not scolding Job for his ignorance but rather for his lack of humility—by attempting to explain how God conducts his activities. Applied to our present discussion, we would dare to suggest that a significant degree of humility is needed by all Christians, to accept—in agreement with various biblical teachings—that God is perfectly capable of fully designing the various life forms we observe, however he pleases, in a way we surely do not understand, while presenting his handiwork to us mere mortals in a format that shows strong evidence of randomness. ✹

It does no good to claim that chance or random processes cannot produce more complex organisms, when those very organisms are measurably more random than are the simpler creatures.

Notes

[1]Henry M. Morris, "The Compromise Road," *Impact* 177 (March 1988): I, ii.

[2]Lee Spetner, *Not by Chance* (Brooklyn: The Judaica Press, Inc., 1998), vii.

[3]Jonathan Wells, "Making Sense of Biology," *Touchstone* (July/August 1999): 55.

[4]Adnan Oktar, "The Evolution Deceit," www.hyahya.org/16understanding03.php, accessed Sept. 23, 2001.

[5]William A. Dembski, "Signs of Intelligence," *Touchstone* (July/August 1999): 80.

[6]____, "On the Very Possibility of Intelligent Design," in J. P. Moreland, ed., *The Creation Hypothesis* (Downer's Grove: InterVarsity Press, 1994), 116; A. E. Wilder-Smith, *The Natural Sciences Know Nothing of Evolution* (San Diego: Master Books, 1981), 85; Phillip Johnson, "Creator or Blind Watchmaker," *First Things* (Jan. 1993): 12; Phillip Johnson, "Immodest Ambitions," *Books & Culture* (Sept. Oct. 1995): 29; Michael Behe, *Darwin's Black Box* (New York: The Free Press, 1996), 191–2; Robert F. DeHaan and John L. Wiester, "The Cambrian Explosion," *Touchstone* (July/August 1999): 65.

[7]See Exod. 28:30; Lev. 8:8; Deut. 33:8; Ezra 2:63; and Neh. 7:65. See also "Urim and Thummim" Trent C. Butler, ed. *Holman Bible Dictionary* (Nashville: Holman Bible Publishers, 1991) for more on this.

[8]Dr. Robert Gange, *Origins and Destiny* (Waco, TX: Word, 1986), 73.

[9]Available in the English translation of *Foundations of Probability Theory* (New York: 1950).

[10]Gregor Mendel *Experiments in Plant Hybridization*, (1865).

[11]www.ncbi.nlm.nih.gov/PMGifs/Genomes/allorg.html

[12]Most techniques used are found in any statistical textbook. Some special techniques of note are: F. N. David, "A Note on the Evaluation of the Multivariate Normal Integral," *Biometrika* 40 (1958): 458–9; W. F. Sheppard, "On the Application of the Theory of Errors to Cases of Normal Distribution and Normal Correlation," *Philosophical Transactions of the Royal Society of London Series A* 192 (1899): 101–67; W. F. Sheppard, "On the Calculation of the Double Integral Expressing Normal Correlation," *Transactions of the Cambridge Philosophical Society* 19 (1900): 23–66.

[13]Clyde Hutchison, Michael Montague, Glenn Morton, Michelle Opp, Gabor Pataki, and Gordon Simons (2001, unpublished manuscript); see also Gordon Simons and Glenn Morton, "The Gene-Orientation Structure of Eukaryotes," *Journal of Theoretical Biology* 22, no. 4 (2003): 471–5.

[14]Henry M. Morris, "The Power of Energy," in Walter E. Lammerts, ed., *Scientific Studies in Special Creation* (Grand Rapids: Baker Book House, 1971), 66; Randy L. Wysong, *The Creation-Evolution Controversy* (Midland, MI: Inquiry Press, 1976), 257; Henry Morris, *The Remarkable Birth of Planet Earth*, (Bloomington, MN: Bethany House, 1972), 1; ____, *Creation and the Modern Christian* (El Cajon, CA: Master Book Publishers, 1985), 214–5; A. E. Wilder-Smith, *Man's Origin, Man's Destiny* (Wheaton, IL: Harold Shaw, 1968), 57.

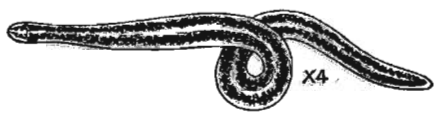
[15]Lee Spetner, *Not by Chance* (Brooklyn: The Judaica Press, Inc., 1998), vii.

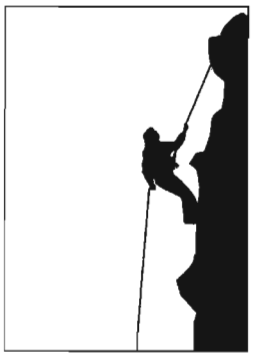
[16]Wells, "Making Sense of Biology," 55; see also Rick Wade, "Defeating Darwinism," in Ray Bohlin, ed., *Creation, Evolution, & Modern Science* (Grand Rapids, MI: Kregel Publications, 2000), 98.

[17]Percival Davis and Dean H. Kenyon, *Of Pandas and People* (Dallas: Haughton Publishing Co., 1993), 66.

[18]Hubert Yockey, *Information Theory and Molecular Biology* (Cambridge: Cambridge University Press, 1992), 81–2.

[19]Dembski, "Signs of Intelligence," 79.





Challenges and Opportunities for Christians in Science at the Beginning of Their Careers

Johnny Lin, Pam Veltkamp. Randall DeJong, Steven Hall, Ruth Douglas Miller, and Don Munro

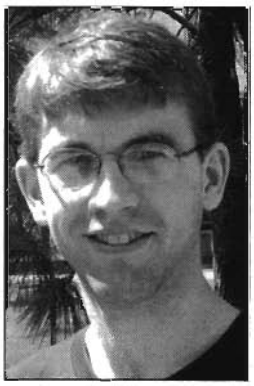
The 2001 American Scientific Affiliation (ASA) annual meeting held at Kansas State University, July 20–23, featured a panel discussion entitled "Challenges and Opportunities for Christians in Science at the Beginning of Their Careers." The members of the panel were all within the first twelve years of their careers and included: Randall DeJong, a Ph.D. student in biological sciences at the University of New Mexico; Steven Hall, an assistant professor of Biological and Agricultural Engineering at Louisiana State University; Johnny Lin, a postdoctoral researcher in climate dynamics at the University of Colorado at Boulder; Ruth Douglas Miller, an associate professor of electrical engineering at Kansas State University; and Pam Veltkamp, an associate professor of chemistry at McMurry University. Don Munro, executive director of the ASA, moderated the discussion.

The panel represented a wide-range of academic experiences, including Christian and non-Christian universities, different places on the career ladder, and different experiences with integrating work with family and marriage. The session was informal, with much exchange of ideas between panel and audience members, and greatly benefitted from the wealth of experience found in the audience. In this article, we share thoughts stemming from this discussion, focusing on three topics:

- Relating to the scientific community
- Living obediently to Christ
- Building communities and networks of encouragement

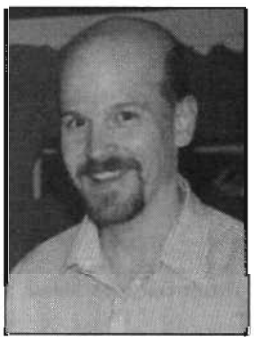
Relating to the Scientific Community

The notion of a conflict between Christian faith and science has been influential in academia in the United States for much of the twentieth century, and many Christians starting careers in science have had to struggle with the questions it poses. What is my relationship with the scientific community? Will my colleagues be hostile or receptive to my faith, and why or why not?



Randall DeJong

Some in the panel have experienced opposition to open expressions of their faith. Munro recounted how once during graduate school he was asked to speak about creation/evolution issues at the local InterVarsity Christian Fellowship undergraduate student weekly meeting. In the room was a cub reporter for the student newspaper who reported Munro's statements but recorded them erroneously or out-of-context. Naturally, this came back to Munro's department and his advisor, who told him, "Keep your mouth shut until you're finished with your Ph.D., and then you can say anything you want!"



Steven Hall

For Hall, hostility to his faith has been personal, as opposed to departmental or cul-

Randall DeJong *recently received his Ph.D. in Biology from the University of New Mexico. He currently works as a postdoctoral research scientist at UNM, studying the molecular genetics of human schistosome parasites and their host snails. He also enjoys volunteer work with InterVarsity at UNM.*

Steven Hall *is an assistant professor in Biological and Agricultural Engineering at Louisiana State University and the LSU Agriculture Center in Baton Rouge, Louisiana. He has degrees in mechanical, agricultural, and biological engineering from State University of New York at Buffalo, University of California at Davis and Cornell University. He and his wife Rebecca teach at churches and universities and participate in a variety of creation care issues. They welcomed Grace, a gift from God, born in September 2002.*

Student and Early Career Scientists Corner

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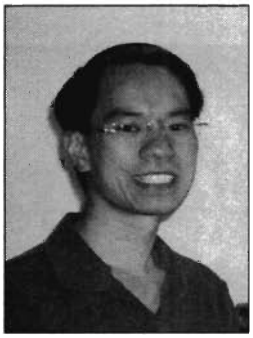
tural. Specifically, while there has been no formal statement limiting his ability to express the basics of his faith, some faculty and staff members have dramatic anti-religious responses. Hall says this has allowed him to witness compassionately about the good side of faith, and he does not condone abuse in the name of Christianity.



Johnny Lin

For Miller, the opposite has been true. In the Department of Electrical Engineering at Kansas State University, 20 of the 24 faculty are confessing Christians. No one she knows has become upset with her because of her faith. In contrast, Miller is often frustrated that the staffs of some of the Christian fellowship groups on campus continue to insist that the university is hostile to Christianity.

Veltkamp, being a faculty member at a Christian college, has not encountered hostility to her faith. However, she has found the tables are turned somewhat. Some of her students, from Christian backgrounds, enter college with doubts about science, such as the validity of evolutionary theories or estimates of the age of the earth. For instance, a few years ago two students were referred to Veltkamp by one of the religion professors: there had been a discussion of the age of the earth in their religion class, and the students were uncomfortable with the concept of an old earth, as well as with the idea that this concept would be taught and accepted at a Christian college, in a religion class. Veltkamp had the opportunity to discuss with these students her own faith journey and how she saw Christian faith and science working together. She also provided them with a few copies of *Perspectives On Science and Christian Faith* to peruse for other viewpoints on their questions.

Ruth Douglas Miller

Lin's experience has been that interest from others in issues of faith, whether positive or negative, has not been very great. He has encountered politeness and respect from his peers, but there has been a barrier to carrying on conversations of greater depth. While he has encountered some antagonism and some genuine interest, issues concerning faith have mostly been ignored.

Such a variety of responses underline the obvious: the relationship between a Christian in science and the scientific community is complex, characterized by everything from hostility to indifference to receptivity. For Christians just starting their scientific careers, the challenges and opportunities in relating to colleagues are also multi-faceted. We cannot assume our colleagues will respond a certain way to our faith. We must instead learn to discern the motivations, attitudes, and views that make up the individual, community, and cultural responses from our scientific colleagues, and dream up imaginative ways to engage them: to meet hostility with truth and love, to counter indifference with the nurturing of interest, and to encourage receptivity with a call to mutual challenge and growth.

Living Obediently

Christian discipleship, being holistic and all-encompassing, also demands an obedient response from the Christian scientist as a scientist. What is the role of excellence for a Christian in science? How do we build a larger vision, to connect our scientific work with the worship and following of God? And how do we accomplish all this while negotiating tenure?

Role of Excellence

Almost every scientist wishes to "succeed" and make an important contribution to his or her field. But how important should this desire be? How integral is being "first-rate" in our fields to our calling as Christians in science? Is it "okay" to be "second-rate" in our field, as long as we are "first-rate" in our walk with Christ?

Hall felt that the core issue is excellence at what cost: the ends do not justify the means, and in the final analysis one needs to be able to live with oneself. In his case, he had to turn down an attractive job offer that required "ethical flexibility." He ended up quitting a job working for a military supplier due to frustrations that at best his work would be totally unused, and at worst he

Johnny Lin *is a postdoctoral researcher at the Climate Systems Center at the University of Chicago. He received his B.S. in Mechanical Engineering and M.S. in Civil Engineering-Water Resources, both from Stanford University, and his Ph.D. in Atmospheric Sciences from UCLA. He studies the interaction of Arctic sea-ice with the atmosphere, and his favorite ice creams are daiquiri ice and French vanilla.*

Ruth Douglas Miller *received her B.S. from Lafayette College, Easton, PA; M.S. and Ph.D. from the University of Rochester, NY, all in electrical engineering. She has been at Kansas State University since 1990, first as an instructor, then assistant professor, and was promoted to associate professor in 2002. She works in the field of Bioelectromagnetics, studying the interaction of electromagnetic fields and biological tissues.*

would contribute to destruction and misery. Another way Hall has seen the temptation to attain excellence "in the wrong way" has been in the allure of seeking funding from agencies that behave in ways at odds with his faith.

As someone with many titles (professor, advisor, mentor, wife, mother) but only 24 hours in a day, Miller realizes that she cannot be number one in each of her roles. Thus, she has consciously set limits as to what she will sacrifice in her quest for tenure, specifically deciding to draw the line at anything that might jeopardize her relationships with her husband and son. She knows that she will not become an engineer whose name everyone recognizes, because she has set her priorities in a different way.

Similarly, Munro has found that there just isn't enough time to excel at everything he's wanted to. At the beginning of his 28-yr. career as a professor at a small Christian college, he went into his job very excited, motivated to bring top-notch research to his school. But soon he found that students and courses needed his time, and that the time constraints at a small college do not generally allow one to do world class research. Munro finally decided to make his contribution in "smaller" things (e.g., studying the ethics of genetic engineering, participating in summer research projects) and in sharing his life and time with students.

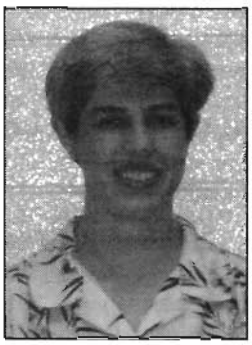
Two themes repeated themselves in the discussion on the role of excellence. First, excellence is both important and desirable: through excellent work, the Christian in science bears witness to the excellence of God. But for each individual, God has given different sets of priorities, gifts, and talents. For some, a more focused pursuit on doing excellent science may be part of that list of priorities. For others, faithfulness to those priorities may require scaling back one's research commitment. Either way, wisdom and discipline in being faithful to God's calling, in all aspects of our lives, is vital for us to put scientific excellence in its proper place.

Vision

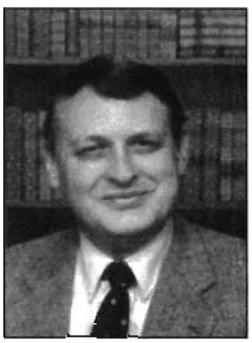
The vision to connect our faith to our work can manifest itself in many ways and areas. For Hall, his position as a faculty member is as a "tentmaker" who has dual callings: witnessing (or "profess-ing," after a similar statement by Cal DeWitt) to students, faculty, and staff; and contributing to society through his teaching, research, and service. As part of that vision, Hall tries to integrate his faith with his research, and finds many opportunities to do so. For example, the theme of the 2001 ASA Annual Meeting, the care and stewardship of creation, readily applies to his work in engineering and ecological health. Miller too has found a number of areas of fit between her work in electrical engineering and her life of discipleship: ethics in technology, for instance, has played an important role. For DeJong, a vision of obedience to Christ in his workplace has shown itself in terms of his interactions with his fellow graduate students. He has found few Christians in biology and finds that kindness goes a long way.

In a Christian college, Veltkamp finds it is easier in many ways to live the vision of being obedient to Christ, since her colleagues also live the same vision. However, in this environment she finds a different, and perhaps unexpected, challenge: complacency about wrestling with how faith and career intersect. When one's colleagues share (more or less) one's own beliefs, it can be easy to stop discussing faith/career integration. At her school, because there are no requirements regarding specific church membership, there is a diversity of Christian faith backgrounds. This has been enriching and helpful to Veltkamp in working against the complacency that can sometimes arise from homogeneity.

But many new scientists find it difficult to latch onto or persevere in a vision of connecting their faith to their work. Questions of "why am I doing this narrowly focused research?" and "what is supposed to be my contribution to the field given my relative



Pam Veltkamp



Don Munro

Pam Veltkamp *earned a B.A. in Chemistry from Dordt College, Sioux Center, IA, in 1984. Her Ph.D. (Analytical Chemistry, 1991) is from the University of Colorado-Boulder. After teaching at Dordt five years, Pam moved to McMurry University in Abilene, TX, where she teaches chemistry and environmental science and is chairperson of the Chemistry Department. She enjoys gardening and bird-watching.*

Don Munro *received his B.S. in Biology from Wheaton College and M.S. and Ph.D. in Zoology from the Pennsylvania State University. He was a US Army officer, taught biology for one year at Radnor Senior High School, and served for 28 years at Houghton College, including 25 years as professor and head of the Biology Department. For the last nine years, he has served as Executive Director of the American Scientific Affiliation and adjunct professor of biology at Gordon College. He is married with two children and two grandchildren.*

lack of knowledge?" are just a few of the struggles new scientists face. As a postdoctoral researcher, Lin was quite surprised to find how the temporary nature of his appointment, and the uncertainty associated with no longer having a graduate advisor to "protect" him in the research community, sapped his desire to live out a vision of integrating faith and learning. As a graduate student, this vision was worked out in the security of a community of like-minded graduate students. What did it mean to work on this vision more or less alone, and in a one- or maybe two-year position? Instead of being confident that God is an abundant God, who will provide in the midst of his research, Lin found his outlook in the world of research to be one of scarcity: there are only so many ideas and resources to go around, and so you are on your own, no one can help you, and no one cares. Where does one go from there?

In answer to these struggles, an audience member noted that even settling into a career does not necessarily bring permanence. Other factors may contribute to a sense of temporariness, such as discovering that one doesn't like one's location and deciding to move. For those in similar situations as Lin, the audience member recommended not focusing on the temporary nature of the situation, but instead to enjoy what is good about it while one is there. God is calling us to our work, wherever that may be. And that audience member suggested recognizing that the church is not only a community in space, but also in time, and that we can commune with the church in the past through the works of past Christian writers.

Building Communities and Networks of Encouragement

In all the areas we've mentioned, learning to relate to the scientific community and live obediently as a Christian in science, a nurturing community is indispensable. For nearly all of the panelists, communities and key individuals have played important roles in their journeys as Christians in science. For Veltkamp, Russ Maatman, an undergraduate chemistry professor and advisor who introduced her to the ASA; Bill and Chris Hooke, who hosted a graduate student Bible study in their home; and Ken Olsen and John Vayhinger, with whom she worked to start the Rocky Mountain local section of the ASA, all greatly influenced her. For DeJong, high school biology teacher Harlan Kredit was an important mentor. (He still remembers Kredit saying, no matter what the weather, "Isn't it a great day to be alive?!") As an undergraduate Miller saw active faith demonstrated in her chosen discipline through Ken Demarest, one of her professors. Hall, Miller, and Lin all benefitted greatly from campus ministries, such as InterVarsity Christian Fellowship's graduate ministry, during their formative years as scientists.

Christians just starting out in science often have twin challenges: to "learn the ropes" of being a member of the scientific community, and to integrate their science and their faith. In both challenges, community is key. During the discussion, audience members encouraged young scientists to maintain affiliation with their professional societies. One academic dean recommended seeking advice from senior faculty members and to be aware what the criteria for promotion are. Upon joining the faculty at Kansas State, Miller found a colleague on the electrical engineering faculty who herself had gone through raising a family while on the tenure-track and thus was able to mentor Miller. It is extremely easy for young scientists to become too focused on the work at hand and to neglect the building up of collegial relationships. Sometimes this can lead to burn-out; other times, the isolation saps creativity and growth as a researcher. Many times, such professional isolation hinders career advancement and joy in one's work.

The importance of community to Christian growth, of having a close connection with a local group of believers, almost goes without saying. Even though young scientists often have "too many balls up in the air," they must maintain fellowship with other Christians, and if possible, with Christian academics. The latter might be done, for example, through a lunchtime book discussion group or a local ASA section. Many universities have a graduate student or faculty/staff fellowship, both of which may be well suited for a Christian postdoc or assistant professor/researcher. Parachurch organizations such as InterVarsity Christian Fellowship, Campus Crusade's Leadership Ministries, and Reasons to Believe may also offer resources for those seeking to grow such communities of scientists. It does not take much for the passion of integrating faith and science to become lukewarm embers. Christians starting their scientific careers need to find others with whom they can speak encouragement to each other.

Conclusion

Christians beginning their careers in science face a variety of challenges and opportunities. Many find themselves learning how to relate to the professional community they have entered, to translate obedience to Christ into their workplace, and begin new (or extend existing) communities that will nurture both their scientific and faith lives. It sometimes seems overwhelming, trying to balance multiple priorities and adjust to new career responsibilities. But with these challenges also come opportunities:

- to learn new skills, both in research and in life;
- to discover new avenues of connecting with scientific colleagues and fellow believers;
- to seek out "iron sharpening iron" relationships that will lead to a deeper connection between faith and work;
- to learn new ways to obey, depend on, and worship God.

Within the craziness of beginning a career in science, as with all aspects of life, there is the opportunity to more deeply know and be known by God. And, because of that, it is a challenge worth meeting.

Book Reviews

Anthropology & Archeology

EXTINCT HUMANS by Ian Tattersall and Jeffrey Schwartz. Boulder, CO: Westview Press, 2001. 256 pages. Paperback; $30.00. ISBN: 0813339189.

Extinct Humans is a richly illustrated interpretive catalog of fossil australopiths and hominids. More importantly, it represents an attempt to promote a paradigm shift for paleoanthropologists. Christians interested in paleoanthropology will find the book valuable on both counts.

No one is better qualified to write a book like *Extinct Humans* than Tattersall and Schwartz. Tattersall is chairman and curator of the Department of Anthropology at the American Museum of Natural History and adjunct professor of anthropology at Columbia University. His books include *The Last Neanderthal, Becoming Human,* and *The Myths of Human Evolution* (with Niles Eldredge). Schwartz is professor of physical anthropology at the University of Pittsburgh and a research associate at the American Museum of Natural History. He is the author of *The Red Ape, What the Bones Tell Us,* and *Skeleton Keys.* In their particular professional positions, Tattersall and Schwartz have perforce a comprehensive grasp of the entire panoply of hominid fossil remains. They are not focused on a single site, like Olduvai Gorge, to the possible unintentional undervaluing of remains from other sites and other times.

The book contains eight chapters. Chapter 1 surveys the evolution of natural history from Aristotle's *Scala Naturae* to the end of the nineteenth century, when *Homo neanderthalensis* was still the only fossil hominid known other than *Homo sapiens.* T. H. Huxley had proclaimed *H. neanderthalensis* to be a direct ancestor of *H. sapiens,* and the Modern Synthesis that developed during the first half of the twentieth century followed his example in endeavoring to determine where each newly discovered hominid species fit in modern man's family tree. Time and place, rather than the taxonomy of the fossils themselves, were the primary criteria used to assign each new species its place in an assumed linear sequence from great ape to humans.

Chapter 2 describes the authors' challenge to the linear view of human natural history which is assumed by the Modern Synthesis. They here set out their thesis that human evolution was branching and bushy rather than linear; that we cannot construct a reliable family tree showing that any particular hominid species was the descendant of any other particular species. They opt for a cladistic approach: the best we can do is to show nearness of relationship between species by cladograms constructed primarily on the basis of degrees of morphological similarity, with time and place playing only secondary roles.

Chapters 3 through 8, constituting the heart of the book, survey virtually all the important fossil hominids discovered in the past 150 years. Nine (!) different australopiths and eight different species in the genus *Homo* are described with respect to the history of their discovery, their anatomical features (illustrated with a wealth of magnificent color photographs and line drawings), and (where present) their tools and cultural remains. Again and again throughout this multi-chapter survey, Tattersall and Schwartz drive home their point that paleoanthropology cannot ascertain linear, ancestor-descendant relationships with any degree of confidence.

The longest chapter in the book (almost twice as long as any other) is Chapter 7, "Neanderthals and Human Extinction." Tattersall and Schwartz dispute the belief of many paleoanthropologists that Neanderthal is ancestral to modern man, or at least that Neanderthal disappeared by inbreeding with *H. sapiens.* The authors reject this hypothesis, citing a welter of morphological differences between the two to make their case, while at the same time asserting strongly that Neanderthal cultural remains give evidence of art, music, and some reverence for the dead, all truly human traits.

I recommend this book highly to Christians who take science seriously. The illustrated catalog of important fossil hominids alone is worth the price of the book. *Extinct Humans* is also valuable for its fresh perspective on human origins. Tattersall and Schwartz's new paradigm may or may not ultimately prevail among paleoanthropologists, but it is one with which Christians should become familiar, whether or not they agree with the proposition that modern man has evolved in some sense from more primitive primates. Many Christians in science maintain that humans were a special creation physically as well as spiritually; others hold that the physical body of humans was the product of evolution. *Extinct Humans* furnishes no data or insights that will change any Christian's views on that question. Nor will the book shed any light on the spiritual nature or heritage of humans. Tattersall and Schwartz are naturalistic evolutionists to the core, and have nothing to say about humankind's creation in the image of God. But what Christian would expect science to provide insight into questions that are spiritual in nature?

Reviewed by Robert Rogland, 702 S. Monroe St., Tacoma, WA 98405.

Ethics

CUTTING-EDGE BIOETHICS John F. Kilner, C. Christopher Hook, and Diann B. Uustal, eds. Grand Rapids: Eerdmans Publishing Company, 2002. 201 pages. Paperback; $22.00. ISBN: 0802849598.

Kilner is director of the Center for Bioethics and Human Dignity; Hook is director of ethics education for the Mayo Graduate School of Medicine; and Uustal is president of Educational Resources in Health Care, Inc. The book is a collection of fifteen essays grouped into four categories: emerging technologies, growing cultural changes, the changing face of healthcare, and proactive perspectives. Each category appears to exhibit a progression from the current medical situation to more futuristic probabilities.

In the section on emerging technologies, it is argued that it would be unethical to hinder research on human genetics xenotransplants, transgenics, artificial intelligence, personhood, cybernetics, and nanotechnology, although there are social, ethical, and legal issues that must be addressed.

The second section deals with cultural issues such as multiculturalism and a bioethical vision. The implications of cultures and belief systems on medical decisions, stem cell research, the anthropological nature of humans, and the dignity of human life at various stages of medical treatment are discussed.

The third section deals with the social and economic changes affecting healthcare. Topics discussed include the financial aspects of managed care, the future direction of healthcare delivery, the growing popularity of spirituality and alternative medicines and their impact on healthcare, the effects of changes in sexual morality, and the spread of AIDS and other sexually transmitted diseases.

The fourth section shifts the emphasis to issues and away from technology. This section includes a look to the future of providing healthcare, the ethical challenges, the media, and public policy challenges. It may be possible to see this section as a capstone to the three previous.

The cumulative thesis of these four sections is not so apparent due to the number of contributions and the variety of topics. The lack of a unifying narrative to pull the essays together is probably the biggest weakness of the book. However, the consistent effort to apply a Christian ethic to both the present and future issues in healthcare and biotechnology will be highly valued by the Christian reader.

This book would be suitable to both generalist and specialist. Young people entering the healthcare scientific fields related to biotechnology will find the book valuable. It would be particularly suitable to those who are in a position involving healthcare and biotechnology policy making. It would be an excellent gift for your local congressman.

Reviewed by Gary De Boer, Assistant Professor of Chemistry, LeTourneau University, Longview, TX 75607-7001.

AT THE BEGINNING OF LIFE: Dilemmas in Theological Bioethics by Edwin C. Hui. Downers Grove, IL: InterVarsity Press, 2002. 385 pages. Paperback; $24.99. ISBN: 083082667X.

Hui has M.D. and Ph.D. degrees and is a professor at Regent College in Vancouver, Canada. The publisher's book description correctly states that this book is "for anyone who wants to think through the biomedical ethical issues of human life at inception on a profoundly Christian basis."

The book is divided into three parts. The first part deals with the meaning of personhood. Its approaches the issue primarily from a philosophical viewpoint but also with some biological perspective. The book convincingly argues that personhood begins at conception. The arguments are carefully laid out with much intellectual rigor but without any hint of emotion.

The second part of the book sets out many fascinating issues surrounding assisted reproduction. These issues include artificial insemination, *in vitro* fertilization, embryo transfer, surrogate motherhood, embryonic manipulation, human cloning, stem cell research, and the human genome project.

The third part of the book discusses abortion in light of the author's view of personhood. This is not a book with easy and clear-cut answers to the questions surrounding the abortion issue. The author first presents both of the extreme viewpoints of abortion, and then discusses many difficult issues that surround the controversy. These issues include rape, socioeconomic factors, genetic defects, and contraception. Although the author believes that personhood begins at conception, he does not conclude that abortion is always wrong.

This is a book that far exceeded my expectations. An educated layperson without any medical training will be able to follow the author's thought process and arguments. The author has written a Christian book that is educational, insightful, and thought provoking. He thoroughly discusses many fascinating issues surrounding bioethics from the perspectives of biology, theology, philosophy, and sociology. I highly recommend this book.

Reviewed by Dan Simon, Assistant Professor of Electrical Engineering, Cleveland State University, Cleveland, OH 44115.

BIOETHICS FROM A FAITH PERSPECTIVE by Jack Hanford. Binghamton, NY: The Haworth Pastoral Press, 2002. 147 pages, index. Paperback; $19.95. ISBN: 0789015102.

About a dozen years ago, my university revamped its General Studies Program and included a mandatory senior capstone course on ethics. At that time I developed and began teaching an "Ethics in the Sciences" course to meet that requirement for our majors. One of the biggest challenges of the course has been to find a text that covers the current ethical challenges facing such topics as science and medicine from a Christian perspective. It was thus with great anticipation that I began reading this book as I hoped it would prove suitable for the course. While I am sure that the book will prove useful to budding ethicists and those with a strong background in philosophy and ethics, I am afraid that it will not provide much use for either science students or the pastors and medical practitioners it seems designed for.

As stated in the Introduction, the purpose of the text is to "show the relevance, significance, and guidance that a faith perspective can offer for dealing with bioethical issues." It attempts to do this through five specific objectives that are dealt with in an overlapping manner in twelve chapters ranging from 3 to 18 pages in length.

While a scientist by training, I had hoped that my minor in Bible, several undergraduate philosophy courses, and over a dozen years of teaching and reading in this area would allow me to understand and apply the material presented in the first five chapters of the text. Unfortunately, it did not as the discourses on the stages of moral development, technical-ethical distinctions, faith perspective, the similarities and distinctions between moral development and faith development and the discussion of whether

Fowler's "faith" meets the definition of "Christian faith" left me befuddled. More importantly, it made me wonder how the typical pastor, medical practitioner, or undergraduate science student would benefit from these chapters. Several excellent points are made here, however, and their further development would have strengthened the text's usefulness. Hanford's recognition of the state of medical ethics, the problems associated with managed health care, and the exclusion of the Christian faith from the public discourse on these issues is right on. His well reasoned discussions of why the Faith of the Bible can and must be used in these areas would, if developed further, be an asset to any Christian involved in these discussions.

In the next five chapters, Hanford seeks to address the ethics involved in transplants, mental health and managed care, genetics, medical technology and care of the elderly. There are several good points made in these sections such as his suggestion that the church become the focal point for securing donated organs. However, the majority of the material suffers from unevenness and inconsistency in the depth, breadth, and manner used in approaching and presenting each topic. As I look over this material again, I am beginning to wonder if perhaps this is due to these chapters being the result of separate presentations, each given for a different type of audience or intent, that have been pulled together for this book.

The final two chapters deal with developing bioethics from a "faith perspective" for pastors and nurses. The author's most salient points revolve around his understanding of the anti-intellectualism of much of the church, the anti-faith bias of academia and the lack of ethics training in America. His solutions are interesting, including an increase in the admittance standards at seminaries, increased academic rigor, and a sort of AMA for pastors to maintain those standards. In discussing the nursing profession, he recognizes the critical role they play and affirms the importance of faith in their profession. However, a pastor or nurse would find little that would truly impact the way they do their jobs or assist them in applying their faith to their professions.

Therefore, those interested in the purely theoretical aspects of bioethics, in summaries of the ethical views of writers in the field or in what the author has written or taught throughout his career might find this text of interest. I am afraid, however, that those of us seeking assistance in developing a practical ethical approach to specific issues, based on Biblical principles, supported by Scripture, will not find much of use.

Reviewed by Scott S. Kinnes, Professor of Biology, Azusa Pacific University, Azusa, CA 91723.

FAITH & SCIENCE

FAITH IN SCIENCE: Scientists Search for Truth by W. Mark Richardson and Gordy Slack, eds. Foreword by Ian Barbour. London: Routledge, 2001. 206 pages, bibliography. Paperback; $15.95. ISBN: 0415257654.

"The whole idea of interviews is in itself absurd," the English man of letters Anthony Powell once noted. Whatever meager insights one may glean from them too often come at the expense of clarity and nuance. So say the critics of the genre.

I am not one of them. To be sure, at their worst, published interviews can be the print equivalent of sound bytes, capturing unguarded comments people might otherwise have hesitated to make. But, done properly, an interview can be an effective vehicle for informative conversation in the loose, unbuttoned style one might expect between colleagues over a cup of coffee.

Faith in Science illustrates the value of a collection of interviews done well. Science writer Gordy Slack and philosopher Philip Clayton interviewed twelve distinguished scientists in 1998 as part of the Science and Spiritual Quest (SSQ) program. *Faith in Science*, which serves as a companion volume to *Science and the Spiritual Quest: New Essays by Leading Scientists* (published by Routledge), explores the interface between scientific inquiry and scientists' religious and/or spiritual quests.

This collection of interviews demonstrates the great diversity of outlooks and opinions that scientists hold when addressing questions related to science and religion. In addition to a variety of Christian viewpoints (ranging from those of biologist and former Catholic priest Francisco Ayala to Lutheran computer scientist and theologian Anne Foerst to Congregationalist Nobel laureate in physics Charles Townes), the editors included interviews with three Jewish scientists (including Nobel laureate in physics Arno Penzias), two Muslim physicists (Bruno Guiderdoni and Mehdi Golshani), and a paganist (virtual reality theorist Mark Pesce).

Since diversity seems to have been one of the editors' chief selection criteria, it is not surprising that no single theme, beyond that of diversity, can be drawn from the book. But there are interesting threads that appear in some of the interviews. Several scientists noted the limits of science as a way of knowing and thinking. Penzias, for instance, confessed that while science provides powerful descriptions of the world, its descriptions will always be incomplete (p. 22). Muslim astrophysicist, Bruno Guiderdoni, used the insights of Bernard d'Espagnat to suggest that reality is veiled; it is never fully accessible to scientific investigation (p. 73). Another related concern was whether science supports the view that the cosmos and life have purpose and meaning. Predictably, the answers were varied.

Another value of *Faith in Science* is that it provides a revealing glimpse of the state of science and religion in the late 1990s. Slack and Clayton's questions were just as illuminating in this regard as the answers they elicited. Clearly, questions related to divine action, the purposefulness of the universe, and the impact of evolutionary thinking on religious views of humanity were central to the field. The degree of fatigue that one sometimes encounters these days when similar questions are raised suggest that the "answers" given in the 1990s were probably not all that satisfactory—exhausting, perhaps, but certainly not exhaustive.

A question kept coming to mind as I read these provocative interviews. What does the preposition "in" suggest in *Faith in Science*? Surely, faith in science means something quite different than faith and science. Is faith in science a goal of science and religion?

It seems that many religious scientists interviewed continue to resort to stances they may well have adopted prior to the vast outpouring of science and religion literature of the 1980s and 1990s. That is, many either functionally compartmentalize their science and their faith, or they cast both in vaguely complementary terms. To the extent that science and religion embrace different methods and epistemologies, efforts to go beyond a loose complementarity—if that is indeed the goal of the science and religion project—risks doing violence to the limits of these different ways of knowing. And if that is so, what is the basis for hoping for anything approaching consonance between them? A few of the interviewed scientists hinted that the conversation between science and religion may well be prompting both a new science, one that is open to beauty and goodness, not just truth, and a new theology, one that recasts traditional notions in new light. If this indeed is happening, then there is hope for faith in science, as well as, presumably, science in faith. But will it be the kind of faith worth believing in?

Clearly, these concerns should not be laid at the feet of the editors of this volume of interviews. But it is the sign of a good book that it provokes the reader to go beyond its specific argument to think about larger implications. Because *Faith in Science* does this, it deserves a broad readership.

Reviewed by Donald A. Yerxa, Professor of History, Eastern Nazarene College, 23 East Elm Avenue, Quincy, MA 02170 and editor of Historically Speaking: The Bulletin of the Historical Society, 656 Beacon Street, Mezzanine, Boston, MA 02215-2010.

BIOLOGY THROUGH THE EYES OF FAITH by Richard T. Wright. San Francisco: Harper San Francisco, 2003. 300 pages. Paperback; $12.00. ISBN: 0069696958.

With a Harvard University doctorate in biology, Wright, an ASA member and emeritus biology professor at Gordon College, has spent much of his life attempting to correlate his knowledge and his faith. This book updates his original 1989 edition, part of a series approaching various disciplines "through the eyes of faith," under the auspices of the Council for Christian Colleges and Universities. Explosive developments in these fields have made the first edition obsolete, making the publication of a second edition especially relevant. A nine-page index plus copious notes and discussion questions enhance the pedagogical value of this book.

Wright states three goals: (1) To "explore in some depth the biblical message of creation and relate it to the current understanding of origins;" (2) To "bring out the biblical message of dominion and show how it applies to interactions of the life sciences with society in medicine, genetics, and environmental concerns;" and (3) To "examine what it means to be involved in redeeming God's creation and reforming our culture and science."

Early chapters cover "Biology and Worldviews," "God and His World," "The Scientific Enterprise," and "Relating Science and Christian Thought." Subsequent chapters focus on four "revolutions": Darwinian, biomedical, genetic, and environmental. Four of the thirteen chapters deal with various aspects of origins, and three with environmental issues.

Jerry Hess commends the book because it "avoids the penchant for encyclopedic perspective and focuses on major issues related to science and Christian faith in a concise and understandable manner." Hess likes the book so well that he says: "If the book is used in several courses during a student's college career, the impact of reading *Biology Through the Eyes of Faith* will be maximized." The book supplements secular biological textbooks instead of aiming to supplant them.

Since ASA members hold a range of views, some will agree and others disagree with Wright's interpretation. He presents several possibilities, but seems to favor the view he summarizes:

> God creating humans ... through a God-guided process of evolution ... In God's timing, he chooses people from a Neolithic culture in the Near East, confers on them his image (full capacity for fellowship with God), and places them in a garden ... Many are able to accept the first few chapters of Genesis as allegory or mythology and still maintain their strong Christian faith (p. 165).

ASA members whose philosophy of origins excludes *Homo sapiens* and perhaps other species from the evolutionary lineage will differ with Wright. For example, the Wheaton College Statement of Faith says: "We believe that God directly created Adam and Eve, the historical parents of the entire human race; and that they were created in His own image, distinct from all other living creatures, and in a state of original righteousness." Those who are inclined toward that view will find Del Ratzsch's *Science & Its Limits: The Natural Sciences in Historical Perspective* (Downers Grove, IL: InterVarsity, 2000) more in line with their interpretation of Scripture.

In addition, Wright and Ratzsch differ on their attitudes toward methodological naturalism. Wright says:

> The progressive-creation and evolutionary-creation paradigms are both compatible with modern science, although only evolutionary creation endorses the approach of methodological naturalism, where only explanations from within the natural world are admitted as legitimate science. This does not deny that God may have used supernatural means in origins; it just refuses to consider such an explanation as scientific.

Some ASA members will prefer Ratzsch's discussion of Christian reservations about methodological naturalism (pp. 122–9 of his book). Professors may want to compare these two before deciding which book, or which segments of each book, to assign to their classes.

Wright moves beyond the theoretical, to practical aspects of the Christian's responsibility to God in realms of biomedical and genetic advances, plus implications for how we handle the environment. He quotes Cal DeWitt: "If God in the final judgment would ask us a question about the Creation, what might that question be?" Wright asks: "Would he ask us *what we thought about how he made the world,* or would he ask us *what we did with it?*"

Reviewed by Dave Fisher, Trans World Radio missionary, editor "Truth in the Test Tube" broadcast from Russia and China, and co-editor of The Newsletter of the ASA & CSCA.

THE GOOD IN NATURE AND HUMANITY: Connecting Science, Religion, and Spirituality with the Natural World by Stephen R. Kellert and Timothy J. Farnham, eds. Washington: Island Press, 2002. 278 pages, index. Hardcover; $28.00. ISBN: 1559638389.

This book is the outcome of a conference, "The Good in Nature and Humanity," held at Yale University in May 2000. It originated in the conviction that modern society's environmental and spiritual crises will not be understood nor resolved until the divide between faith and reason is breached and science and religion are effectively reconciled. Included among the twenty contributors to the volume are some of North America's most published writers on the subject.

Chapter one is an attempt at bridge building between science and spirituality. It examines some of the things that divide—science's reductionism and religion's dogmatic inflexibility—and some that unite, including respect and reverence for the natural world, a shared sense of wonder. The main body is divided into three parts: Scientific and Spiritual Perspectives of Nature and Humanity; Linking Spiritual and Scientific Perspectives with an Environmental Ethic; and From the Perspective of the Storyteller. Endnotes provide biographical details of contributors, as well as subject and author indexes.

The book's value lies, not in any consensus reached on spirituality nor in any agreed actions to avoid environmental disaster, but in presenting a cross-section of contemporary views on science and spirituality and the growing awareness that the world now seems ready to accept faith and reason as complementary approaches.

I recommend the volume as a thought-provoking, and at times inspiring, sample of divergent modern thinking on the subject. There are some literary gems, such as: "But ultimately, this great mystery of religion and religious experience lies beyond the vision of even our most powerful microscopes and telescopes—like dark matter, it eludes detection. It is as elusive as the human heart, as stunning as the discovery of relativity, as unique as a fleeting snowflake, as alluring as a loon's call, as beautiful as clouds at sunset, and as haunting as a forest at night" (p. 70). The book could almost be dedicated to the memory of Aldo Leopold, the most frequently quoted author.

Topics range widely: world religions, environmental values and ethics, intergenerational justice, cosmology and cultivation, geology and theology, work and worship, hunting and spirituality, Gaia, biophilia, global economics, map making, and much more. Issues are complex: "... don't make the mistake of thinking you, or I or anyone, knows how the world is meant to work. The world is a miracle, unfolding in the pitch dark. We're lighting candles" (p. 240).

There is much here to challenge and sharpen our thinking. Common assumptions linger, for instance, that description of evolutionary process automatically rules out purpose. Some find "not the slightest scrap of hard evidence" that spirituality is not a delusion (p. 99). For others, ultimate spiritual reality seems to be no more than our total human response to nature (p. 169). Are we in danger of taking a utilitarian approach? Is spirituality to be embraced not because it is true but because it is part of universal human evolutionary behavior that enhances our chances of survival (p. 49)? Are we denied the possibility of making universal truth claims (p. 23)? Must religion play a supporting secondary role, with only science and technology indispensable to the task (p. 65)?

There is, however, also much to encourage us, with affirmations of "a personal God who knows and loves all into being ..." (p. 109), and calls for us to express our wonder at and celebration of creation. The approach is science-based; I found no vague New Age type spirituality, but rather a sensitive view of nature as an essential element in spiritual health, where "the fresh-air sanity of natural wildness is our best, perhaps our only, antidote to the suffocating cultural pathology we euphemize as civilization" (p. 186). The current spiritual quest is of critical importance to life on Earth: "our success in gaining access to our deepest wisdom ... will truly dictate what life will be like for all future generations" (p. 158).

Reviewed by Bryan Ezard, Linguistic and Translation Consultant, Summer Institute of Linguistics, Australia.

NATURE, HUMAN NATURE, AND GOD by Ian G. Barbour. Minneapolis: Fortress Press, 2002. 170 pages. Paperback; $12.00. ISBN: 0800634772.

Barbour is Bean Professor Emeritus of Science, Technology, and Society at Carleton College, Northfield, Minnesota. He has written *When Science Meets Religion* (2000), *Religion and Science: Historical and Contemporary Issues* (1997), and the *Giffard Lectures* (1993 and 1995). His books have been translated into some foreign languages. In addition, Barbour has authored articles on the topics of science, technology, and religion, and he has been interviewed on national television and radio outlets.

Barbour states in the introduction that the aim of this book is to develop the idea of integration of science and religion. In his previous books, he has discussed how science and religion sometimes conflict and require dialogue for interfacing. To address integration over a broad range of topics, Barbour divides this book into five sections in which he discusses evolution, genetics, neuroscience, artificial intelligence, ethics, and environmentalism. Each section is well documented. Barbour relies heavily on the process theology of Alfred North Whitehead throughout the book. One of the five sections is completely devoted to the ideas of process theology and its relation to the understanding of nature and human nature.

The idea of process theology describes God's nature and evil in a way that may differ from many Christians' traditional understandings. The idea ascribes limitations to God's power as a consequence of God's contribution of empowerment to his creation. Barbour writes that "... process thought suggests that the limitations of divine power are the product of metaphysical necessity rather than voluntary self-limitation." The emphasis is on the integrity of creation which reflects the creator. Therefore, discontinuities in that created design are less necessary if the design itself allows for the process of God's work. An example may be of God working within the uncertainties within systems described by quantum mechanical theory. The process system has implications for human nature in addi-

tion to the nature of God and the cosmos. The characteristics of human nature and the ability of people to choose their actions within the confines of genetic determinism are discussed.

Barbour is quite knowledgeable about current integration efforts. The strength of the book lies in its attempt to integrate characteristics of fundamental scientific theories with a model of an understanding of God and humanity. This strength may also become a weakness as immanence, God's prominence in creation, is emphasized over transcendence, God's existence beyond the created universe. (Whitehead believes in a transcendent God.) Nonetheless, I am sure that some readers may be uncomfortable with the fine line between process theology and pantheism.

This book is suitable for laypersons and professionals, particularly those interested in integration or process theology. Neophytes may find the book a bit too dense and may wish to refer to some of Barbour's earlier works.

Reviewed by Gary De Boer, Assistant Professor of Chemistry, LeTourneau University, Longview, TX 75607-7001.

A SCIENTIFIC THEOLOGY: Reality, vol. 2 by Alister E. McGrath. Grand Rapids, MI: Eerdmans Publishing Co., 2002. xvii + 343 pages. Hardcover; $50.00. ISBN: 0802839266.

This is the second volume of a work in process that will eventually comprise three volumes. The first volume, *Nature*, appeared in 2001 and was reviewed in this journal in September 2002. This second volume explores the notion of realism in both science and theology. The three volumes are a scientific theology because they are informed by the methods and mindsets that can be brought from the study of science to inform the study of theology. In particular, in this volume, McGrath argues that just as the methods of science assume an objective reality to be discovered and understood, so theology can be conceived as a study of what can be observed of God. To say this in another way, the author describes his focus in this second volume as being on the epistemological and ontological status of the real world. The first volume laid a foundation by considering the theological view of nature or creation. And the third volume will show how to build a theoretical framework around these ideas.

This volume does not present part of a detailed Christian theology covering the traditional topics. Rather, the project strives for an understanding of an approach to theological reasoning. McGrath is strongly committed to realism—the universe and God really exists and can be studied—but presents his analysis in a post-Enlightenment, postmodern context. Simple objective approaches to realism have been invalidated, but radical responses that no reality can be found or known are also unacceptable. An important shaping influence on his thinking is the *critical realism* of Roy Bhaskar.

The author explicitly goes beyond a theistic position that sees God only as creator of the knowable universe, arguing specifically for a scientific theology that incorporates the distinctive emphases presented by the teaching about Jesus in Christian revelation and tradition. The book is based on wide reading in science, theology, and other fields, and is extensively documented. There are 730 footnotes, and a bibliography with 317 entries. Curiously, there is more material used in the body of the book than appears in the bibliography (for example, Richard Dawkins appears in the index but the book cited in the body of the text, not just in footnotes, in the pages referred to by the index does not appear in the bibliography). I have not been able to infer the criteria used to determine what appears where (more than half of the works cited in the first fifteen footnotes of the first chapter are not in the bibliography). I suggested in reviewing the first volume that a presentation would be welcome for more general readers that did not include the extensive response to previous work—and the extensive documentation required to support that analysis. A private communication sent from the author in response suggests that such a publication may be prepared after the third volume is complete, and I still believe it would be welcome.

This is a valuable book that is, like the companion previous volume, worthy of careful study. It has stimulated me to think more precisely and also to read further in some of the materials it references. I look forward to reading the final volume.

Reviewed by David T. Barnard, University of Regina, Regina, SK, S4S 3X4 Canada.

HISTORY OF SCIENCE

EVOLUTIONARY THEORY AND VICTORIAN CULTURE by Martin Fichman, Amherst: Humanity Books, 2002. 224 pages. Paperback; $21.00. ISBN: 1591020034.

Fichman is a professor of humanities and history at York University. He has written at least two other books: *Science, Technology and Society* and *Alfred Russel Wallace: A Biography*. This book is a study of the cultural controversies on the meaning of evolution. There are eight chapters which cover topics like evolutionism in cultural context, social Darwinism, Transatlantic evolutionism, human evolution, the differences between Wallace and Darwin, evolutionary ethics and religion. The final chapter is on contemporary debates.

The book begins by noting that the eighteenth century saw the rise of the earliest modern attitudes towards science. D'Alembert, Voltaire, and Hume among others led the way in advocating a greater control over the world through science. The nineteenth century saw the rise of the professional scientist. Wallace, Lyell and Darwin were among the first. The professional scientists forged strong links between technology and science, altering the geopolitical power balance. Countries in which this professionalism was most profound were world powers.

But this had implications for the philosophical world as well. Science began to challenge religious beliefs, even though many of the leading scientists were also spiritualists in the broad sense. Increasingly through the century, the common people found themselves less and less able to partake in the great debate because to learn the issues required years of study. Darwinian evolution, however, gave rise to a debate in popular literature about the place

and nature of humanity. A cartoon which appeared in Punch, in which a tuxedoed gorilla is introduced by a stately butler as "Mr. Gorilla," said volumes about the Victorian views on slavery, our relationship to the natural world and the difference between human and animal nature. The cultural debates were held at this level.

Fichman's discussion of the current debate covers young-earth creationism, and the ID movement. It seems oddly out of place and isolated within this volume. And maybe that is how it should be given the title of the book is about Victorian culture. Davis, Kenyon, Behe and Dembski are hardly Victorian figures. I actually found this discussion disappointing because I wanted to read the book to learn about Victorian culture. The author was all over the place temporally, especially in the latter half of the book.

The biggest weakness in the book is the paucity of nineteenth-century documents consulted. Out of 300 references in the bibliography, only twenty-nine are from the nineteenth century. The rest are from twentieth century historians who are interpreting the nineteenth century. Of these twenty-nine, sixteen are from Darwin, Huxley, Lyell and Wallace. If this is modern historical research, it seems to have much in common with the apocryphal story about the medieval scholastics who were arguing, from Scripture, about how many teeth the horse had. A young man suggested they open the horse's mouth and count. They threw him out of the room. It seems that historians no longer have to actually read the primary literature of the period of their researches. This book is good for a review of twentieth century viewpoints of what Victorian culture was like. It lacks the authentic feel of actual Victorian life.

Reviewed by Glenn R. Morton, Ramsden Lodge, 103 Malcolm Road, Peterculter, Scotland AB14 0XB.

WORLDVIEW: The History of a Concept by David K. Naugle. Grand Rapids, MI: Eerdmans Publishing Company, 2002. xxiii + 384 pages. Paperback; $26.00. ISBN: 0802847617.

Naugle, professor of philosophy at Dallas Baptist University in Dallas, Texas, shows that our "worldview" influences the way we look at everything, even in the way we look at so-called "objective" proofs. What looks "objective" to one person may be considered "subjective" by another, even when both individuals are Christians. Thus, Naugle concludes that when we do not understand the "worldview" of the person with whom we discuss issues, the discussion is fruitless.

In the first eight chapters, Naugle traces the concept and history of world views. He explains the views of Abraham Kuyper and his followers. Kuyper, a Dutch pastor and theology professor, became Prime Minister in The Netherlands. One of his well-known sayings was "All of life is religion." Many years after Kuyper's death some of his pupils formed the Association for Calvinist Philosophy. Prominent among them was Kuyper's pupil Vollenhoven, whose doctoral thesis was "Mathematical Philosophy as Seen from a Theistic Point of View." In it he showed that no unity of thought existed in mathematical philosophy. Later, as professor of philosophy, he wrote *The Necessity of a Christian Logic*. Still later, in a lecture I attended, he warned against the use of the words "objective" and "subjective" since they are so imprecise.

This book makes it clear that it is not sufficient to assume Christians come from the same perspective when discussing such topics as creation and evolution. Naugle thinks no progress can be made unless we first agree about basic philosophies of life. This is an important book. I highly recommend it.

Reviewed by Jan de Koning, 20 Crispin Crescent, Willowdale, ON, M2R 2V7, Canada.

DEATH AND DENIAL: Interdisciplinary Perspectives on the Legacy of Ernest Becker by Daniel Liechty, ed. Westport, CT: Greenwood Publishing Group, 2002. 301 pages. Hardcover; $66.95. ISBN: 0275974200.

Everybody dies. Humans are aware of this, and it creates terror in them. This ever-present fear of death, though it may not be conscious, is the motivating force behind every act. This is the core thesis of Ernest Becker's Pulitzer Prize winning book, *The Denial of Death*. Since the book was first published in 1973, *PSCF* readers might ask why is it mentioned here. Because this book has spawned a school of thought (Generative Death Anxiety) and national organization (Ernest Becker Foundation) to perpetuate and investigate the implications of Becker's theory, it is essential for an understanding of *Death and Denial*.

Becker's theory is reductionistic in that it explains everything by one organizing principle. It has been supported by some research. One of its central ideas is summarized by Otto Frank's maxim, "To be able to live one needs illusion." This is because the fear or terror of death is so overwhelming that it would be paralyzing if not controlled by heroic illusions. Becker describes humankind's dismal state in *Escape From Evil*: "Life on this planet is a gory spectacle, a science-fiction nightmare in which digestive tracts fitted with teeth at one end are tearing at whatever flesh they can reach, and at the other end are piling up the fuming waste excrement as they move along in search of more flesh."

In the preface to his book, Becker refers to Samuel Johnson's famous observation that the prospect of death wonderfully concentrates the mind. This prospect has led Becker to believe that people never fully live because their "deepest need is to be free of the anxiety of death ... but it is life itself which awakens it and so we must shrink from being fully alive." Jesus came to earth to "free those who all their lives were held in slavery by their fear of death" (Hebrews 2:15).

This present book is a collection of twenty-five essays by scholars from a variety of disciplines who discuss how Becker's theory has impacted their fields of interests. The basic idea emerging from their various considerations can be summarized in one long sentence: people's awareness of their mortality produces anxiety which leads to repression which leads to idiopathic psychic energy which leads to creativity, heroism, hostility, racism, religious chauvinism, violence, and other expressions of normal and pathological behavior. Specific topics integrated with Becker's

thoughts include science, evil, forgiveness, neurotic types, psychotherapy, heroes, toxic leaders, Buddhism, God, and illusion. Articles of potential and particular interest to Christians include Sally Kenel's "Reality Check: Mortality Awareness and Christian Anthropology" and Jerry Piven's "Transference as Religious Solution to the Terror of Death."

In this review, a great deal of attention has been focused on Becker because those unfamiliar with his thought will not be attracted to this book. While this book discusses a morbid subject, it is not altogether depressing. It has some salient and trenchant ideas which can provide insights into some of life's most baffling conditions and behaviors. The writers of this compendium expand and apply Becker's thoughts to a variety of situations and thinkers from any discipline will profit from reading it.

Reviewed by Richard Ruble, John Brown University, Siloam Springs, AR 72761.

THE MAN WHO FOUND TIME by Jack Repcheck. Cambridge, MA: Perseus Publishing, 2003. 229 pages, appendix, bibliography, acknowledgments. Paperback; $26.00. ISBN: 073820692X.

This book is a biography of James Hutton, the eighteenth-century Scot who first proposed and demonstrated that the processes of orogeny and erosion have been shaping the face of the earth for an unknowable but incredibly long period of time. In Hutton's own words, "As there is not in human observation proper means for measuring the waste [i.e., erosion] of land upon the globe, it is hence inferred, that we cannot estimate the duration of what we see at present, nor calculate the period at which it had begun; so that, with respect to human observation, this world has neither a beginning nor an end." As far as modern geology is concerned, then, Hutton originated the concepts of uniformitarianism and the antiquity of the earth.

Repcheck is a historian and book editor, not a scientist by training; however, he has published a number of geology books at Princeton University Press. He collaborated with several geologists and historians of science in writing *The Man Who Found Time*. It is a popular history, not written for academics. Repcheck has told Hutton's story simply and well.

Despite this, I am sorry to report that the book contains egregious errors of fact, particularly in the background material. Did you know that "the Vulgate ... would serve as the basis of the King James Bible. It is still the foundational Christian Bible of all those in use today"? Protestant Bible translators from the King James men on would be surprised to know that. Did you know that "the prophesy [sic] of Elijah ... proclaimed that the last two thousand years of the total six thousand would be the Age of the Messiah"? That is not in my Bible. Did you know that "biblical chronology, as the discipline of precise biblical dating was called, was one of the most rigorous 'sciences' of the pre-Renaissance era"? That would have been a surprise to Aquinas, Grosseteste, and Bacon. Did you know that after the fall of Rome "the old Roman Empire held on for another couple of centuries in the guise of the Byzantine Empire"? The latter "fact" would have surprised the Turks, who took Constantinople nearly a thousand years after the fall of the Western Empire. Did you know that Castle Rock in Edinburgh was "easily defended" and that "a surprise attack was simply impossible"? The historical truth is that Castle Rock changed hands a number of times (e.g., Robert Bruce took it from the English) and always by surprise attack.

Other historical assertions are misleading if not flat-out false. Repcheck states: "The King James Bible, first published in the seventeenth century verified [the creation of the earth six thousand years earlier] by placing specific dates for the key events right in the margin." The casual reader is likely to infer from this statement that the King James translators put dates there. Only later does Repcheck mention that Archbishop Ussher came up with the dates that subsequently appeared in editions of the KJV some forty years after its first publication. Again, Repcheck states that "we know" that the Septuagint was the Bible used by Jesus and all of his followers—a dubious claim at best. And he claims that Isaac Newton "[insisted] on utilizing the scientific method, building theories by accurate observation, then verifying them through rigorous yet repeatable experiments." While that may be true of Newton's *opticks*, it cannot be said about the laws of motion and universal gravitation introduced in the *principia*.

I do not mean to be picky, but the glaring historical errors, inaccuracies, and misleading impressions found in the background material call the usefulness of this book into question. While one could presume that Repcheck researched Hutton's life and work more thoroughly than background events, I confess that I am left without confidence that the central part of the book is free from error. *The Man Without Time* is an easy read, and no doubt gives an essentially accurate picture of Hutton's life and work, but the reader should be prepared to read things that just are not so.

Reviewed by Robert Rogland, Science Teacher, Covenant High School, Tacoma, WA 98465.

NATURAL SCIENCE

ENTANGLEMENT: The Greatest Mystery in Physics by Amir D. Aczel. New York: Four Walls Eight Windows, 2002. 302 pages. Hardcover; $25.00. ISBN: 1568582323.

Former ASA Annual Meeting keynote speaker, the Nobel-Prize-winning physicist William D. Phillips, said: "Entanglement—along with superposition of states—is the strangest thing about quantum mechanics." This is also the opening quote from the chapter of Aczel's book on the quantum possibilities of teleportation, "practiced" routinely in sci-fi such as *Star Trek*. But before he engages in speculative applications of quantum mechanics, Aczel explains for a general readership the strange phenomenon of entanglement, named originally by Erwin Schrödinger, whose famous equation describes the quantum wavefunction of a particle.

Entanglement is a relatedness between particles that share a common experience, such as photons emitted simultaneously from the same atom. Though separated by distance, these particles somehow "stay in touch" with each other. These photons, though they travel away from each other, maintain what Einstein deridedly called a "spooky action at a distance." They continue to exhibit behavior that shows they maintain a relationship that is independent of distance and is immediate. Though entanglement does not allow the communication of information exceeding the speed of light, it violates the spirit if not the law of special relativity.

The phenomenon was first discovered by Thomas Young in the early 1800s, with his famous double-slit experiment, which is still a mystery over two centuries later. Young demonstrated that if a beam of electrons were directed toward two thin slits in a plate, that they formed a wavelike interference pattern on a screen behind the plate. The electrons behaved like waves. If either slit were blocked, the electrons would form a single distribution behind the open slit, as expected of a particle beam. The intriguing question is: which slit does a particular electron go through to contribute to the wave pattern? And quantum theory says: both slits, as though their separation were not an issue. This suggests the nonlocality property of entangled particles.

In the style of George Gamow's *Thirty Years That Shook Physics*, Aczel sets forth the personalities (with photos) and their arguments and accomplishments (with illustrations) that map out the history of this strange phenomenon. Einstein, Podolsky, and Rosen wrote a famous physics paper ("EPR") that drew a clear line in the sand for quantum mechanics by those who opted for hidden variables to account for these strange aspects of quantum mechanics that contradicted large-scale physics. Decades later, John Bell wrote a paper, introducing Bell's inequality, which offered a route for experimentally deciding whether Einstein or Neils Bohr was right. Aczel describes the work of entanglement physicists up to the twenty-first century, and their experiments that show beyond doubt that something "spooky" really is going on—and that it is even beginning to be used for practical applications such as encrypted (secret) transmission of information. A recent experiment involving entanglement of three particles raises the question of the extent to which particles entangled as a single quantum system can be scaled up to the macro level.

Some physicists covered in the book, many personally interviewed by the author, are John Wheeler, Anton Zeilinger, Michael Horne, Abner Shimony, Alain Aspect, P. K. Aravind, Danny Greenberger, Nicholas Gisin, Cliff Shull, John Clauser, Yanhua Shih, and others. Aczel is physics professor at Bentley College in Waltham, MA.

This book relates to ASA interests in that it clearly leaves the reader wondering whether humanity is now engaging eternity through physics, where time and location lose their limitations. It raises the possibility that large-scale "impossibilities," such as the resurrected Christ passing through the locked door of the upper room might involve large-scale quantum coherence not otherwise observed yet, though suggested by entanglement physics. For physicists, this book has largely a physics-community appeal, but for nonphysicists, Aczel does a good job of clearly explaining the greatest current mystery in physics, with just enough logic and detail to give insight into the wonders, but without requiring fluency in mathematics.

Reviewed by Dennis L. Feucht, 14554 Maplewood Rd., Townville, PA 16360.

TREE OF ORIGIN by Frans B. M. de Waal, ed. Cambridge, MA: Harvard University Press, 2001. 311 pages, endnotes, bibliography, index. Paperback; $17.95. ISBN: 0674010043.

This book was an outgrowth of a session of a 1997 symposium at Cold Spring Harbor Laboratory. Six of the nine authors of articles in this book were participants in that session. Frans de Waal, the editor, is a professor of primate behavior in the psychology department of Emory University. He has written many books including *Good Natured: The Origins of Right and Wrong in Humans and Other Animals, Peacemaking among Primates*, and *Animal Social Complexity*. The nine articles in this book investigate various areas of human social evolution by examination of primate behavior. Among the topics covered are sexual behavior, the role of meat eating and meat-sharing, the origin of cooking, the development of language from primate grooming and cultural primatology.

Anne Pusey discusses chimpanzee social organization and reproduction. Her account of a genocidal war among the chimpanzees clearly shows a parallel between what chimps do and what humans have done in history. The main difference is that the victors appear not to rape the loser's females. Male chimps seem to be defending a feeding area rather than engaging in conquest for power's sake.

Frans de Waal in his article "Apes from Venus" compares human sexuality with that of the promiscuous bonobos who are similar to us in engaging in non-reproductive sex. These apes have sex as a means of reducing group tensions.

Karen Strier notes the great similarity among primates for philopatry, the reproductive pattern in which males stay in place and females have a higher chance of changing groups and living with their mate's group. This behavior has profound implications for the dispersal of mtDNA and implications for interpreting mitochondrial Eve, who is too often erroneously proclaimed by Christian apologists as the biblical Eve.

Craig Stanford uses chimpanzees to illuminate our love of meat. Chimps prey on the colobus monkeys and have been known to kill 800 kg in a single season. Contra the old early twentieth-century "Man the Hunter" thesis, which advocated that man with his weapons provided for the tribe, Stanford notes that possessing meat is a path to political power and sex among both chimps and primitive foraging peoples.

Of all the articles in this book, that of Richard Wrangham is the most interesting. The brain may represent 2% of our mass, but it uses 20% of our daily energy supply. Wrangham notes that the fossil record shows three things occurring around two million years ago which are consistent with cooking. The size of the hominid guts shrink, which should mean less digestion and thus less

nutrition, but the brain-size simultaneously expands, which requires much more energy, and the tree-climbing adaptations (long arms) were finally lost. Cooking meat and vegetables breaks down complex molecules and allows their nutrients to be digested much more efficiently. This in turn allows a smaller gut to deliver higher caloric content to a growing brain. And fire finally allowed the early hominids to sleep on the ground rather than in the trees. Fire deters those nasty night predators, like lions. Added to this is some archaeological support for the use and control of fire at Swartkrans, South Africa, shortly after this time.

Richard Byrne discusses animal social interactions which include behaviors we would consider sinful, such as lying to obtain food, and deceitful actions to cheat on the sexual rights of others. Chimps instinctively follow the political advice of sixteenth century Niccolo Machiavelli on how to get and hold political power. Robin Dunbar discusses how language replaced primate grooming behavior and predicts the natural human group size which is borne out by observation. Charles Snowdon discusses the origin of language from primate communications and William McGrew shows how culture, previously believed to be solely a human trait, is also possessed and transmitted to future generations by chimps.

The book is a fascinating window on the similarities between human and animal behavior which is sure to disturb many anti-evolutionary Christians. The similarity between these primate behaviors and that of our own forces one to consider our relationship, not only with our God but also with the creatures.

Reviewed by Glenn R. Morton, Manager of Subsurface Technology–North Sea, Ramsden Lodge, 103 Malcolm Rd., Peterculter, Scotland.

AFFLUENZA: The All-Consuming Epidemic by John De Graaf, David Wann and Thomas Naylor. San Francisco: Berrett-Koehler Publishers, 2002. 268 pages, index, bibliography, notes. Paperback; $16.95. ISBN: 1576751996.

It started with two PBS documentaries, the first of which aired in September 1997. Using the virus metaphor, the authors tackle a root problem in American life: too much "stuff." Driving into almost any middle class suburban neighborhood at dusk one can see the symptoms of this disease. Driveway after driveway is filled with shiny recent vintage cars. Looking in the garage, if the door is open, one can see why the cars are parked outside, for the garage is full of other things. But life is not a "stuff-eating contest," they write (p. 36). The best things in life are not things.

Toynbee once wrote that the measure of a civilization's growth was its ability to shift energy and attention from the material side to the spiritual, aesthetic, cultural, and artistic side. It is clear, write the authors, that the American civilization of the early twenty-first century is, by this measure, a miserable failure. The obsessive pursuit of material "blessings" is accompanied by rising debt, longer working hours, environmental pollution, loneliness, family conflict, stress, television shows that are 33% commercials, and spiritual hunger. The average new home today is 2300 square feet, about double what it was fifty years ago. It is also more than twice the distance to the workplace with a commute time (and cost) nearly three times higher. Mother Teresa once visited the USA to receive an honorary degree. She remarked on the material richness and spiritual poorness of the people she met. The authors argue that Americans have defined the "good life" as a "goods life." Consumption was a negative word 100 years ago; it meant to exhaust, to waste. Now we are all "consumers."

Affluenza is divided into three sections: symptoms, causes, and treatments. The three authors are, respectively, a television writer/producer, a former EPA staffer and author, and a professor emeritus (Economics) at Duke University. The book includes many illustrations by David Horsey, a Pulitzer Prize winner cartoonist.

This is not a "scholarly" book, but one aimed at Joe and Suzy Six-pack. For a sophisticated (and religious) discussion of the issues, I recommend *The Consuming Passion* (1998, edited by Rodney Clapp). That book has a deep analysis of the American drive for material wealth along with an in-depth treatment of the ethical issues involved. *Affluenza* is much more a blunt instrument as it takes the approach "we are in trouble, this is why, and this is what we must do about it."

In spite of its origins, and although much of the text appears to "dumb down" some of the details, this is a good book, one to read, and one to give—perhaps to your young offspring not yet entirely caught up in the American "rat race."

Reviewed by John Burgeson, 2295 E. Iliff Ave. #101, Denver, CO 80210.

CORPSE: Nature, Forensics and the Struggle to Pinpoint the Time of Death by Jessica Snyder Sachs. Cambridge MA: Perseus Publishing, 2001. i-x, 259 pages, index. Paperback; $15.00. ISBN: 0738207713.

The doctor met with the family in a private room to inform them that Dad had a pulmonary edema and congestive heart failure. He was eighty-nine years old and death was near. The daughter said that her dad donated his body to science. The hospital agreed to follow his wishes. Most medical schools do not need elderly cadavers. However, they seldom turn down a bequest, especially when it comes from families of benevolent financial donors.

If the university is involved in forensic research, Dad may be headed to the Body Farm. Best-selling author Patricia Cornwell came up with this name for this three-acre parcel of land near the University of Tennessee football stadium. Here Professor Bill Bass and his students place dead bodies in "the ideal habitat for replicating murder in all its popular outdoor setting....[they use] a well trampled field littered with rusting cars and surrounding...wooded hillside tangled with underbrush and laced with deer droppings ... [to] chart the effects on decay rates of temperature, humidity, rainfall and soil pH. They ... leave some bodies exposed, others buried at various depths, and still others locked in car trunks, stuffed in garbage bags, wrapped in blankets, naked or heavily clothed." All in the name of science.

Entomologic research and documentation evolved through the centuries. As early as the fourth Century BCE, Aristotle wrote that maggots and insects "come into being

not from union of the sexes, but from decaying earth and excrements." Bass seeks to combine and catalogue the data gathered.

Author writer Jessica Snyder Sachs examines this world of the forensic sciences in Corpse-Nature, Forensics and the Struggle to Pinpoint the Time of Death. She is the former editor of *Science Digest* but now works as a freelance science and health writer. Her work appears in *Discover, National Wildlife, Parenting* and *Redbook*. Sachs is a storyteller. She carefully defines her territory and terminology, then writes in a clear but unemotional manner. Sachs is a serious scientist so this text will not appeal to Baby Boomers who let funeral directors take care of body preparation or cremation of their next of kin. This material is not for the squeamish. For law enforcement personnel, it is a godsend.

The Body Farm is not Sachs' only venue. She is a science historian who documents forensic anthropology. However, the work done by these forensic entomologists and anthropologists in Knoxville fascinates her. Bass and his staff refined both the art and science of determining time of death. They often testify credibly in courts of law. Still, scientists of today stand on the shoulders of peers who preceded them and built a foundation for their work.

During World War II, research began on post-mortem identification of human remains left on the battlefield in Europe and the South Pacific. In 1939, Wilton Krogman published *Guide to the Identification of Human Skeletal Material*, the first detailed text for investigation of homicides which was readily adapted by the military. Sachs says that the "first bona fide celebrity" in forensic anthropology was Lawrence Angel who called himself *Sherlock Bones*. He raised the awareness that police officers and coroners needed training. Angel claimed that most of the medical examiners in America attended one of his seminars.

Sachs does not need the visual autopsy scenes from CSI: Crime Scene Investigation or HBO's Six Feet Under. She tells her tales without photos or illustrations because of her craft of the English language. Readers would enjoy Sach's writing if they found interesting Sherwin Nuland's book *How We Die: Reflections on Life's Final Chapter*. Sachs lacks the raw emotion of Nuland but writes equally as well. *Corpse* is both science and drama. It should appeal to anyone who loves science and celebrates the sanctity of life.

Sachs followed up with a new book, *Time of Death: The Story of Forensic Science and the Search for Death's Stopwatch* (Heinemann, 2002). Her other books include *The Encyclopedia of Inventions* (Franklin Watts, 2001) and several volumes of Grolier's *New Book of Popular Science*.

Reviewed by David Becker, writer-in-residence, Acedia Institute, Colorado Springs, CO 80906.

ORIGINS & COSMOLOGY

WHEN WORLDS CONVERGE: What Science and Religion Tell Us about the Story of the Universe and Our Place by Clifford N. Matthews, Evelyn Tucker, and Philip Hefner, eds. Chicago: Open Court Publishing Company, 2002. 403 pages, indices. Paperback; $28.95. ISBN: 0812694511.

The Parliament of World Religions meeting in Cape Town, South Africa, in December 1999 afforded the opportunity for twenty-two scientists, theologians, historians of religion, and a science writer to discuss topics in science and religion. The Carus Family Foundation and the John Templeton Foundation supported the meeting and production of this book.

Three major sections respectively take up issues in cosmology and the evolution of life on Earth and elsewhere, religion and ecology, and the ways in which religion and science may enrich one another. The chief focus is humankind's place in the universe. Distinguished participants in this dialogue include Astronomer Royal Sir Martin Rees, cosmochemist Clifford Matthews, anatomists Matt Cartmill and Philip Tobias and physicist George F. R. Ellis.

ASA members will find useful summaries of key areas of contemporary astronomy, physics, and human biology. The middle section details the ways in which specific religious traditions (Judaism, Jainism, Native American, Buddhism, Christianity, and Confucianism) may inform and be informed by ecology. An overall premise of the book (although not subscribed to equally or in the same manner by all participants) is that science and religion need each other if world views are going to be properly robust to deal with reality as we find it. A few of the chapters by scientists, e.g., Cartmill and Rees, display either hostility or intense apathy toward organized religion. On the plus side, readers can thus get a good feel for the "majority" view among scientific elites and the daily challenges Christians in scientific circles face. Other contributors, like the devoted Quaker George Ellis, take a more appreciative view and describe a complementarity approach. Overall this collection of essays does a good job summarizing current views and puts forward much food for thought. This book could be fruitfully used with students in a seminar course or in a church-based setting followed by discussion.

Reviewed by Dennis W. Cheek, John Templeton Foundation, Five Radnor Corporate Center, Suite 100, 100 Matsonford Road, Radnor, PA 19087.

THE MESSAGE OF CREATION by David Wilkinson. Downers Grove, IL: Intervarsity Press, 2002. 279 pages, study guide. Paperback; $15.00. ISBN: 0830824057.

This book is in the Bible Themes subset of the Bible Speaks Today series. These cover topics (salvation, the cross, etc.) that run throughout Scripture. Passages relating to the theme are examined in somewhat less depth than a full-fledged commentary, with emphasis on practical applications for Christians today.

Englishman Wilkinson earned a Ph.D. in astrophysics, and is now a Methodist minister and scholar in apologetics. He uses his scientific background not only in the expected places (relating God's creative activity to science), but also frequently in his illustrations. This should suit ASA readers well.

I am pleased that this book is not limited to "the usual suspects." Of the twenty passages considered, only five are from Genesis. Wilkinson recognizes that biblical teaching on creation is much richer than "origins," so he also takes the reader through songs of praise for the Creator, descriptions of Jesus as Lord of creation, lessons to be learned from the Creator, and the ultimate fulfillment of creation. Helpful applications are drawn for each; many of these stray from the topic of creation but they are always germane to the passage.

Perhaps the book's most praiseworthy aspect is its focus on the *message* of Scripture. While the typical science-related questions are not ignored, the author relentlessly insists that our goal should be to receive the messages God is trying to convey in these passages, and that most if not all of our Creator's messages do not depend on our interpretation of exactly how and when he did the creating.

Wilkinson also insists on the centrality of God's most exalted message: Jesus Christ. In numerous places, Christ is affirmed as Lord of creation and as the center and foundation of our faith. Warnings are given against basing our faith (and our apologetics) on things other than Christ, including science and human philosophical arguments.

Readers of this journal may want to know where the author stands on issues like the age of the Earth and evolution. I must reemphasize that such issues are peripheral to the book, as Wilkinson continually focuses on the *messages* of the Bible. For example, his exposition of the ways Christians relate Genesis 1 to science is relegated to an Appendix, and even there he says: "*The writer of Genesis, inspired by the Holy Spirit, is more concerned with who God is than how he made the Universe.*" In that context, the author finds no reason to reject any of modern science, though he roundly rejects the scientism of those who see science as the only source of worthwhile knowledge. He says little about the Intelligent Design movement, but he does criticize reliance on the design argument for tending to promote a "god of the gaps" and remove Jesus Christ from his rightful place as the focus of our faith and our apologetics.

The book is written well and at an accessible level. The author has wide-ranging interests, referencing not only Calvin and C. S. Lewis but also *The Matrix* and *Hitchhiker's Guide to the Galaxy*. While British in tone and in some of its illustrations, it is still readable for those of us who think footballs are oblong and barely have heard of David Beckham. Slightly frustrating were several footnotes pointing to books that are not in print in the U.S.

The Message of Creation would be an excellent resource for ASA members, pastors, and anybody who wants to delve into what the Bible has to say about our Creator. It could also be used for group study. The church would benefit greatly if more people followed Wilkinson's approach of focusing not on alleged science/faith conflicts, but rather on the message of God's written word and the centrality of his incarnate Word.

Reviewed by Allan H. Harvey, 1575 Bradley Dr., Boulder, CO 80305.

DESIGN AND DISORDER: Perspectives from Science and Theology by Niels Henrik Gregersen and Ulf Görman, eds. London: T&T Clark, 2002. 232 pages. Paperback. ISBN: 0567088685.

This book, one volume in the series, Issues in Science and Theology, published under the auspices of the European Society for the Study of Science and Theology, contains nine essays dealing with the relationship between divine design and disorder in the universe. Gregersen is research professor in theology and science at Aarhus University, Denmark, and Görman is professor of ethics and philosophy of religion at Lund University, Sweden. Both editors contributed essays to the book

Although the contributors offer significantly diverse perspectives, all reject divine intervention in the universe subsequent to the initial creation. The editors explicitly state in their preface: "We hope to have provided a volume that shows how the issue of design can be discussed in other frameworks than that of an anti-naturalist approach to design." The essayists take a dim view of Intelligent Design and other attempts to undermine the evolutionary paradigm.

In his introduction (chap. 1), Görman briefly introduces each of the essayists, noting that they all challenge "the received view" of design in nature in one way or another.

John Barrow's essay, "How Chaos Coexists with Order" (chap. 2), reviews a variety of current physical concepts and theories offered as explanations of the natural order, only to conclude that "the structure of the world around us," in particular the organized complexity we see in nature, "cannot be explained by the laws of nature alone." He suggests that organized complexity in nature "relies on that other complexity called 'intelligence' to act as a catalyst and midwife for its creation."

John Hedley Brooke revisits Darwin on order and design in chap. 3. Brooke's essay consists of a fairly long account of Darwin's own intellectual odyssey followed by a superficial critique of Behe's arguments in *Darwin's Black Box*.

Chapter 4, "Beyond the Balance: Theology in a Self-Organizing World," is Gregersen's own contribution to the book. He affirms at the outset that "we need more than variation and selection to explain the intricate world of biology," proposing that "the neo-Darwinian Synthesis needs to be supplemented (though not replaced) by theories of chemical pathways and self-organization."

I found John Puddefoot's essay, "Landscapes of Human Discourse" (chap. 5), abstruse and confusing. Even those who understand it will have to agree that it does not grapple with the question of design and disorder in the universe.

Isabelle Stengers, well known for her work with Ilya Prigogine, is the only contributor who explicitly declines to describe herself as a Christian. Paradoxically, her essay (chap. 6) acknowledges that "biblical creationists" have valid criticisms of materialistic monists like Dawkins. While not offering her own solution to the question of design in nature, she aligns herself generally with Whitehead's approach to religion and science.

Christoph Theobold, SJ, offers a Thomistic perspective in "On Finality in Creation Theology" (chap. 7). He has

reservations regarding the anthropic principle, apparently because he believes it leads to rejection of an Aristotelian/Thomistic view of creation (and therefore provides a flimsy foundation for faith.)

In "Design in the Universe and the Logos of Creation" (chap. 8), Alexei Nesteruk brings an Eastern Orthodox perspective to the question of design in nature. His essay goes back to the Greek Fathers (Athanasius, John Philoponus, Maximus the Confessor) to develop a theory of the relationship between the Christ, the Logos of God, and the rational principles giving form and order to the world (the *logoi* of creation).

Willem Drees (chap. 9) concentrates on disorder rather than design. He summarizes his essay in two theses:

> (1) Disorder in nature calls into question a wide variety of projects in "science and theology," as too many projects are based on mistaken assumptions of harmony.
>
> (2) Disorder in nature is a reality which can be considered as if it were designed to call humans to responsibility, to serve God and each other with all our heart and soul as well as with all our power and mind.

The essays in this book have something for every Christian interested in the design and disorder in nature. The various authors bring a European perspective not commonly encountered in writings on this side of the pond. I recommend the book highly.

Reviewed by Robert Rogland, Science Teacher, Covenant High School, Tacoma, WA 98465.

SCIENCE AND GOD: Our Amazing Physical and Economic Universe—Accidental or God Created? by M. L. & John G. Greenhut. Lanham, MD: University Press of America, 2002. 170 pages. Paperback. ISBN: 076182250X.

Numerous physical scientists have argued for the anthropic principle—that a finely tuned universe by and from the Big Bang manifests intelligent design in structure, intelligent purpose in function, and creative power in origin. Here two, very well-published economists try to supplement those arguments with a similar argument from what they call the "economic universe."

The authors are serious students (certainly not teachers) of natural science but clearly not of philosophy, as their survey of its history readily reveals. They appeal to many cosmological arguments but doubt that any, or all, can prove God's existence. They seem certain, however, that "the contention that randomness could produce order over [enough] time, is in our view, a *per se* rejection of science." Such surely seems logical, but logic fails vis-a-vis God apparently. Science can only be rhetorical persuasion regarding its origin and goal, the Alpha and Omega.

They find both the universe and the university (of human knowledge) so amazing that their very possibility is unbelievable. They mean—without using the term—stupefying, awe-full, wondrous, beautiful (harmony in clarity). Not just multiple universes, but even nuclear realities seem more unbelievable than a Divine Creator. But wisdom does not necessarily provide a Grand Unified Theory.

Unfortunately, their book is a jumble. Only 90 of 170 pages present the arguments. The rest are made up of a preface, a foreword, two postscripts, two postludes, and eight appendices. They claim their audience will be, and is meant to be, scientific lay people, but their arguments are usually expressed in terms (and letters) of higher mathematics.

There are some basic contradictions. "There had to exist *eternal* (pre-Big Bang) matter ... in [a] neutral state." Yet they end the book with eight arguments that the universe is only 5,000 years old. All of the evidences for its vast time, they suggest, are an intelligent-designed illusion, a "duck-soup smoke screen by a Loving God." In fact, "if one uses Riemannian geometry instead of Euclidean geometry, the date of the Big Bang would be cut down by billions and billions and millions and millions of years."

There is significant silliness at times, as in their "The Grand Design in our Oligopolistic-Oligopsonistic Economy" which apparently designates any economy—anywhere, anytime, of any size. And there is outright madness in their arguments, first, that an(y) economy is a finely tuned equilibrium of an infinite number of relations and interconnecting occurrences, and second, it therefore must be a God-created intelligent design that complements the IDs in the physical universe. Their interest in presenting economic realities in forms of higher mathematics would surely give Alan Greenspan a stomachache. As vice president of mining, drilling, and investing companies and as a registered financial planner, if they had ever showed up as the business consultants (they claim to be), I would have called the goon squad.

That is the most amazing thing about this book. The authors, open to all knowledge, wanting to integrate it all, searching for a GUT, acknowledged experts in economics, do their worst work and show their greatest weakness precisely in discussing economics. There are better books by far.

Reviewed by Richard J. Rolwing, 7651 Burkey Ave., Reynoldsburg, OH 43068-2658.

CREATION by Hans Schwarz. Grand Rapids, MI: Eerdmans Publishing Company, 2002. 254 pages, indices. Paperback; $29.00. ISBN: 0802860664.

Recent years have witnessed a significant industry development in the area of engagement between modern science and religion/theology. Much of the writing in this arena frequently suffers from a lack of sophistication and understanding by the theologian or religious studies scholar of the science in question. This is often coupled with a naïve or even dismissive approach to theology or respective world religions shown by a (frequently renowned) scientist. Fortunately, as with any maturing field, this chasm is narrowing as more and more individuals develop some reasonable or even profound competence in what used to be a forbidden or foreboding intellectual terrain, some with singular and positive effect (e.g., John Polkinghorne, George Ellis, Philip Clayton, John Haught, Robert Russell, Alister McGrath, Thomas Torrance, Howard Van Till). Hans Schwarz can certainly join this elite company as an active German Lutheran theologian who comprehends signifi-

cant dimensions of the modern scientific enterprise. Some of his prior theological work probes issues in Christology and eschatology. He now complements these contributions by considering creation, both as a doctrine and from the standpoint of what insights modern science might provide on this ancient and venerable theological topic.

Since the author has held appointments in both the United States (Lutheran Theological Southern Seminary in Columbia, SC) and Germany (University of Regensburg), the book displays wide knowledge of people, movements, and thoughts on both sides of the Atlantic in both Anglo and non-Anglo (admittedly mainly German) circles. Many key ancient and modern theologians who have written on either science or creation are discussed including Augustine, Barth, Bonhoeffer, Luther, Moltmann, and Pannenberg, with a heavy emphasis on the Germanic theological tradition. Scientists and organizations active in contemporary science and religion dialogue are also prominently on display (e.g., ASA, Barbour, CTNS, Davies, ESSSAT, John Templeton Foundation, Peacocke, Polkinghorne, and von Weizsäcker). Throughout, the book displays an appreciation of the complementarity of both science and theology to understanding this important Christian doctrine but avoids the non-overlapping majesterial argument advanced by the late Stephen J. Gould in *Rock of Ages*.

The author works hard to show how science has often been a bastion and staging ground for atheism or agnosticism and an uneasy place for many Christians, the kind of reality that contemporary science actually reveals, the rapprochement that occurred in the latter part of the twentieth century between science and Christian faith, and a nuanced understanding of the doctrine of creation in light of these many and varied developments. No mention is made in the book of either young earth creationism or the intelligent design movement—possibly because these movements have only found large followings among evangelical Christians and churches in the United States. Some important recent theological work by Anglo scholars on creation is not mentioned (e.g., Colin Gunton, Alister McGrath, Keith Ward) but this oversight should not hinder anyone's acquisition of this important treatise.

Reviewed by Dennis W. Cheek, Vice President for Venture Philanthropy Innovation, John Templeton Foundation, Radnor, PA 19087.

HOW LIFE BEGAN: Answers to My Evolutionist Friends by Thomas F. Heinze. Ontario, CA: Chick Publications, 2002. 158 pages, index. Paperback; $8.50. ISBN: 0758904797.

The book presents a rebuke of atheistic chemical evolution in favor of an unspecified but non-evolutionary theistic process. The five chapters address topics such as the self-assembly of proteins and other biopolymers, descriptions of chemical processes in cell biology, and intelligent design. The final chapter offers an evangelical Christian message of a creator God who is interested in the reader. There are no illustrations or diagrams. The author cites many reputable journals, and some less reputable journals, as well as many mainstream biology and geology textbooks. Much of the book addresses the historical development of chemical evolution theory with particular attention being paid to changes in the theory as they have occurred over the past several decades.

It is the author's conviction that current evolutionary theory cannot explain the chemical formation of proteins, enzymes, RNA, DNA, or any other biochemical molecule. Though much of the author's discussion of the historical development of the theories of chemical evolution is informative and well constructed, his conclusions take on the sensationalistic and ridiculing tones of the typical young earth proponent. Heinze speaks of hidden scientific secrets that prove the impossibility of chemical evolution and implies the existence of scientific conspiracies. Heinze also correlates the teaching of evolution with moral degradation in American society. Though Heinze makes use of many of the rhetorical techniques and social logic of the young earth advocates, he does not overtly declare himself to be a young earth proponent. Rather, Heinze aligns himself with the intelligent design movement and cites Behe and Dembski quite heavily.

The strength of this book lies in its summary of the evolution in theories of chemical evolution. Heinze explains many aspects of science, such as chirality, in an easy to read, lively style that the most readers will appreciate. Heinze is fairer to science than most young earth antievolutionists and deserves some credit for his efforts in this regard. Although Heinze presents the questions and problems of chemical evolution in a fairly honest approach, he does not carry these desirable qualities through into his interpretations and conclusions. The book's strength, in its easy to read writing style, evolves into a weakness as sensationalism and logical fallacies become predominant in Heinze's philosophical, social, and theological evaluations. For example, Heinze fixes the cause of many current social problems on the teaching and acceptance of biological evolution. Heinze says, "Darwinism is the grinch that stole hope. Guns in school are just a symptom." Such statements may inspire the choir, but they do nothing to convince the wary reader who questions the legitimacy of such logic.

This book is available on line at no cost. For those interested in Heinze's summation of the historical development of chemical evolution theory, I would suggest that they go there. For serious readers interested in an integrated approach to Christian faith and origin science, I would suggest looking elsewhere.

Reviewed by Gary De Boer, associate professor of chemistry at LeTourneau University, Longview, TX 75607-7001.

PHILOSOPHY & THEOLOGY

PANDEMONIUM TREMENDUM: Chaos and Mystery in the Life of God by James M. Huchingson. Cleveland, OH: The Pilgrim Press, 2001. x + 230 pages. Paperback; $17.00. ISBN: 0829814191.

Huchingson's goal in writing this book is summarized in the following thoughts:

> The notion of complexity, the common object of study in several ... new sciences, is itself suggestive of a whole new host of insights and concepts around which to build a new cultural paradigm, a cosmology

> or world view founded in notions of interaction, interdependence, and diversity. If history repeats itself, this cosmology will likely lead to a new cycle of theological reflection concerning the nature of God and the creation as reinterpreted under the rubric of complexity (p. 39).

To get to his "new cultural paradigm," Huchingson begins by telling us that we base our theology, in part, on concepts we already have. The computer is so all-pervasive in our society that we are going to remodel our theology from our knowledge of computers. In particular, he believes that we should, and will, use the concepts of information theory to help shape the theology of the twenty-first century. He is familiar with theology, being a professor of religious studies at Florida International University. Although scholarly, his book is readable. As a non-theologian, I believe that he is right. Our familiarity with computer concepts will inform our theology, either as we deliberately set out to incorporate such concepts, or just because such concepts are part of the lens with which we view the world.

He spends three chapters setting up his theological background. A fourth is "A Primer of Communication and Systems Theory." I doubt if most computer users, including professional theologians, have much notion what systems theory, or information theory, is all about. With this lack, I doubt that their theology will reflect these areas in any satisfactory form. I was hoping that Huchingson was going to remedy all of this. It seems likely that he could have. He knows his theology, and seems to know enough about systems theory and information theory to be helpful in explaining them to others. Probably anyone reading this who knows either of these areas fairly well can immediately think of some connection to theology that would be helpful in thinking about God, or in doing "God-talk," as Huchingson literally translates "theology." For example, if prayer is communication, then information theory may be helpful in thinking about prayer.

However, this is not where Huchingson wants to go. In chapter five, he discusses the idea of original waste, the formless void from which God created things. This is the *Pandemonium Tremendum* of his title. Yes, there may be a relationship to information theory. But then, in chapter six, he loses me, or, rather, he tries to lead me onto a path which, if I understand him, I do not think I should follow. I quote Huchingson: "The *Pandemonium Tremendum* is this source of abundance without which God could not be God" (p. 116). "... the *Pandemonium Tremendum* is the reason for God's absolute sovereignty and the limitless source of variety for the creation" (p. 137).

Unless I misunderstand the author completely, he is claiming a much greater role for chaos than either Scripture or common sense allow, coming close to making the original chaos more important than the omniscient, omnipotent Creator. He seems to recognize this, to some extent. In his final chapter, "Evaluating the Model," he says:

> We have identified several weaknesses in this system either as inconsistencies or lingering, inadequately answered questions. One concerns the ontological subordination of God to the *Pandemonium Tremendum*. The answer given to the cosmological question—why God exists—has the deity arising from the chaos as a spontaneous posit, the primordial decision that determines God ... How is it possible for the primordial chaos, over an eternity of turbulent mixing, to give rise to an enduring entity or ordered state capable of fending off the destructive scouring of the chaos? (pp. 219–20)

How, indeed?

Huchingson has much to say that is good. His analysis of the original language of Scripture and his willingness to try to bring insights from science to bear on theology are among the things about this book that are to be commended. For myself, I regret that he seems to have used these tools to undermine his view of God's power.

Reviewed by Martin LaBar, Professor of Science, Southern Wesleyan University Central, SC 29630.

HEARING THINGS: The Mystic's Ear and the Voices of Reason by Leigh Eric Schmidt. Cambridge, MA: Harvard University Press, 2002. xvi + 318 pages. Notes, index. Paperback; $17.95. ISBN: 0674009983.

"*Speak Lord, for thy servant heareth*" (1 Sam. 3:10). Christians hold diverse understandings of the way they hear the voice of God. In this work, Schmidt, Princeton Professor of Religion, tackles the question of how the Enlightenment influenced and clarified the "devotional ordinariness of hearing voices, the everyday reverberation of spoken scriptures, and the expectation of conversational intimacy with Jesus (as well as angels and demons) common in pietistic Christian circles" (p. vii).

Schmidt wants to discover what happened to Christian practices in the light of various Enlightenment ways of thinking and the tactics of reformers of "enthusiastic" popular devotion. Not surprisingly the Enlightenment effort to debunk religious voices saw instead "more prophets, tongues, and oracles ... the modern predicament actually became as much one of God's loquacity as God's hush" (p. 11). As evangelicals (especially the early Methodists) came to absorb the thinking of Scottish Common-Sense Philosophy and the new science, the old conflict between the demystifyers and Christian devotionalism (the notion that God speaks and hears) acquired a modern look.

Demystification (separation of the real from the false) was deemed important to make sensory impressions reliable—the passions, credulity, ecstasy, and Christian proclamation possessed an ambiguous, unstable power which made its careful management especially urgent. Schmidt concludes: "However intent deistic skeptics were in their practices of demystification, the path of the Enlightenment proved treacherous, littered with blockages, switchbacks, and outright reversals" (p. 8).

Chapter 1 debunks two received views: (1) that the Enlightenment obsession with vision, optics, and literacy displaced *traditional* aural and oral cultures, and (2) that the modern loss of hearing reflects the loss of divine presence in the emergence of a *secular worldview*. Schmidt deftly identifies the weakness of these views in demonstrating that they were more than matched by a new understanding of the ear and new expressions of what Augustine earlier described as "the light in my inner self,

when my soul is bathed in light that is not bound by space; when it listens to sound that never dies away" (p. 36). Prayer remains a practice which involves a speaker-listener relationship conditioned by the Holy Spirit.

Chapter 2 describes a variety of individuals who struggled with the call to preach the Gospel in austere circumstances. Schmidt finds that the centrality of preaching in Christian worship was complemented by a "spiritual hearing" that prompted an immediate response as in the call to be a preacher. Quakers, Baptists, and itinerant non-denomination preachers emphasized this immediate inner call. Countering this approach was a view that a congregation called the minister in a careful public constitutional manner which barred "restless and turbulent persons" (John Calvin, p. 42). The Puritans stressed formal preparation and trial before ordination.

Chapters three through five consider (1) oracles (clairvoyants, mediums, fortunetellers, tongue-speakers) whom the Enlightenment particularly enjoyed debunking; (2) ventriloquists, whose art moved from demonic possession to a rationalistic critique of religion to a popular entertainment; and (3) prophets, including trance-speakers and mediums of all sorts, who proliferated through the nineteenth and twentieth century.

The telling of this tale ranges from descriptions of tongue-speaking Scottish Presbyterians, Swedenborg's Church of the New Jerusalem, and the sacramental powers of the telephone to camp-meeting enthusiasm, the magic lantern and the speaking trumpet.

Schmidt concludes that much of twentieth-century American religion is still taken up with these issues – the persistence of Enlightenment models of pathologizing religious voices, the culture of showmanship's absorption of religion's oracular power, and the popular surfeit of Pentecostal tongues and channeled spirits. He suggests, however, that the modern displacement of prayer for "quality" interpersonal relationships and the absorption of religion into discourses on ecology and therapy offers a religious absence that would be unthinkable. Amen!

While beautifully crafted as an academic production *Hearing Things* has limited value for the evangelical reader as it does not offer *a theological base* for voices – a deliberate (p. 33), but unfortunate choice.

Reviewed by J. W. Haas, Jr., Emeritus Professor of Chemistry, Gordon College, Wenham, MA 01984.

WHAT IS RELIGION? by Robert Crawford. Independence, KY: Routledge, 2002. 234 pages. Paperback; $20.95. ISBN: 0415226716.

In Robert Crawford's *What Is Religion?* today's most popular religions (Judaism, Christianity, Islam, Hinduism, Buddhism) are described in relationship to their rituals, scriptures, women, liberation, divisions, and behavior. Chapters of interest to *PSCF* readers include "Confessing a Murder," a presentation of Darwin's theory; "Is the World Designed?" a discussion of whether the earth is designed or accidental; and "What Are We?" an exploration of human nature. In his concluding chapters, Crawford contemplates religion's definition and future.

Crawford, professor of religion with the Open University, has taught in four foreign countries. He has written six other books including his recently published *Can We Ever Kill?* His *The God/Man/World Triangle* was nominated for a John Templeton Award for theology and the natural sciences. After many years of teaching the subject, Crawford wrote *What Is Religion?*

This book has several attractive features. It is reasonably priced, succinct, up-to-date, and evenhanded in its approach. Although it has seventeen chapters, they are compressed into 234 pages including endnotes and an index. It would be an appropriate selection for a college course in religion, a church study group, a laypersons' book club, or someone interested in a brief summary of what religion is and where it is likely headed.

Reviewed by Richard Ruble, John Brown University, Siloam Springs, AR 72761.

Social Science

SPIRITUAL, BUT NOT RELIGIOUS: Understanding Unchurched America by Robert C. Fuller. New York: Oxford University Press, 2001. 212 pages. Hardcover; $25.00. ISBN: 0195146808.

Although over 90% of all Americans believe in God or a Higher Power, only 62% are connected with organized religion. About one-seventh are "secular humanists" who reject all supernatural understandings of the world, but about one in five are unaffiliated, yet "spiritual, but not religious." Impatient and disgusted with institutional religion or feeling harmed by it, their individualized spirituality picks and chooses beliefs and practices from a wide range of alternative religious philosophies. Believing each person has the right to direct one's own developmental life journey, they reject churchianity and explore that which lies beyond material reality to affirm their inner self potential.

In this fascinating book, Fuller, professor of religious studies at Bradford University and the author of *Naming the Antichrist* and *Alternative Medicine in American Religious Life*, surveys the history of such people in America, summarizes their alternative world views, and describes the "new eclecticism" of their psychological spirituality. The words *religion* and *spiritual* formally are synonyms that connote belief in a Higher Power, imply a desire to connect with it, and indicate rituals and behaviors fostering that connection, but most Americans now associate the word *spiritual* with the private realm of thought and personal experience, while *religion* is relegated to the public realm of membership and participation in religious institutions.

Fuller reminds us that about 85% of colonial Americans were not church members. The majority engaged in various magical and occult practices, including astrology, fortune-telling, divination, witchcraft, and healing practices (amulets, charms, potions, "supernatural" herbs, magic, etc.). "What is certain is that, from the outset, Americans have had a persistent interest in religious ideas that fall well outside the parameters of Bible-centered theology" (p. 15). Deism, Enlightenment rationality, Freemasonry,

Universalism, Swedenborgian metaphysics, Transcendentalism, mesmerism, spiritualism, New Thought, Hermetic science, and Theosophy all made their mark before or during the nineteenth century.

The thirst for the paranormal has found its way into trance channeling, angelology, near-death experiences, *The Celestine Prophecy,* the human potential movement, *A Course in Miracles,* fascination with the mysticism of Eastern religions, feminist and ecological spiritualities, neo-paganism, witchcraft, New Age spirituality, and other spiritual phenomena. Unease with separation of the cure of souls from the cure of bodies has contributed to the popularity of alternative medicines, healing practices, and therapies that draw upon occult and metaphysical traditions. Psychology, often used to define mature faith, has become a secular successor to religion. Even churches, trying to satisfy the popular quest for self-actualization, however labeled, have made "spiritual psychology" their focus of attention.

In his wide-sweeping analysis with its index and twenty-five pages of reference notes, Fuller convincingly demonstrates that the new "seeker spirituality," in contrast to the "habitation spirituality" of active membership in a particular religious heritage, is not new. He capably suggests that the cultural influence of the "spiritual, but not religious" philosophy, bolstered by both scientific and pseudo-scientific developments, is gradually gaining dominance over institutional religion in American society. The huge national bookstore chains, with their large sections on the Bible, Christianity, and Judaica but even larger sections devoted to Eastern religions, New Age spirituality, and self-help philosophies, are emerging as "the virtual synagogues of spiritual instruction" that help people weave together their personalized spiritualities while "eschewing the one-size-fits-all faith of established churches" (p. 155). Analysis of the extent to which this trend is reshaping the personal faith of church members and possibly serving as a major impetus in the changes, growth, and decline of Christian congregations and denominations could be the next significant scholarly and scientific research task in the study of religion.

Reviewed by David O. Moberg, Sociology Professor Emeritus, Marquette University, 7120 W. Dove Ct., Milwaukee, WI 53223.

THE VARIETIES OF RELIGIOUS EXPERIENCE: A Study in Human Nature by William James. 1902; centenary ed., Independence, KY: Routledge, 2002. 415 pages. Hardcover; $18.95. ISBN: 0415278090.

This book is a classic. That is why a centenary edition has been issued. In 1902 when it was first published, *The Nation* said this book was "epoch-making" and predicted that it would become a classic, and so it has. In *The Varieties of Religious Experience,* William James shows why he is one of the most lucid, charming, insightful and brilliant writers America has ever produced. He is called "America's foremost psychologist" by psychology's renowned historian Edwin Boring. Gertrude Stein captured the admiration subsequent generations have held for William James when she said, "Is life worth living: Yes, a thousand times yes when the world holds such spirits as Professor James."

Ideas contained in *The Varieties of Religious Experience* were first delivered by James in Edinburgh as the Gifford Lectures and later transcribed into this book. In it James described religious experience in a systematic, colorful, and empirical way. He dealt with a variety of religious topics including conversion, saintliness, mysticism, near-death experiences, and polytheism. He believed religious experience was worthy of scholarly study, and he devoted a substantial part of his time and writings to it. James defended the right to believe in the existence of God because it makes people "better off," although he thought there was no scientific evidence for God's existence.

James' emphasis on the psychological study of religion established a legitimate field of study in contemporary psychology. For people interested in learning about the psychology of religion, the first book they should read is *The Varieties of Religious Experience.* Far from being erudite and pedantic, it is immensely readable and highly insightful. While evangelicals may discover points of debate, they may also come upon new ways of describing humanity's propensity for religious experience.

Reviewed by Richard Ruble, John Brown University, Siloam Springs, AR 72761.

THE SPIRITUAL DIMENSION OF AGEING by Elizabeth MacKinlay. London, England, and Philadelphia: Jessica Kingsley Publishers, 2001. 272 pages. Paperback; $22.95. ISBN: 1843100088.

Stimulated by increasing awareness of the spiritual dimension in health, MacKinlay examines its relationships with religion, faith, and spirituality, especially as people grow older. This book's topics include meaning in life, images of God, the spiritual journey, perceptions of self-sufficiency and vulnerability, wisdom for the move from provisional to final meanings, fear and despair, hope, humor and laughter, horizontal and vertical social relationships, isolation, preparation for aging, and many others. The author, a senior lecturer at the School of Nursing in the University of Canberra, Australia, is both an experienced nurse and an ordained Anglican priest. She has been a university chaplain and is the inaugural director of the Centre for Ageing and Pastoral Studies.

MacKinlay's findings about spirituality from in-depth interviews on meaning in life with twenty-four diverse volunteers aged 65-plus are interwoven with information and perspectives drawn from a wide range of other gerontological resources to produce a coherent account of the spiritual dimension of aging. She interprets spiritual wellness as a movement toward wholeness that can continue throughout the entire lifespan. Rather than a state of being, it is a process that is as basic to healthy aging as physical and psychological wellness.

Although this study is the product of research "down under," its research findings and conclusions are applicable to people worldwide. In many ways it complements the book on *Aging and Spirituality* (Haworth Press, 2001) that I recently co-authored and edited. It is easy to use as a resource because the 135 sources it cites are alphabetically listed in References, there is both a Subject and a Name

Index, and each of its fifteen chapters ends with a brief summary.

I recommend this book for both educational study and personal reading. Although written for the general market, it does not reduce spirituality merely to feelings or a set of mythological beliefs, nor does it assume all religions are equivalent, even though it has only passing mention of non-Christian religions. It covers the major topics that ought to be infused into the awareness of all who work with aging people, whether in volunteer services or in professions like nursing, pastoral care, or social work, and it often mentions topics needing additional investigation. "The findings of research into the spiritual dimension ... can only be of value if ... professionals are in touch with their own spirituality" (p. 239).

Reviewed by David O. Moberg, Sociology Professor Emeritus, Marquette University, 7120 W. Dove Ct., Milwaukee, WI 53223.

THE ECONOMIC LAWS OF SCIENTIFIC RESEARCH by Terence Kealey. New York: Palgrave Macmillan, 1997. 396 pages. Paperback; $26.95. ISBN: 0312173067.

Government funding of scientific research is a massive waste of money. Technological progress is not attributable to science. Privately funded and hobby scientists have been the most productive. Sound preposterous? Kealey is a Cambridge University biochemist who challenges widespread myths about the relationships of science, technology, and economics.

He begins with the "linear model" of Francis Bacon, that government-funded science drives technology, by showing historically that the technological advancements of skilled, uneducated workers in England drove the technical advancement that led to scientific investigation. Basic science today contributes about 10% to new technology; 90% is driven by existing technology, just as old science largely drives new science.

Kealey compares the history of development of science and technology in Britain and France. The essential difference between the two countries was that the British government adopted *laissez faire* policies while the government of France ran every aspect of French society. Yet Britain grew rich and France remained poor. Technical progress relied upon the inventiveness of local engineers who could afford to do private development due to low taxes in Britain.

British science was funded largely by hobbyists, industry, and private endowments of university science. Hobby scientists included Cavendish, Darwin, and Royal Society president William Parsons. The increasing wealth of Britain enabled thousands to passionately take up science as a hobby. It flourished until 1914, when *laissez-faire* Britain ended. As Kealey observes:

> The loss of the hobby scientists has been unfortunate because the hobby scientists tended to be spectacularly good. They were good because they tended to do original science. Professional scientists tend to play it safe; they need to succeed, which tempts them into doing experiments that are certain to produce results. Similarly, grant-giving bodies which are accountable to government try only to give money for experiments that are likely to work. They represent the development of established science rather than the creation of the new. But the hobby scientist is unaccountable. He can follow the will-o'-the-wisp.

Economic charts and tables appear in Kealey's account of economic history since the 1870s and the trend is clear: "In the long term, there is only one factor that determines the rate of economic growth: productivity." And innovation is "a crucial contributor to improvements in productivity." Government investment is inadequate; the USSR invested to excess yet did not grow. In 1960s America, after twenty years of huge government investment in science, officials started to doubt the Baconian model. The defense department commissioned a vast study, *Project Hindsight*. "Indeed, the evidence suggested that, if anything, it was the unexpected discoveries made by technologists or engineers that boosted pure science, rather than the other way around."

Running through Kealey's book are the negative effects of war on science. "During war, a government must intervene to regulate all aspects of a nation's life, and that experience of government control legitimizes *dirigisme*, central planning and dependence on the State."

Kealey then turns from history to the logic of why the Baconian model fails. "Governments are dreadful judges of commercial opportunities." He gives recent examples.

In the chapter, "The Real Economics of Research," Kealey delivers on the book's title, and gives the three laws of funding for civil R&D, along with copious data in support.

In the last chapters of this content-intensive book, Kealey argues that both British and American research and development are not in decline, and that one must be careful not to confuse rates with absolute amounts for developed countries.

Finally, he widens the scope to philosophy of science, in which he denounces the influence of Rousseau's anti-science and pro-statist views on Hegel, Robespierre, Marx, Hitler, Lenin, Mao, Mussolini and Matthew Arnold.

This book is recommended reading or as a reference on the relationship of sci/tech to the larger world of economics, politics, and philosophical concerns.

Reviewed by Dennis L. Feucht, 14554 Maplewood Rd., Townville, PA 16360.

GOING PUBLIC: Christian Responsibility in a Divided America by Lawrence E. Adams. Grand Rapids, MI: Brazos Press, 2002. 192 pages. Paperback; $18.99. ISBN: 1587430304.

Are the people of the United States of America politically and morally polarized? Adams, associated with the University of Virginia, assumes the answer is obviously "yes." He addresses these questions to the conservative Christian community: what is the role of the church in the public square, how can the church express this role, and is it necessary or possible for society to have a common ethic? His goal is to encourage Christians to understand the American culture so as to engage public life responsibly.

The book was done as part of a research fellowship under the auspices of the University's Post-Modernity Project.

There is much to admire about this book; the author writes clearly and with passion. The polarization argument is well developed, although much is taken for granted. For instance, he posits certain moral positions as obviously "Christian" and other positions as obviously "not Christian." But this is a consequence of his writing for a designated target audience. He expresses his personal unhappiness with American society's opting for "life, liberty and the pursuit of happiness" and argues for a state which ought to be one "existing primarily for the glory of God, and to see his will be done on earth as it is in heaven" (p. 63).

This statement made me question whether the author would speak at all of religious pluralism. Somewhat to my surprise, he did not. Indeed, the survey data he cites speaks of America as being made of just five religious groups: evangelical and mainline Protestants, orthodox and progressive Catholics, and secularists. In the world of Adams, it appears, Muslims, Mormons, Jews, Unitarians, American Indians, and a host of other minority groups, do not exist. In my view, this oversight weakens many of the author's arguments.

The timeliness of Adams' book makes it worth reading, but perhaps not keeping. Geoffrey Layman's recent book, *The Great Divide*, does a better job of addressing the issues, if not with the insights that came from the election of 2000. And the book by Robert Fowler, *Religion and Politics in America*, is another recommended read on this topic. I treasure both of these books in my own library.

Reviewed by John Burgeson, 2295 E. Iliff Ave. #101, Denver, CO 80210.

THE AMERICAN SPIRITUAL CULTURE: And the Invention of Jazz, Football, and the Movies by William Dean. New York: Continuum International Publishing Group, Inc., 2002. 240 pages, index, notes. Hardcover; $24.95. ISBN: 0826414400.

Dean is professor of constructive theology at the Iliff School of Theology and the author of five previous books, one of which won an award for excellence from the American Academy of Religion in 1995. In this provocative volume, he analyses the spiritual culture of the United States. American citizens are religious, he argues, not only in the obvious ways like attending religious services but also in other ways that reflect their common heritage as a culturally displaced people.

In the introduction, Dean writes: "I describe an America that harbors its own distinctive spiritual culture. This culture has guided America for one simple reason: Americans have believed that it speaks for a truth, even a reality, greater than America" (p. 9). The book is one person's answers to discovering both what that spiritual culture is all about and what the grounds are that support it. The book consists of two separate parts and a somewhat controversial conclusion.

In part 1, "God the Opaque," Dean discusses reductionism, which he labels "America's Reigning Religious Skepticism" (p. 34). He refutes the reductionists' (Durkheim, Freud, Segal, Guthrie and others) claim that the divine grounding of America's culture has disappeared, that the spiritual culture is based on nothing but itself, and that the claims of religion are "like shouts in an empty canyon" (p. 34). This was, for me, the book's high point. He then lays out the task for the religious critic, one which begins primarily by not adopting the world views of nonreligious inquiries. Subsequent chapters describe the American character as being that of a pragmatic "displaced person." There is a commentary on William James who had explored religious experiences in others without having one of his own. In James' final months of life, he broke through the "irony of atheism" into theistic richness. Dean returns to this theme at the end of the book.

In part 2, "America the Visible," Dean describes the inventions of jazz, football, and the movies as particular forms of the American spiritual culture. He discusses what each of these activities suggest, both about the American culture and about the Ultimate Reality that is active in it. "In their devotion, jazz fans show their appreciation for, among other things, improvisation; football fans suggest their ambivalent negotiation with violence; and movie fans manifest their desire for self-creation through fantasy. In each case, the enthusiasts telegraph their view of what is most (religiously) significant in their world" (p. 114). I read this part of the book several times, each time gleaning more insight into its thesis.

At the book's end, Dean offers a "Conclusion," a four-page brief titled "The Irony of Atheism." Out of secularization, he argues, religious experience often arises. Dean concludes, powerfully, by citing from Thornton Wilder's play, "The Skin of Our Teeth," an ironic look at the history of humankind. In the last speech of this play, the character Sabina speaks directly to the audience: "This is where you came in. We have to go on for ages and ages yet. You go home. The end of this play isn't written yet."

This book is an important contribution to understanding the peculiar American character. Robert Bellah, in a back jacket recommendation, sees it as both "intensely readable" and targeted to a "large audience of scholars and lay people alike." I would not recommend it, however, to less than a college student, and then only one with training in both the sciences and humanities. With that caveat, I recommend the book highly.

Reviewed by John Burgeson, 2295 E. Iliff Ave. #101, Denver, CO 80210.

Letters

An Author Responds to a Negative Book Review

I would like to respond to a review of my book, *Evolution and the Problem of Natural Evil*, which was published in the September 2002 issue of *PSCF* (p. 204). The reviewer, John Burgeson, of Durango, Colorado, clearly did not take the time to work through and understand the various pro-theistic arguments that are put forth in this book. He criti-

cized a mere three statements in the entire book, all three of which are based on a misreading (and hence misunderstanding) of my original text.

For instance, Burgeson makes the claim that I confused methodological naturalism for atheism on page 42 of the text, but this simply isn't the case. Methodological naturalism is entirely consistent with both theism and atheism. However, it has been used by many atheists and agnostics as a reason for excluding the basic idea of a Creator from the realm of modern science. Therefore, when I state that "methodological naturalism is the atheistic paradigm that implicitly forbids any evidence for design from being seriously considered by working scientists" on page 42 of *Evolution and the Problem of Natural Evil*, I am not confusing methodological naturalism for atheism. I am simply stating that methodological naturalism is the underlying concept that is often used to justify the exclusion of God from science. In this sense, it is frequently used as a tool by nonbelievers.

However, it is also true that a broadly defined "theistic science" makes equal use of methodological naturalism, because the very idea of "methodological naturalism" is itself religiously neutral, which simply means that it can be used by both theists and atheists alike. So, while it is indeed the case that some atheists utilize the principle of methodological naturalism as a reason or "excuse" for excluding God from the modern scientific enterprise, it is equally true that many theistically-oriented scientists utilize this very same methodological principle in their accumulation of physical data.

The reason for this is not far to seek—methodological naturalism is simply a methodological tool that is routinely used to empirically study and analyze the physical realm. This is why it is religiously neutral—because the idea of "God" is not a legitimate part of the data-gathering stage of the modern scientific method, as I point out at length in *The God Hypothesis*. It is only in the "data interpretation stage" of the modern scientific method that the idea of God is able to make its way into the realm of physical science at all, and this fact remains true in virtually all forms of "theistic science."

Burgeson's second criticism centers around my claim that a theistic interpretation of the physical data is inherently simpler-and therefore more in keeping with the principle of Occam's Razor-than are virtually all non-theistic interpretations of the very same data. The truth of this claim is self-evident: a single divine Law-Giver is indeed simpler than any conceivable non-theistic explanation of our physical universe, whether it involves billions of years of random selection or a postulated infinity of possible worlds.

It is also true, however, that the simplest explanation for any given phenomenon doesn't always have to be the correct one, and I don't imply anything to the contrary in *Evolution and the Problem of Natural Evil*. I simply point out that in the history of modern science, Occam's Razor has turned out to be an important and valuable means of approximating conceptual accuracy in the physical sciences. Virtually all of history's greatest scientific thinkers have repeatedly utilized this principle of simplicity in their theorizing. It is on the basis of these two facts that I claim that a theistic interpretation of modern science is more in line with Occam's Razor than is the converse. Moreover, this hypothesis seems to render a theistic interpretation of the physical data more accurate overall, at least when we look to the validity of this principle in the past. But again, this doesn't necessarily mean that the simplest interpretation of the data will always be true, and I never implied this in my text.

In any event, the history of modern science teaches us that theorists who ignore the principle of Occam's Razor do so only at their own peril. But if this is true, and if it is also true that a theistic interpretation of the physical data is more in keeping with this Principle of Simplicity than is virtually any imaginable non-theistic interpretation, then there is nothing wrong with the conceptual "embracing" of this type of theistic interpretation.

Burgeson also asserts that I mistakenly conclude (on p. 136 of my text) that "modern science affirms scientism." This, of course, is a gross over-simplification of what is actually stated in the text itself. To be more precise, I merely stated that "given the development of the modern scientific worldview, which includes an affirmation of the ideals of predictive determinism, reductionism, and scientism, the notion of theistic evolution came to be understood as a contradiction in terms." Now, there is a huge distinction to be drawn between modern science itself, and the modern scientific "worldview" that espouses it. Virtually everyone agrees that the basic units of modern science are the observable facts and laws of the natural world. These empirical facts are, once again, religiously neutral. It is only when we progress to the data-interpretation stage of the modern scientific method that the very notion of a possible Creator (along with other conceivable explanations) come into play. But this is precisely what a "worldview" is in the first place: a philosophically-based interpretation of the empirical facts themselves.

Burgeson thus doesn't appear to appreciate the huge distinction between the empirical facts of modern science itself, and the modern scientific worldview, which is a philosophical interpretation of these very same physical facts. For while the empirical facts of modern science are both religiously and philosophically neutral, and hence do not either affirm or disconfirm the metaphysical belief of "scientism" (which states that the physical objects that modern science studies are the only types of entities in existence), it is an entirely different matter with the modern scientific worldview, which does indeed affirm the philosophical notion of "scientism," since this nontheistic worldview is based upon the underlying presumption that physical objects are the only types of "things" in existence.

It is Burgeson's implicit conflation here of "modern science" with the "modern scientific worldview" that has led him astray. The empirical facts of modern science are clearly not to be confused with any type of philosophical worldview that seeks to interpret the underlying meaning of these same basic facts.

These are the only specific criticisms that Burgeson mentions in his short "review" of my book, yet they were enough to lead him to dismiss the remainder of the book out of hand. Indeed, he explicitly states that he only "skimmed" through most of the text, which is a clear mistake, given the extreme subtlety and complexity of this particular issue.

In fact, Burgeson eventually contradicts his own conclusion that the majority of the book is simply "useless," and is therefore "not to be recommended." How can he coherently make this claim, when he also openly states that my classical Christian approach to solving the theodicy problem is "fairly adequate"? Given the profound complexity of the theodicy problem, it follows that a "fairly adequate" solution is a highly significant one indeed. Indeed, the theodicy problem is widely recognized by virtually all philosophers and theologians as the single most difficult conceptual problem in academia today. Nevertheless, in the very same paragraph in which Burgeson judges my theodicy to be "fairly adequate," he goes in the very opposite direction by judging the book itself to be "simply useless." Is it even possible for a "fairly adequate" solution to the problem of evil to be "simply useless" at the same time? I don't see how.

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The Reviewer Responds to Author

Michael Corey's *Evolution and the Problem of Natural Evil* addresses what is, perhaps, the major philosophical question confronting the Christian faith. I commend him for his attempt to address that problem, which has engaged our species for well over 2000 years. It may well be that his book will bring a measure of stability to some Christians who look for more certainty in their theologies than some of us have been able to find.

The librarian at the Iliff School of Theology, a Methodist seminary in Denver, clearly thought the book was of sufficient importance to place a copy in the Iliff library, and it may well be that my assessment is incomplete. I suggest that those with an interest in the problem of theodicy might do well to look at Corey's book, along with David Ray Griffin's recent book, *Religion and Scientific Naturalism: Overcoming the Conflicts* (State University of New York Press, 2000). Griffin solves the theodicy problem quite well, but as I see it, at an expense of an inadaquate theology. Corey has, likewise, solved the theodicy problem, but at the expense of an inadaquate view of the scientific enterprise.

In rereading my review, I agree with Corey that I may have been overly harsh. Perhaps the title led me to expect more than the author was prepared to offer. But serious readers of it will have to decide this for themselves. When you find a copy on the library shelf, take time to look it over.

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Beyond the Hills of Seely

I thank Paul Seely for his comments (*PSCF* Letters, June 2003) on the interchange between Art Hill and myself on the Noachian Flood (*PSCF* Letters, March 2003). It was my hope to encourage a dialogue between *PSCF* readers on this topic.

I both agree and disagree with Seely about "accommodating the cultural understanding of the time." The cultural perspective of a biblical people must always be figured into the equation of how to interpret Scripture, but the question still remains: Can the historical accuracy of the Bible be trusted? (By "historical" I not only mean history and pre-history in the traditional sense, but also the historical, time-related disciplines of archaeology, geology, astronomy, etc.). It is my belief that the Bible in its original (autograph) text accurately records historical events, *viewed within the culture (worldview) of those times.*

I'll give an example. In an upcoming article in *PSCF* entitled "Making Sense of the Numbers of Genesis," I try to explain that the Mesopotamians incorporated two numbering systems into their world view: (1) a numerological (sacred) system, and (2) a numerical (real) system. Two primary sacred numbers were sixty (the base of the Mesopotamian sexagesimal system) and seven, and the patriarchal ages from Adam to Noah are based on either or both of these numbers in some combination or permutation. In order to understand the very difficult topic of the long ages of the patriarchs and the chronologies of Genesis, one *must* understand the world view of the Mesopotamians—that their concept of the meaning of numbers differed drastically from our own. The biblical statement that Noah was 600 years old at the time of the Flood (600 = 60 x 10, a "perfect" number to the Mesopotamians) can be understood numerologically from a Mesopotamian world view, but this "cultural accommodation" does not negate the biblical truth that there was a historical Flood, that God purposely produced this Flood for His own purposes, and that God worked through a specific historical man (Noah) to accomplish those purposes. It seems to me that "cultural accommodation" can be carried only so far if the integrity of the Bible is to be preserved.

Now, to address some of the more specific comments in Seely's letter.

1. Seely's comment: " the 'whole earth' of Gen. 8:9 that was flooded is the same 'whole earth' that the three sons of Noah later populated" (i.e., the extent delineated in Genesis 10). Actually, the geographical extent of the Table of Nations (Genesis 10) may be even wider than specified by Seely. The commentaries I've read extend the Table of Nations to Spain in the northern Mediterranean region, to the whole North Africa region, and to all of the Arabic nations. (Or as the Hebrew scholar Cassuto has remarked: "the Table of Nations included only those nations in contact with Israel—not all of the nations of the world"). The key here is that the extent of the "whole earth" expanded geographically over time commensurate with the expanded world view of the biblical writers. In Noah's time, the "whole earth" meant just the Mesopotamian alluvial plain; later in time when the Table of Nations was written down it referred to the-then geographical extent of the Semito-Hamitic language nations in contact with Israel. In Acts 1:8 time (first century AD), the "uttermost parts of the earth"

probably referred to the Near East, parts of Europe (including Great Britain colonized by the Romans), parts of Asia, and parts of Africa (in the north and around its coastal areas). Today, from our world view, it means the entire planet Earth. Thus, the term the "whole earth" is to be understood arbitrarily rather than for any specific point in time, and the extent of Noah's Flood cannot be equated with that of the Table of Nations as has been suggested by Seely.

2. Seely's comment: "Old Testament scholars say the 'whole earth' flood of Noah goes back to the Earth being as completely flooded as it was in Gen. 1:2." I have never heard this interpretation before, but just because some Old Testament scholars say it, does not mean it is necessarily the correct interpretation. All of the commentaries I have read on Gen. 1:2 imply that this verse is describing the early, formless state of the Earth – it implies nothing about a "flood." Could this interpretation of Old Testament scholars be more integrally related to a particular cosmology (theology) of *their* time than to two different physical events described by the Bible?

I would argue that neither of Seely's reasons are justification for giving up the historical accuracy of the Bible or for postulating an "accommodating" God. How do other *PSCF* readers feel about this?

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"Subtle Energy" May Not Be Demonic

Burkholder in "What is the 'Subtle Energy' in Energy Healing?" (*PSCF* 55 [2003]:104–16) argues that the subtle energy is psi (chi, qi) and warns against many unorthodox medical practices as demonic signs and wonders. But the connection between acupuncture and demonic power is without firm basis. All ancient practices of medicine were related to religion in some ways, only in the recent secularized Western society are orthodox medicine and religion separated. During the nineteenth century in Western society, Thomsonianism (the idea that all diseases were caused by cold and could be cured by heat), homeopathy (the principle of like is cured by like), hydropathy (the philosophy of water cure), and Graham's Christian Health Movement (the use of dietary regimens for disease prevention that started the Kellogg and Post cereal companies) represented a physiological Arminianism, which claimed that individuals could take control of their own physical salvation, even though these practices did not educe any metaphysical theory of healing. However, Swedenborgianism and mesmerism, which sprang up during the same time, did connect the physical and spiritual realms. During the late nineteenth century chiropractic and osteopathic medicine emerged from mesmerism and gradually muted their references to metaphysical concepts of disease. (See Robert C. Fuller, *Alternative Medicine and American Religious Life* [New York: Oxford University Press, 1989]). From this short summary one can see that unorthodox or alternative medicine may not relate to the spiritual realm and can be separated from earlier metaphysical speculation in a later stage of development.

Chinese philosophy, like Greek philosophy, was not related to religion through its historical development. Traditional Chinese medicine did not have a strong religious tie, though its theory is related to Taoism through coexisting in the same cultural environment. But Taoism was originated as philosophy, only later emerged with religious rituals. Even under anti-religious and materialistic communist rule of China, traditional Chinese medicine, including acupuncture, was promoted. (See Bill Moyers, *Healing and the Mind* [New York: Doubleday, 1993]). Therefore, the demonic connection of acupuncture is very weak. This hypothesis is plausible only if one considers all non-Christian philosophies or ideologies as demonic idols replacing the Christian theology.

Traditional Chinese medicine is based on a totally different theory of physiology. There is no scientific proof that the theory is true. However, there are still many unknowns in the world, and one should not attribute any unfamiliar theory to demons even if Chinese theory of psi has been appropriated by the New Age Movement. The correct attitude should be to explore any medical intervention, to see its usefulness and limitation, and to disregard any historical metaphysical baggage. (See John P. Newport, *The New Age Movement and the Biblical Worldview: Conflict and Dialogue* [Grand Rapids, MI: Eerdmans, 1998]). Modern cancer chemotherapy was discovered through herbal medicine, although herbal medicine was related to animism or shamanism in the past. Also many useful pharmaceutics, discovered through luck and subsequently verified by clinical trials, did not have good physiological explanations first, and some still don't have.

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